

**CROSS-ENTERPRISE DOCUMENT SHARING (XDS)
IMPLEMENTATION BASED ON BLOCKCHAIN TECHNOLOGY**

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ABSTRACT

On the increasing demand for a better quality of healthcare services, some topics involve healthcare information technology in terms of operational efficiency. Healthcare information sharing and interoperability between healthcare organizations are one of the major solutions to improve healthcare service quality. However, the healthcare industry poses many challenges that inhibit solutions to become reality. The Integrating Healthcare Enterprise (IHE) initiative to standardize healthcare information sharing methods to address health document sharing issues between different enterprises, Cross-Enterprise Document Sharing (XDS.b) Profile allows the adopted organizations to share health documents simultaneously using the central exchange.

Like other industries, cyber-security threats have threatened the healthcare information domain. These threats increase the difficulty in the development of health information sharing networks and causing damage to healthcare enterprises. These cyber-threats can cause damage to the industry in many aspects, especially those cyber-attack that targeting integrity and availability of data. These kinds of cyber-attacks can severely hinder the continuity of medical operations, potentially resulting in the cost of a patient's life. There are many solutions technology proposed to deal with these kinds of cyber-attacks. One of the technologies that are the trend to deal with cyber-threats threatening integrity and availability of data is Blockchain technology.

Several pieces of research have proposed the concept of using Blockchain technology to solve health information sharing issues but, there are still many limitations that prevented Blockchain technology from effectively integrated with data like health information. This is where the IHE XDS.b profile could be used with Blockchain technology to allow health document sharing through the decentralized networks while address cyber-security issues through unique characteristics of Blockchain technology. In this work, we propose the approach for integrating Blockchain technology with the IHE XDS.b profile which results in the new concept of health information exchange.

KEY WORDS: HEALTH INFORMATION / INTEROPERABILITY /
INFORMATION SHARING / INFORMATION SECURITY / BLOCKCHAIN /
SMART CONTRACT / IHE / XDS

298 pages

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LIST OF ABBREVIATIONS

Abbreviation		Page
IHE	Integrating Healthcare Enterprise	1
XDS	Cross – Enterprise Document Sharing	1
XDS.b	Cross – Enterprise Document Sharing Set-b	1
IDE	Integrated Development Environment	44

CHAPTER I

INTRODUCTION

With the transition from the age of paperwork to digital records, the healthcare industry is now undergoing digital transformation. Efficiency and continuity are the main factors that driven the healthcare industry to change. Paperwork starts falling behind when a huge amount of data is produced by healthcare service operations from day to day. Health information undeniably has become an important component in developing efficient healthcare services [1–6]. On the increasing demand for the better quality of healthcare service, there is the topic that involves healthcare information technology in terms of operational efficiency. Healthcare information sharing and interoperability between healthcare organizations are one of the major solutions to improve healthcare service quality. Patient's health document data are scattered across different healthcare organizations, due to the foundation of healthcare informatics are separately developed by different organizations. Each healthcare organization has its own method to process and handle healthcare information. This makes it hard for one healthcare piece of information to interoperate with other. Lack of interoperability prevents many opportunities for healthcare service quality improvement. The patient may need to take extra repetitive care procedures when visiting a new hospital. Mistakes in communication between different physicians can cause misdiagnosis. So, there are many demands from the patient side that want their health journey to be connected and improve healthcare service quality.

To enable health information sharing from just one organization with another can cost much more than the benefit they can gain. Sharing health information with not fully-trusted party exposing vulnerabilities to the business model. The risks and benefits to the organization from sharing their patient information with others may not be worth it as compared to the risk. For example, health information sharing allows the physician to access a patient's health history in other hospitals give decent improvement to service quality, in turn, exposing the information access to cyber-criminal and provide a chance for business competitors to gain an advantage. This creates high friction for one

organization to share their information with others. It was even more difficult for an individual patient to integrate their healthcare with different providers. This makes the interoperability issue to be extremely difficult for every single organization to solve on its own. It revealed that these interoperation problems cause a huge decrease in inefficiency in healthcare operations and result in lower quality of healthcare service [7–14]. But there is still no efficient way to be best solve the problem yet. That means there still have an open issue on how to solve interoperability in the field of healthcare. [7,9–11]

That way many initiatives start to standardize healthcare information technology to allow healthcare organizations to be able to interoperate with each other. Integrating Healthcare Enterprise (IHE) is one of the well-known initiatives that provide specifications for using healthcare informatics standardization. IHE provides an implementation framework and guideline for developing a health informatics system. For health document sharing between different organizations, IHE provides a Cross-Enterprise Document Sharing (XDS.b) profile. The profile act as a guideline for the system developer to implement their system to meet the requirement where the system can share health document with other organizations. This profile will be the main focus of this work, to deal with the health information sharing problem.

In the current age of information digitalization, cybersecurity has become an important issue for many organizations and individuals. Anyone can become a target of cyber-attacks. The healthcare industry is one of the major targets that become a victim of cyber-attacks each year [15]. Followed by the digitalization of hospital operations and information systems, the amount of cyber-attack and variations rise as the technology developed. These incidents variant from breaches in personal health information to the larger size of attacks which can potentially halt hospital operations that cause damage in various kinds. It may cost the hospital more than a million, or even cost individuals' life because of the incident for the worst.

There are many kinds of incidents targeting the healthcare industry. In recent years, one of the major incidents found throughout the industry is a hospital data breach. Data breaches often appeared in the form that hospital data got compromised by hackers. The compromised data can be valuable in the criminal world as it can be used for various kinds of criminal activities like identity theft, blackmailing, or social engineering

because the data may include patients' personal information and their health condition. This kind of incident can potentially cost hospitals 'a trust' issues from their patients, as individuals' medical conditions and privacy are being exploited. Also, there is the case that not just gain unauthorized access to patient's private data but, take over the data or even wipe all important data out of existence. 'Ransomware' and 'Wipeware' are the main cause of these threats. Ransomware takes over ownership over data away from the hospital system and encrypts all the data which often takes an important role in hospital operation. At the same time, Wipeware will delete all the data from the victim machine. This mostly causes great disruption in hospital operation as consequence. Incidents that showed up in recent years seem to target healthcare organization more frequently, as the industry still have poor cybersecurity practices [16]. Many incidents [16–18] showed that social engineering launched on healthcare employees is on rising. The threat has the potential to seamlessly blend into hospital workflow and made it hard to be noticed. However, follow these incidents, many stakeholders in the healthcare domain start to implement cyber-security to their organization infrastructure.

At the foundation, each organization must start with educating their employees on cyber-security awareness to reduce the risk of cyber-incident that may cause by human error or human vulnerabilities. Next, define organization policy and management plan that help prepare against cyber-incident. When employees and management level of organization have prepared cyber-security, the organization will focus on cybersecurity of the technology layer. There is various kind of tools and technology that was invented to mitigate cyber-incidents. Some may have been made to prevent exploitation of existing technology while some may have been made to directly deal with known and upcoming threats.

One of many concepts invented to mitigate these threats is the decentralization of data. The concept of decentralization was made to mitigate most incidents and threats that involve single-point of failure vulnerability. In the case of the healthcare industry where the loss of patient data can cause many major damages to the affected organization and their patient, decentralization of data can help reduce damage caused by the case. There is more than one benefit that healthcare document data can gain from decentralization. Decentralization allows patient data that scattered across healthcare domains in different organizations to link to each other. As healthcare document data

can be scattered across the different organizations within the healthcare industry, it also increases the chance that its copies can survive cyber-incidents. Even in case, that document in one organization got compromised, there is a chance that copies of compromised data also exist in other organizations. The survived copies can make a substitute for the original that got compromised. However, this is only possible if there is a point that lets every organization in the network know which document exists in which organization. This is where the concept of the IHE Cross-Enterprise Document Sharing Profile fits in. Combined with Blockchain technology that makes the Document Registry entry persist and immutable, this ensures that every organization in the network will always know the whereabouts of document they need within the network while the entry itself cannot be tampered or deleted by any actor with ill intention.

This work will introduce another way to allow health document sharing between healthcare organizations with increased protection against cyber-threats, by using a combination of Blockchain and IHE Cross-Enterprise Document Sharing (XDS.b) Profile.

1.2 Problem Statement

There is no reliable software platform that supports securely and confidentially sharing healthcare documents between healthcare systems and organizations. The platform must allow sharing of healthcare documents between different healthcare organizations while still maintaining the confidentiality of data and also help mitigate emerging cyber-threats in the healthcare domain that tend to tamper with integrity and availability of data. The platform must act as the health document exchange medium that has distributed, decentralized, persistent, confidential, and immutable availability characteristics.

1.3 Objective

1.3.1 Design and implement Document Registry Blockchain shall follow the requirement for document registry defined in the XDS.b integration profile from IHE.

1.3.2 Design and implement Blockchain smart contract shall provide the main function to Document Registry Blockchain as healthcare document registry which comprises of health document registering function and health document search

function.

1.3.3 Design and implement Blockchain smart contract shall have additional function to record healthcare document exchange between participate node.

1.3.4 Deploy and evaluate the functionality of Document Registry on Blockchain.

1.4 Scope of Project

1.4.1 Design and implementation of Document Registry Blockchain shall follow requirements defined in XDS.b integration profile from IHE.

1.4.2 Design and implementation of Blockchain smart contract within Document Registry Blockchain that gives the main function as healthcare document registry and additional function as healthcare document exchange history record.

CHAPTER II

LITERATURE REVIEWS

2.1 Integrating the Healthcare Enterprise (IHE)

Integrating Healthcare Enterprise initiative (IHE) is an initiative founded by RSNA and HIMSS that works closely with the healthcare industry to improve the integration, exchange, and sharing of information technology systems in the healthcare sector. IHE appreciates the use of established standards such as HL7 and DICOM to meet specific needs or clinical needs to support optimal patient care. A system developed following IHE will be able to communicate better with each other, be easier to implement, and enable care providers to use health information more effectively. This helps enables accessibility to the information which enables usability whenever and wherever it is needed. The initiative is responsible for providing services for interoperability, specifications, and tools. They also work with industry, health authorities, clinicians, and users to develop, test, and implement solutions that meet important health information needs based on established standards [19].

2.1.1 IHE Process

Figure 2-1 shows the IHE Process where the initiative gathers developers and users of healthcare information technology in a recurring four-step process. In this process, technical and clinical experts first define key use cases for health information sharing, and then technical experts create specifications for communication between systems to solve the use cases. IHE participants also select and optimize established standards during this step. After that, the industry implements the defined specifications which would be called “IHE Profile” into their healthcare information technology system. The initiative then tests implemented systems to ensure that the resulting implementation of IHE Profiles will provide benefit for the implementer and make their works compatible with others in the healthcare industry. The initiative committees follow the process as shown in Figure 2-1 to address interoperability in various healthcare service areas including Information Technology Infrastructure.

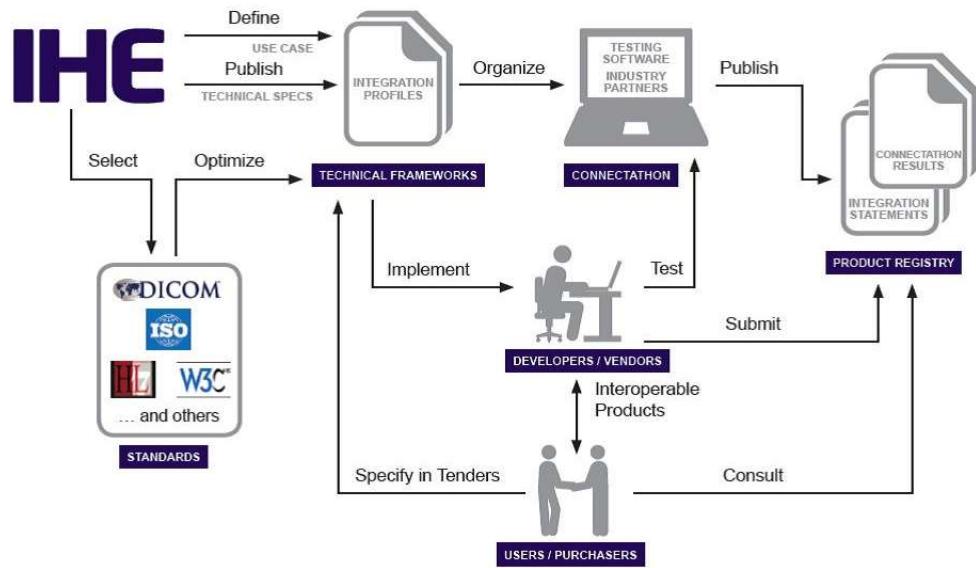


Figure 2-1 IHE Process to create guideline for implementation of health information technology

[20]

2.1.2 IHE Integration Profiles

IHE Integration Profiles or IHE Profile are products of the IHE Process which provide a framework based on standards for sharing health information within the sites for healthcare services and across the networks. The framework address interoperability issues related to information access for the healthcare given to providers and patients in an area of clinical workflow, administration, information infrastructure, and security, etc. IHE Profile was purposely designed to offer a clear implementation path for IT developers to develop and implement IT systems for a healthcare organization that meets the needs and is compatible with the environment of the healthcare industry while also aiding them in dealing with various kinds of communication standards existing within the healthcare IT domain. These profiles organize integrated functions through the coordinated implementation of established health information sharing standards (such as HL7, W3C, DICOM, and safety standards). IHE Profiles also provide definitions for implementing standards to meet the clinical needs and demands. [21] Each profile defines the participants (the actors), transactions, and information content required for implementation to resolve clinical use cases by referencing the corresponding standards. IHE Profiles that have undergone IHE Process, tested, and deployment in real-world settings and have reached the approved status, will be

published in documents called "IHE Technical Frameworks" (IHE TF). Each IHE clinical domain has one corresponding framework, with each framework may be comprised of multiple volumes. The Technical Frameworks provide detailed explanations for each IHE Profile specified by their interoperability issues and dependencies among the Integration Profile.

2.1.3 IHE Information Technology Infrastructure Technical Framework

The IHE IT Infrastructure Technical Framework (ITI TF) defines the implementation of existing standards to establish medical information sharing that supports the best patient care. The framework is expanded every year after the public review period and is regularly maintained through identification and corrections through errata. IHE ITI TF identifies a subset of the functional components of healthcare companies, called "IHE Participants", and uses "transactions" to illustrate their interactions based on a set of standards-based coordination. The body of transactions was described within the framework in detail. The IHE ITI TF is divided into four volumes. The first volume describes the concept detail of IHE ITI Integration Profiles. The second volume is divided into four sub-volumes; a, b, c, and x which describe the concept detail of all transactions present in the framework. The third volume provides a further explanation of the specifications of cross-transaction and content used in Document Sharing Profiles. The fourth volume provides additional national extensions related to the framework.

2.1.4 Cross-Enterprise Document Sharing Set-b (XDS.b) Profile

Cross-enterprise document sharing set-b (XDS.b) configuration file facilitates registration, distribution and access to patient electronic health records (EHR) throughout the healthcare enterprise network [22]. The profile focuses on providing a specification for managing the sharing of health documents between any healthcare enterprise in accordance with standards, ranging from doctors' private offices to acute care in inpatient facilities. XDS is a generic term to reference all XDS profiles which are Cross-Enterprise Document Sharing Profiles [23]. In IHE ITI TF Vol.1 declared that the term XDS within the IHE ITI TF currently refers only to XDS.b. The main goal of the XDS.b profile is to allow XDS Affinity Domain members to share health documents via XDS Document Registry. That means, its process mainly about makes metadata of documents within the XDS Document Repository available on XDS Document Registry

entry. This allows any XDS Document Consumer to visit XDS Document Registry and seek the document they need before retrieve it from the XDS Document Repository that the document belongs to.

The process overview of Cross-Enterprise Document Sharing (XDS.b) profile is described in Figure 2-2. The figure also showed sequence of process along with involving XDS actors and XDS transaction format. At the beginning, each health document will be created from its sources along with its metadata attributes. These sources will be called ‘XDS Document Source actor’ which can be any machine involved in healthcare service, for example; CT scanner, laptop in each physician office, or central computer in medical lab. Next, these created documents along with its metadata will be sent to data storage which act as document repository. These repositories will be called ‘XDS Document Repository actor’ which usually be some kind of computer or server that was assigned to keep medical document available for use. According to XDS.b profile, XDS Document Source will send document metadata in the format of Provide and Register Document Set-b (ITI-41) format. In some case, XDS Document Source and XDS Document Repository may integrated together. This is called ‘XDS Integrated Document Source Repository actor’. The XDS Integrated Document Source Repository functions the same way as XDS Document Source and XDS Document Repository will do but, combined together.

Once the document and its metadata are sent to the XDS Document Repository, the repository will index and make the document available for use. At the same time, XDS Document Repository registers metadata along with identifier and locator of the repository itself to local document registry. The message transaction in this process will follow format of Register Document Set-b (ITI-42) transaction. The document registry will be referred to as "XDS document registry participant". XDS Document Registry is software or machine that keep all document metadata and its corresponding repository from all connected repositories available for discovery. Commonly, XDS Document Registry should be database that keep document metadata from all connected repositories available for discovery through database query. However, there are no restriction from XDS.b profile for method to keep these data and how to discover each document metadata using specified document metadata attributes. There are just requirement that require XDS Document Registry to be able to accept value of specified

document attributes from XDS Document Consumer and return the matched document to the consumer.

In XDS.b profile, ‘XDS Document Consumer actor’ can be any kind of software or machine that allow user like healthcare employees to access health document or medical document they need. There are no restriction in XDS.b profile that specified XDS Document Consumer actor to be different software or machine from other actors. XDS Document Consumer actor will just require user to specify value of known document metadata attributes which will allow XDS Document Repository to search for matching document metadata in its database. After received document attributes value from its user, XDS Document Consumer actor will send the specified attributes to XDS Document Registry. This message transaction will follow format of Registry Stored Query (ITI-18). Then, XDS Document Registry process received attributes by search for matching document metadata and return full document metadata which it found to XDS Document Consumer. XDS Document Consumer actor show founded result to its user. The user pick the right document they need and issue to XDS Document Repository corresponding to the document for document retrieval via XDS Document Consumer actor. XDS Document Consumer will send document retrieval request transaction in the format of Retrieve Document Set-b (ITI-43). After XDS Document Repository received document retrieval request from XDS Document Consumer, the repository will seek for the specified document and return the document to XDS Document Consumer. XDS Document Consumer actor will make the retrieved document available for user to use.

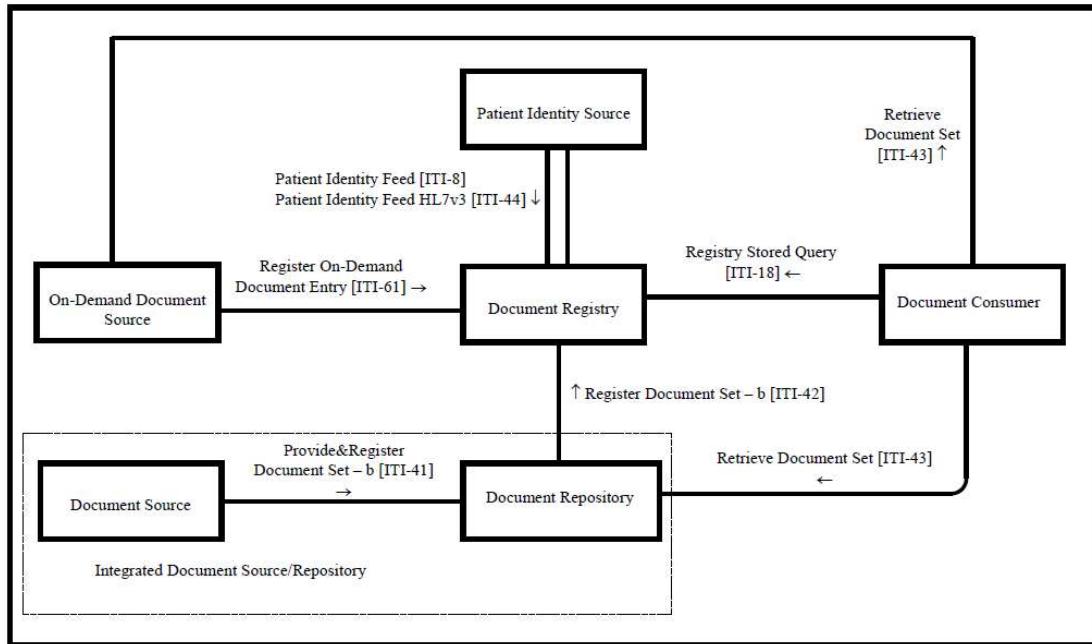


Figure 2-2 Cross-Enterprise Document Sharing - b Diagram [22]

2.1.5 XDS Transaction Format Types

In XDS.b profile, all messaging transaction will be in the form of XML format with schema depend on each types of transaction. Types of XDS transaction format vary upon involving actors and its purpose.

2.1.5.1 Provide and Register Document Set – b (ITI-41)

Provide and Register Document Set – b (ITI-41) transaction format defines XML schema for message that sends metadata of document from XDS Document Source actor to XDS Document Repository actor for store into document repository. This type of transaction mainly requires XDS Document Source to include all available metadata attributes of created document for other XDS actor. XDS Document Repository actor would need to acknowledge to XDS Document Source if it successfully received document and its metadata.

2.1.5.2 Register Document Set – b (ITI-42)

Registering a document set-b (ITI-42) defines an XML schema for a message that sends the metadata of the documents available in the repository from the XDS Document Repository participant to the XDS Document Registry participant to register the document to the Document Registry entry. Main purpose of this type of transaction

is to pass document metadata stored in repository to XDS Document Registry actor addition with attributes about the repository. XDS Document Registry actor will need to respond back to XDS Document Repository actor when received the transaction and register it to document registry entry.

2.1.5.3 Registry Stored Query (ITI-18)

Register Stored Query (ITI-18) is general XML schema format that used by one actor to query for data from another actor in entire IHE IT Infrastructure Framework. In this work, the transaction will be used by XDS Document Consumer actor to request for document metadata it seek from XDS Document Registry actor. Any document metadata attributes known by XDS Document Consumer will be included in the transaction. XDS Document Registry will use specified metadata attributes to search for matching document metadata inside document registry entry. XDS Document Registry will need to respond to XDS Document Consumer actor that it received the request. XDS Document Registry also needs to return search result to XDS Document Consumer.

2.1.5.4 Retrieve Document Set (ITI-43)

Retrieve Document Set (ITI-43) define XML schema for XDS Document Consumer to request document retrieval from XDS Document Repository. Different to other transactions involved in XDS.b profile, Retrieve Document Set transaction only contain few essential attributes to allow retrieval of document from document repository. XDS Document Repository will need to acknowledge to XDS Document Consumer when received the transaction before return the requested document.

2.1.6 Transaction Object Type and Metadata Attributes

In each transaction, there are set of metadata attributes that represent the document. These metadata attributes are categorized to three sections. SubmissionSet (Table A-1) represent information associated with submission of document since it was created by the source. Folder (Table A-2) represent group that the document belongs to. DocumentEntry (Table A-3) represent the document itself.

2.2 Blockchain Technology

2.2.1 Definition of Blockchain

The blockchain is a list of records, called "blocks", which are linked to each other in an encrypted manner and have security features [24]. Blockchain technology allows data to be stored and exchanged based on peer-to-peer levels. Blockchain data can be structurally shared, consulted, and secured relied on consensus-based algorithms (generally called "Consensus") [25]. In the blockchain ledger, it is a sequence of blocks containing a list of transaction records similar to a regular public ledger [26]. Participants in a Blockchain network have records of all blocks and transactions with these records stored locally on the computers that belong to each participant in the Blockchain network. Any kind of change made to the Blockchain requires consensus between the participants of the network. The idea of blockchain was later combined with other technologies and computing concepts to create modern digital currencies (called "cryptocurrencies"), which protect electronic cash through the encryption mechanism components of the Blockchain, replacing the central repository or authority.

In 2009, with the launch of a cryptocurrency network called "Bitcoin", Blockchain technology became widely known to the public. This was the first widely known Blockchain network, and its purpose was to serve as a new type of digital currency, followed by multifunctional Blockchain such as Ethereum has its own application platform. For cryptocurrency Blockchains like Bitcoin, the Blockchain is used to record the transmission of digital information representing electronic cash that occurs in a distributed system. These transactions act as digital evidence which allows Bitcoin users to transfer their rights over each unit of Bitcoin currencies to others, the distributed nature of the Blockchain ledger makes them available for public verification. Blockchain was designed to defy the concept of having a single centralized system as the host of the network which subsequently allows the concept of decentralization to take the place by having many members of the network equally maintain the replicated distributed ledger. Combining the concepts of "Block" and "Chain" of encrypted hashing, the Blockchain will be durable for any attempt to change the information recorded in the distributed ledger. With the contribution of the Blockchain developer community, the technology can now be used in various applications and is being studied for further use in many industries [27].

2.2.2 Benefit of Blockchain

Blockchain is tamper-proof. Blockchain ledgers are implemented in a distributed manner, giving them natural data distribution. The technology is also based on decentralization which eliminates the need for a central authority. The Blockchain enables the Blockchain user community to record transactions in the shared ledger within the community. Under the normal conditions of the blockchain network, any transaction cannot be changed once it is released [27].

2.2.3 Blockchain Characteristics

Key characteristics of the Blockchain can be vary depend on its setup and environment of usage. According to many sources, key characteristics of the Blockchain may be summarized as followed:

2.2.3.1 Decentralization

Decentralization is the foundation of Blockchain technology as response to problem of centralized system. In centralized system, especially centralized database, there is a chance that the database got compromised by hacker. Other than rely on backup data, there are very few options to deal with the incident. This makes the compromised database become single point of failure which prevent follower system to operate. Decentralization of data was proposed to scatter the chance of single database from getting compromise. This makes decentralized database network have more resistant against incident threatening centralized data. Even hit by incident that aims to compromise the data. If at least half of decentralized network survived the incident, the data survives the attack.

2.2.3.2 Immutable

With utilization of cryptographically hashed chain combined with decentralized network, the Blockchain technology ensures that any data published on Blockchain cannot be deleted or modified. If there are any modification made to content of published data, it will cause change on the hash chain and detected the network. Any action that causes change to hash chain will be negate by majority of the network. This mean if anyone want to temper with published data on Blockchain, they will need to compromise the entire network at once. Any survived node has chance to notify the abnormal to the entire network.

2.2.3.3 Transparency

As the foundation of Blockchain is to have all participant nodes have the exact same copy of Blockchain ledger, it passively gives transparency to published data. It is impossible for anyone to secretly hide something inside Blockchain without let other participants in the Blockchain network know.

2.2.3.4 Distributed

Blockchain has distributed characteristic by design. All nodes will have the same Blockchain ledger. Any contents published to Blockchain ledger are passively distributed to all Blockchain node. With consensus algorithm, it requires that the publishing content either sent to all nodes before accepting to publish or being accepted then send to all node, to complete consensus. So, Blockchain ensures that any data published to the chain are distributed to all connected nodes.

2.2.3.5 Trusted

In public network where anyone can participate or in permissioned network where participants are not completely trust each other, trust is the main factor that define usability of decentralized network. Along with Blockchain technology, consensus solve the issue about trust by eliminate the chance of any single node participate in Blockchain to have absolute control over publishing data when certain condition is met. It can rely either on randomness or specially designed algorithm depend on each consensus method. When none of any single node can have absolute control over publishing data on the Blockchain, made it extremely difficult for someone to temper with target data. Many consensus methods ensure that it will much more expensive for anyone to attempt on tempering with publishing data when compared to benefit they can get. This passively establishes trust between all participant nodes.

2.2.4 Blockchain Types

When considering the scope of participants who can participate in a specific Blockchain network, Blockchain can be classified into three types of Blockchain networks.

2.2.4.1 Public Chain

Public Blockchain is the type that allows anyone to participate in the network either participating as client/user node or miner/validator node. This type of Blockchain mostly has no specific rule, policy, or agreement for participants to enter the network. The type is suited best with the network environment where its data is not required to be kept confidential from the public.

2.2.4.2 Private Chain

Private Blockchain is the type that allows only a limited number of members to participate. This type was invented to be more compatible with the environment that participant nodes are members of a specific organization or community where the Blockchain ledger may record confidential information limited only to participants.

2.2.4.3 Permissioned Chain

Permissioned Blockchain is the type that allows only selected members of a specific community or affinity domain to participate, and it is also known as consortium Blockchain. Permissioned Chain is different from Private Chain in terms of scalability. As the private chain was limited for pre-selected members, the permission chain may further extend its member to a larger group of members via policy or agreement accepted by original participants. At the same time, the permission chain will not allow anyone to participate in the network as the Blockchain ledger may contain confidential information limited to the accepted group of participants.

2.2.5 Blockchain Components

2.2.5.1 Transaction and ‘Block’

Each of individual information represent change or cause of actions in information system are stored within Blockchain as “Transaction”. Several transactions being publish to Blockchain within the same time interval are put in the same “Block”. To form each single block, miner or validator needs to hash transaction together. The resulting hash value represents integrity of each block. If there are any change apply to transaction in the block, it will cause hash value of the block to change. Format of block vary depends on each Blockchain platform and its use case. Some platforms may publish in a form of plaintext just to act as the source of truth for every participating node to look without constraint. Some platforms may bound transaction or block to unique address to extend variation in accessibility. Some platforms may encrypt block to

maintain confidentiality of data. Transaction and Block are the key component which determine purpose and application of Blockchain.

2.2.5.2 Cryptographically hashed ‘Chain’

Other than the concept of “Block”, The Blockchain concept also introduced the concept of “Chain”. As integrity of each Block represent by its hash value, integrity of entire Blockchain represent by all hash value of all Block within “Chain”. The foundation of “Chain” concept is by chaining hash value of all blocks together. This can be done by include hash value of block formed in previous time interval into the current block to generate its hash value. Any changes made to any one single block will alter hash value of the entire chain that come after. This makes it harder to alter data that published within Blockchain. It requires anyone who want to alter the data to apply change to all blocks that come after the target block until the current one to make the change valid. Combined with decentralization characteristic of Blockchain network, this makes data exist in Blockchain nearly impossible to alter.

2.2.5.3 Distributed network of participate ‘Node’

Any machine that participates in the Blockchain network is called “Node”. Nodes represent the population of each Blockchain network. Each node keeps the same copy of data in Blockchain which is the Blockchain ledger and always tends to in sync with each other via Blockchain-specific protocol depend on each platform. In the case of Ethereum, the platform utilize devp2p protocol which allows each Ethereum node to connect with others at a peer-to-peer level [29]. If there are any differences in data between nodes, the version of data is being held by a minority of participating nodes. They will be clarified as false before rejected by the entire network and replaced by the right version accepted by the network. In each Blockchain network, some nodes may participate as "miners" or be elected as "validators" of the network at each different time interval. Miner/Validator nodes have a duty to perform the task which maintaining the consensus of the network. The Blockchain can be alive only if they are at least one participating node to maintain the Blockchain, while the strength of its characteristics depends on the number of participating nodes. In most cases, more participating nodes mean stronger Blockchain.

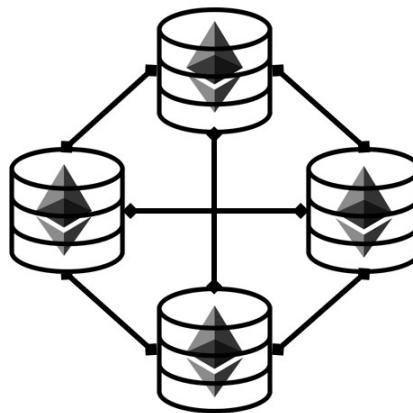


Figure 2-3 Blockchain network formed from the participation of Blockchain nodes

2.2.5.4 Consensus

Each Blockchain network must have its own consensus within the network. Specifically, it is not just the consensus between the member but the built-in consensus mechanism within the communication protocol connects each member in the network. The consensus mechanism acts a vital role to ensure the integrity of the Blockchain ledger by ensuring that everyone in the network is holding the same copy of the Blockchain ledger and no one has full control over data adding to the Blockchain ledger or have the right to select which version of the Blockchain ledger for the network to maintain. There are many variations of consensus invented since the beginning of Blockchain technology. Each has its own method of investing resources to achieve complete consensus. The existing consensus concept at the time can be divided into three major types based on the participation of Blockchain members who declared to act as maintainers of the Blockchain ledger.

2.2.5.4.1 Competition-based consensus

The type was the first to introduced along with the beginning of Bitcoin Blockchain which called "Proof of Work" (PoW). The competition-based consensus like PoW requires Blockchain maintainer node (which was called "miner") to invest computational resources on competing with other miners to solve the specific mathematical puzzle which only computational power can effectively solve. The first miner who can solve the puzzle will have the right to add the adding Block to the Blockchain ledger and receive a reward declared by the network which would

compensate the investment. In the case of PoW, a miner must randomly generate a correct "nonce" number that when hashing together with the hash value of the adding Block will result in a hash value with a digit of '0' beginning specified by the network (such as 0x000000abcd). This kind of puzzle ensures that the chance where malicious actors want to attempt malicious activity on the specific transactions on certain Blocks is at least possible. Combined with the increase in the number of miners entering the competition given that chance becomes nearly impossible to achieve. This consecutively ensures the integrity of the Blockchain ledger and gives transparency to Blockchain. The scenario of competition-based consensus suited best to Public Blockchain where anyone can participate in Blockchain. The more miner entering the competition means the more reliability and transparency for the Blockchain. Additionally, the reward-based nature of the concept can even further synergize the Blockchain to have more miners participate in the network. However, due to the competition will have major of computational power invested in achieving consensus, that means the environment where computational power is limited and precious to its member will not be compatible with this type of consensus.

2.2.5.4.2 Randomness-based consensus

The type was originally introduced as an alternative to a competition-based consensus like PoW and to address the problem where major computational power will be wasted in achieving consensus. The concept proposes utilizing randomness to aid in the selection of the Blockchain maintainer at a certain time. Widely known consensus mechanisms that can be categorized to this type are "Proof of Stake" (PoS) and "Proof of Authority" (PoA) which using pseudo-random algorithm combined with additional factor to determine for the node that has the right to add Block to the Blockchain ledger at a certain time (which would be called "validator"). Both PoS and PoA require validator candidate to place "the bet" on "the stake" which would mostly be cryptocurrency circulating in the network. The one with a higher bet put on a stake will have a higher chance to be selected as the validator of the time. However, there is still a chance that the one with a lower bet can be selected as the validator instead. The one that has been selected as the validator will gain all the bet placed on the stake. That means each candidate needs to take an equal risk to gain and loss their available bet. This

consecutively results as distributed right amongst the network similar sense to what achieved in competition-based consensus.

As this type of consensus act as an alternative to competition-based consensus, that means the environment best suited with this type of consensus is where its member cannot effort to lose computational power in competition-based consensus altogether.

2.2.5.4.3 Majority-based consensus

This type of consensus was also introduced as another alternative to a competition-based consensus like PoW. The original concept of this consensus type was originated from the "Practical-Byzantine False Tolerance" (PBFT) method. The method was invented for the traditional logic systems to determine for decision the system would take in the assumption that the majority of its members are on the "good side" and will take responsibility to help the system achieve the best decision. Implement to Blockchain, the consensus mechanism requires all participate node to act in a similar fashion to the validator. The network will only accept the adding Block to the Blockchain ledger when the adding version is the similar version in a majority of the network. This means it requires the adding Block to be the version that 2/3 of all member nodes propose to add to the Blockchain ledger. This eliminates the chance where malicious actor which assumed to be the minority of the network to attempt malicious activity on the adding Block. However, due to the majority-based nature of the type, it is only compatible with Blockchain types with only known members including Private and Permissioned Blockchain.

2.3 Ethereum and Smart-Contract

Ethereum is one of the well-known open-source Blockchain platforms. The platform initially invented by the developer named Vitalik Buterin and further develop and maintain by the Ethereum community [28]. The main approach of Ethereum Blockchain is about the use of Blockchain technology for applications other than cryptocurrency. The platform was the first to propose the concept of a 'smart contract' that enables programming over Blockchain technology.

2.3.1 Smart Contract

The concept of smart contract was initially proposed by Ethereum [28, 30]. Now the word ‘smart contract’ become common word to describe feature that allows developer to design the content that publishes to Blockchain and its computational behavior. In Ethereum, smart contract code is written with Solidity programming language. Smart contracts define what behavior the contract will do when open/view by user. Smart contracts rely on Ethereum Virtual-Machine (EVM) which allow host machine of Ethereum client to be able to execute smart contract Solidity code. EVM was designed to allow portability of Ethereum platform and always packed with Ethereum client. Now there are many interface tools developed by Ethereum community that allow Ethereum client to work with major programming languages. This further extend usage of smart contract to infinite possibilities.

Solidity is Javascript-like programming language that is specifically designed to use with Ethereum smart contract [30]. The main purpose of the programming language is to act as the middle between human-understandable language and computer language. It reduces difficulty for developer to design behavior of their smart contract on Ethereum Blockchain. The language is update and maintain by Ethereum community.

2.3.2 Quorum [31, 32]

Quorum (or later renamed as GoQuorum) is an Ethereum-based distributed ledger protocol forked of go-ethereum enabled for transaction/contract privacy and a wider range of majority-based consensus mechanisms compatibility. The platform was initially developed by "JPMorgan" and further developed and maintained by the Quorum community. Quorum enables the usage of PBFT by inventing a PBFT-inspired consensus algorithm called Istanbul BFT which was adapted to be compatible with the Ethereum Blockchain environment. The platform also offers the “7-Nodes Example” [33] for developers to invent and test their Blockchain concept which is useful for the development with the limited computational resources available.

2.4 Related Work

There are many research proposing about decentralize healthcare information with Blockchain technology. The goal of decentralization and implementation of each work have many variants. These are several works that proposed interesting idea and concept about implement healthcare informatics system based on Blockchain technology.

2.4.1 A Blockchain-Based Approach to Health Information Exchange Networks [34]

The work proposed about using Blockchain like central hub for health information exchange. The main goal of this Blockchain concept is to connect all bread and crumb of patient health information together by allow participate node to discover health information data they seek and its location within Blockchain ledger, increase interoperability in health information exchange. Their main contribution is the concept that suggests the use of FHIR health information exchange standard combine with Blockchain technology. Each transaction on Blockchain will contain FHIR locator of actual data along with its index which make each transaction available for search. Due to the limit of health information that it requires certain amount of confidentiality, this makes it not really compatible with platform open to public like Blockchain. Store actual data somewhere else outside Blockchain and put its locator into Blockchain for use. With known secure index, this Blockchain helps connect patient information that is scattered across healthcare industry together. The work also gave suggestion about how health information Blockchain should look like and what it should have by common. There also other major contributions that use secure index for searching on encrypted data and ‘Proof of Interoperability’. This work suggests that if health information is kept within Blockchain in encrypted form, it should also contain secure index which will allow data search even the data is encrypted. This should reduce the difficulty of implementing health information with Blockchain. And other major concept proposed in this work is ‘Proof of Interoperability’. Based on Proof of Work consensus, the work suggest that computational resource should not be wasted unnecessarily. Instead of putting computational resource to competition for consensus, it should be used to verify interoperability of participate health data instead. However, they didn’t propose about how the consensus should work in detail. This work gave a good example of how

Blockchain can have potential to solve issue that common in healthcare industry like interoperability. Additionally, they also proposed many concepts that can be a good foundation for using Blockchain technology with health information.

2.4.2 A Case Study for Blockchain in Healthcare: “MedRec” Prototype for Electronic Health Records and Medical Research Data [35]

Main goal of MedRec is to provide Blockchain that acts as a middle for health information exchange while allow Blockchain participants to gain benefit from participation. They chose Ethereum as Blockchain platform for the system. Ethereum provide smart contract and address based access for the work. This work assumes that miner/validator nodes are health institution that have demand for large amount of health information data to use in their research. Miner/validator node will be rewarded with anonymized health data which can be used in research involve health data analysis. Additionally, MedRec proposed about allowing patient to have consent about usage on their data. Give more control over individual health data. The work also adopted cryptographic key scheme proposed by Zyskin et al. [36], to ensure that only authorized party can access patient health information published on Blockchain. Additional to these main contributions, they also gave suggestions about factor that should keep continuity of Blockchain and how Blockchain element provided by platform like Ethereum can be useful. One of interesting concept is about using Ethereum address as patient identifier. Due to all identities exist on Ethereum Blockchain are assigned with unique address, these unique addresses can reduce complexity in patient identifier management if designed properly. MedRec gave a good example of concept that needed to maintain continuity of Blockchain network by allowing participant to gain benefit from participation in some way. At the same time, MedRec is another good example that using Blockchain technology to aid health information exchange issue. And the last, MedRec have shown flexibility of smart contract and how it can be useful when implement with healthcare information.

2.4.3 Blockchain-Based Data Preservation System for Medical Data [37]

This work used Blockchain to keep data that need to have confidentiality preserved. Regardless of what kind of data, this Blockchain allows user to design what data they want to keep in Blockchain. The chosen data will be encrypted before publishing into Blockchain. The goal of this Blockchain concept is to preserve medical

data inside Blockchain away from any tempering attempt while keep it secret and always available for its owner. Instead of let data available to public, this work has demonstrated how Blockchain technology can be used in different approach like keeping medical data available to only authorized entity.

2.4.4 Blockchain-Based Electronic Healthcare Record System for Healthcare 4.0 Applications [38]

The work has gathered research proposing the Blockchain concept from 2016 to 2019 that would benefit the healthcare industry by enhancing the capabilities of electronic health records. The work has well explained the overall concept of implementing Blockchain technology to electronic health records developed over the years. They also proposed another approach of implementing Blockchain technology for electronic health records by using IBM Hyperledger fabric as a medium for health information exchange in a similar fashion with MedRec which prioritize efficiency in handling huge number of transactions in the meantime. The contribution in the work inspires and encourages the idea of enhancing the existing EHR system with Blockchain technology as it provides the characteristics of distribution and decentralization.

CHAPTER III

PROPOSED METHOD

This chapter explains the proposed method. The first section introduces the use case scenario of the proposing concept. The second section explains the main concept design of this work. The third section explains the design of Blockchain infrastructure that would be compatible with implementation on the IHE XDS.b Profile. The fourth section explains the integration of Blockchain technology into the IHE XDS.b Profile. The fifth section further explain the detail regarding the main function of our implementation. The last section shows the process flow of the XDS Document Registry Actor as an interface between the XDS system and the Blockchain ledger.

3.1 Use Case Scenario

Imagine the example case, Mr. Peter Parker is a normal person. One day he got bit by a strange spider. Mr. Parker then visits Hospital A located in Bangkok for diagnosis. A doctor at Hospital A diagnosed that there is no unusual effect on Mr. Parker and heal the bite wound for him. The event and diagnosis result were recorded within Hospital A. Later, during his travel to Chiang Mai, Mr. Parker found an unusual effect from the bite. He then pays a visit to Hospital B for diagnosis. Without the health information sharing standard implemented, A doctor at Hospital B will have difficulty accessing the last diagnosis result for Mr. Parker, which is unknown to them that it can be located in Hospital A. The situation becomes even worse when the health information system of Hospital B was hit by ransomware and went down. That means a doctor at Hospital B cannot know that what happened to Mr. Parker. On the other hand, with IHE XDS Blockchain implemented, even Hospital B hit by ransomware, a doctor at Hospital B can use an alternate machine to access the XDS Blockchain ledger and discover that there is the latest diagnosis result for Mr. Parker available at Hospital A. A doctor then gains access to the diagnosis result and able to identify that Mr. Parker was afflicted by unknown genetic mutated symptom caused by the spider bite. Allow the doctor to prevent a further harmful consequence.

3.2 Concept Design

As introduced in Chapter I, the unique nature of the healthcare environment that emphasizes confidentiality of data gave limits to implementing Blockchain technology into the industry. Patient data cannot be put directly into Blockchain as it will become persistent following Blockchain characteristics while increasing difficulty in ensuring data confidentiality when its replica is distributed all over the network [26, 27, 39]. So instead of risk confidentiality of healthcare data by publishing it directly into the Blockchain network, we propose using IHE XDS.b Document Registry Actor to act as a health document exchange medium for the Blockchain network. The profile is best compatible with Blockchain technology as decentralization will secure the availability of the health information exchange by eliminating the need for the organization that will act as the central hub for the exchange avoiding a single point of failure problem. At the same time, there is no longer a need to publish health documents directly into the distributed network, reduce the risk against the confidentiality of the data. Additionally, in this work, we further extend the usability of the profile by allowing the organization that has shared health documents from its source to also act as an additional data backup for the original by providing additional access points (URLs) for the document. That mean, even the source of health document become unavailable due to unpredictable circumstance like a cyber-incident (i.e., Ransomware threat), the network will still have a chance to access the compromised document via an alternative source available from a shared peer. This extends the benefit of the health document sharing network and encourages the growth of the health document sharing community even further indefinitely.

Following Figure 2-2, the XDS Document Registry actor who acts as a hub for health document exchange would normally host a database that allows XDS Document Consumer Actor to query for information of health Document they seek. The existing solution for the database is the utilization of SQL or non-SQL centralized database depend on each XDS Affinity network. In adaptation for this work, we propose replacing these centralized databases with a Blockchain ledger which innately distribute the registry amongst the network while also benefit from Blockchain characteristics. This consecutively transforms the XDS Document Registry Actor host by each XDS Affinity domain member into a Blockchain node. Each node will now serve as a

decentralized XDS Document Registry Actor who will joint cooperatively keep, operate, and maintain the Blockchain ledger which now contains the entire health document registry entry for the network.

3.3 Blockchain Design

Considering the environment of the XDS Affinity domain network, the network is comprised of members who are hospital or health institution that entered the network intending to share their health document and access health document shared from other. Each member entering the network are expected to have been selected by the network and have an agreement with the network to voluntarily share health document from their XDS Document Repository Actor to the network while not exposing information shared within the network to the outside. Following Blockchain Types mentioned in 2.3.2, the network is not suitable with the Public Chain as they are not accepting anyone into the network without pre-selection and a proper agreement. At the same time, they are also not suitable with the Private Chain as the XDS Affinity domain network was designed for scalability and not fixed to any specific organization. That means the XDS Affinity domain network is best suitable with the Permissioned Chain type as it was designed for scalability welcoming more members to join the network over time under the condition that joining members are accepted by the network and have a proper data sharing agreement.

Meanwhile, following the Blockchain consensus mentioned in 2.3.3.4, the XDS Affinity domain members were not pre-determined to invest a high amount of computational resources for entering the network and were not expected to gain direct profit from participation in maintaining the network. That means the consensus mechanism with computational resources inefficiencies like competition-based and profit-dependence mechanism like randomness-based are not the choice of consensus for the network. Then the remaining majority-based consensus will be the most suitable choice available. The start point of majority-based consensus will be PBFT as the basis of the type. With the nature of the XDS Affinity domain network which pre-determined the joining member, this should prevent the chance for the bad actor to control the majority and secure Blockchain characteristics for the network consecutively.

3.4 Integrating Blockchain with XDS.b Profile

For the implementation, following Figure 2-2, we assume that the ITI-61 transaction is unessential for the current usage of the work. The patient identification was assumed to be already standardized amongst all members of the network, eliminates the need for the ITI-44 transaction from consideration. This left the XDS Document Registry Actor Blockchain to only interact with the remaining XDS Document Repository Actor via ITI-42 transaction and XDS Document Consumer Actor via ITI-18 transaction (as shown in Figure 3-1).



Figure 3-1 XDS Profile within the scope of interest for this work

Following Section 2.1.4, all Blockchain nodes will receive ITI-42 transactions from their local XDS Document Repository Actor as normal XDS Document Registry Actor would do, before transitioning the transaction into Blockchain Smartcontract and publish into the Blockchain ledger. Likewise, the health document query via ITI-18 transactions from local XDS Document Consumer will be interpreted and interact with Smartcontract consecutively. Note that the XDS Document Consumer Actor will still be required to directly issue ITI-43 transaction to the XDS Document Repository Actor hosting the health document to retrieve it. The Smartcontract will act as a medium for each node to perform the task to add data, read data, and search for data within the Blockchain ledger (as shown in Figure 3-2) allow the Blockchain technology to effectively integrated into the XDS system.

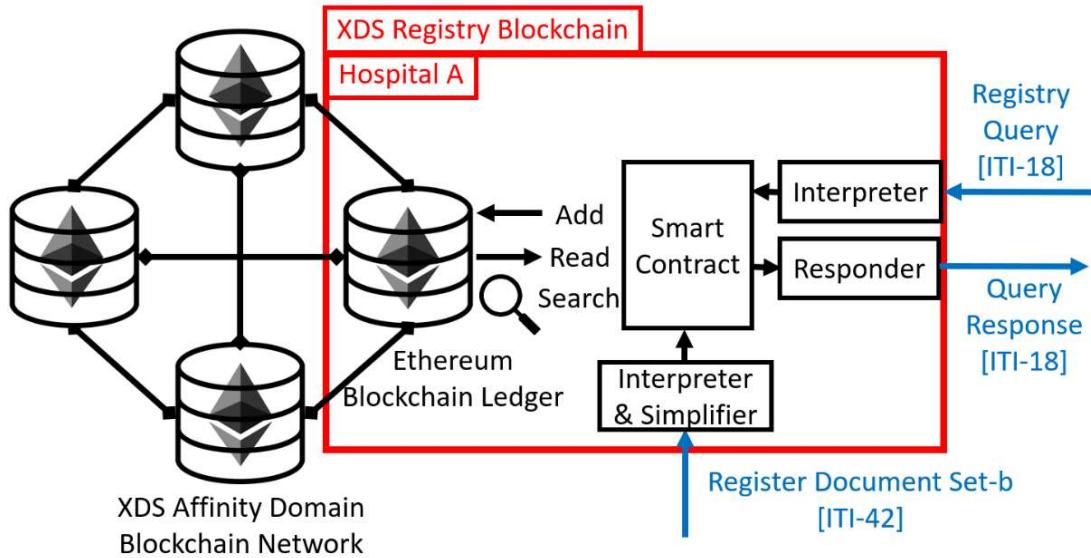


Figure 3-2 Integrating Blockchain into XDS.b Profile

3.5 Design Functions

3.5.1 Document Register

This is where XDS Document Registry Actor registers health document metadata set within ITI-42 transaction received from XDS Document Repository into the Blockchain ledger. This function enables sharing of health documents to the XDS Affinity Domain Blockchain network as well as allowing the shared document to be registered as an alternative source. There are 2 Smartcontract functions related.

The first function is the document registering function, the function act as part of the XDS Document Registry Actor to store the value of health document metadata interprets from ITI-42 transaction into the Blockchain ledger. This function act in a fashion similar to a programming variable where certain values were assigned to a specific variable for usage within the program, a whole set of metadata value is assigned into single Smartcontract function transaction. The function also automatically assigns each set of metadata with an identification number to be used for common understanding amongst the Smartcontract to differentiate each set of metadata belong to each health document. The identification number also essential for search operation which would be further explained later.

The second function is the checker function which will check for the last identification number assigned to the published set of metadata. This function allows

Smartcontract to keep track of the identification number previously used and prevent duplication. Each time a new set of metadata entering the Blockchain ledger, the identification number which would be assigned to the metadata set will be additively increased by 1 from the previous.

3.5.2 Document Search

The search operation allows members of XDS Affinity Domain Blockchain to discover health documents existing in the network by searching for registered metadata set belong to the document within the Blockchain ledger and gain access to actual documents using access information provided in the metadata. There are 2 Smartcontract functions related.

The first function is the read function where Smartcontract allows the XDS Document Registry Actor to read the value of metadata stored within the Blockchain ledger. This function only needs identification number input to return metadata value to the XDS Document Registry Actor program.

During the search operation, the XDS Document Registry Actor will be the one to handle the search keyword. The Actor performs sequential searches on each set of registered metadata using the assigned identification number for iteration until the matching result was found or reached the end of the iteration. The Actor then triggers the return query result function.

The second Smartcontract function is the return query result function where the Smartcontract returns the whole set of metadata specified as the search result to the XDS Document Registry Actor. The version of the return value omitted by this function is different from the read function in terms of compatibility with the ITI-18 transaction format. The XDS Document Registry Actor then sorts the result into an ITI-18 transaction and return it to the XDS Document Consumer Actor.

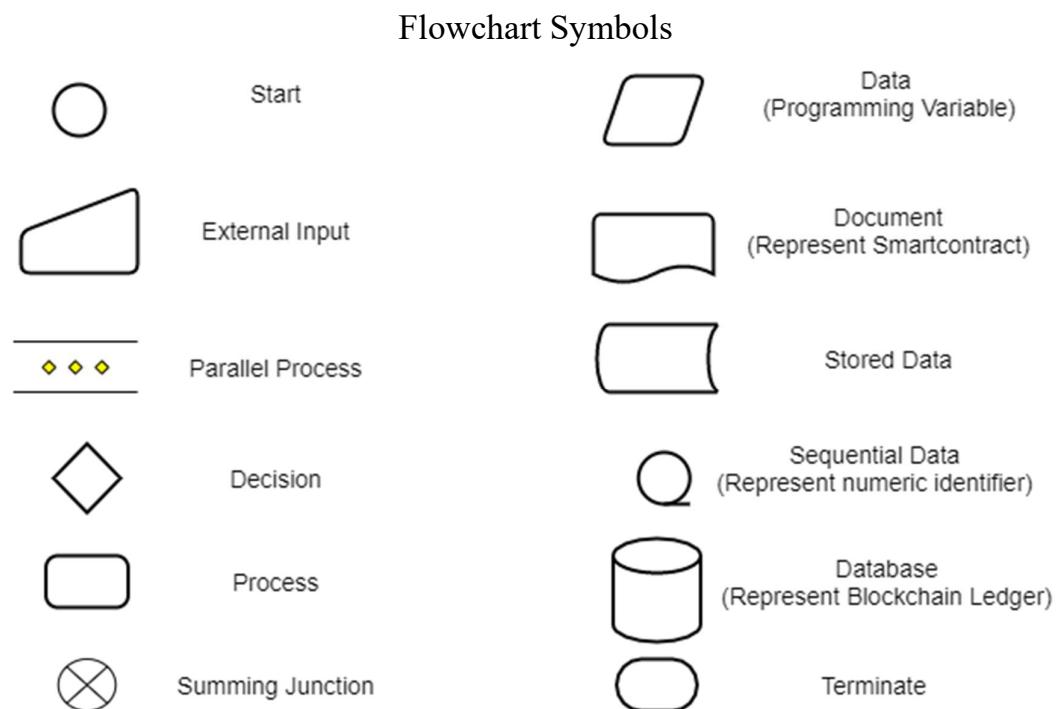
Following the normal process of IHE XDS.b Profile in Section 2.1.4, the XDS Document Consumer will then use health document access information provided within the search result metadata to gain access to the XDS Document Repository hosting the document. Then negotiate for document exchange using the ITI-43 transactions outside the Blockchain network.

As mentioned in Section 3.2, after receiving the document shared from its original source, the shared peer will also want to register the document into the XDS

Document Registry to let the network know that now they can act as an alternative source of the document for the network.

3.6 Process Flow

Figure 3-3 showing the process flow of the XDS Document Registry Actor which acts as a medium between the Blockchain ledger and XDS System.



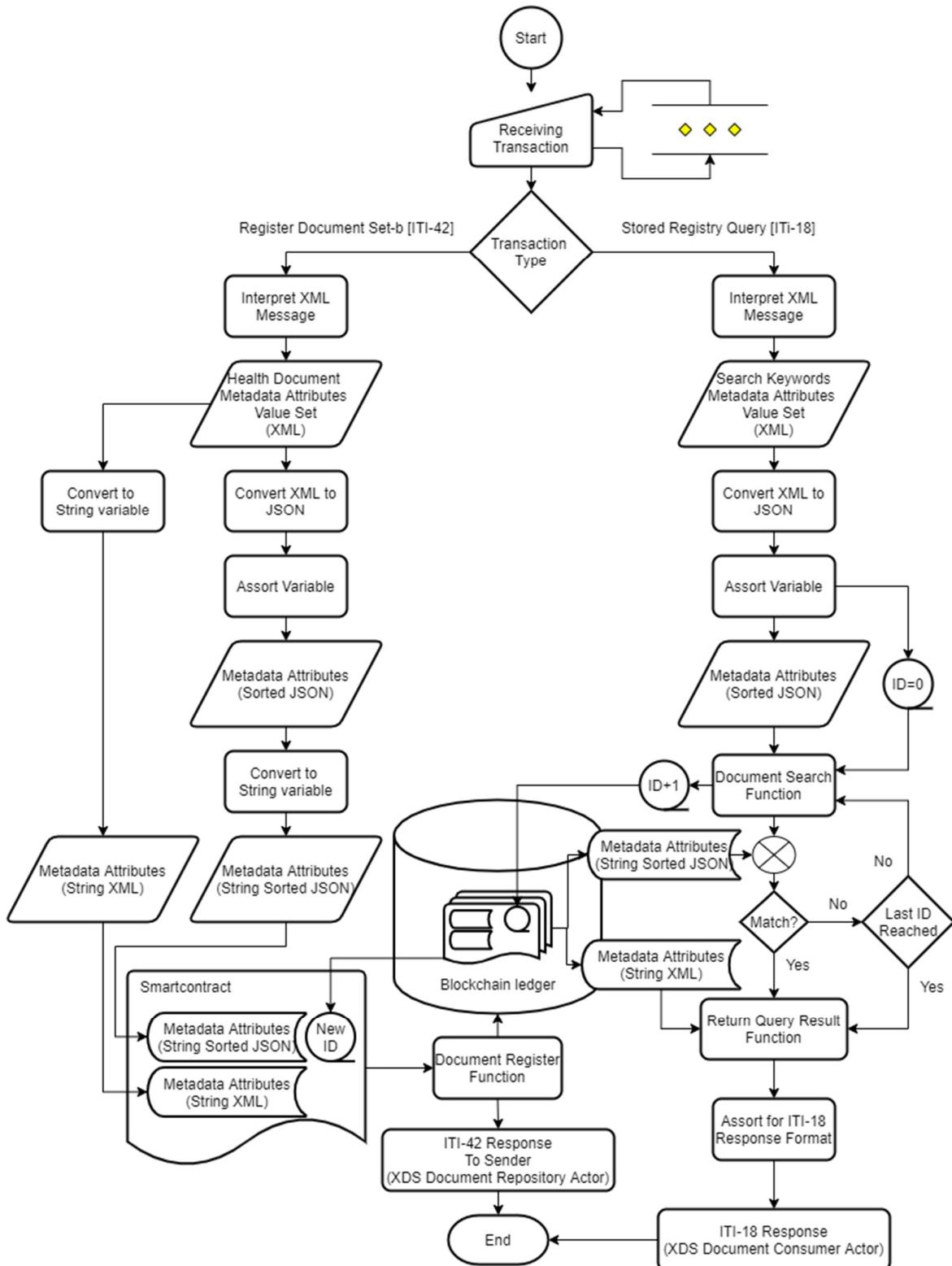


Figure 3-3 The process Flow of XDS Document Registry Actor

CHAPTER IV IMPLEMENTATION

This chapter emphasizes the implementation step for this work. Begin with the setup method to establish a small Blockchain network for development which will describe the installation method and system specification. The second section then explains the implementation of each XDS Actor including its native programming code and corresponding Smartcontract detail. After that, the third section will explain the setup for the performance evaluation experiment and following with the experiment result in the last section.

4.1 Blockchain setup

4.1.1 Machine Specifications

For the implementation, the main machine was the best machine available for the implementation and compatible workflow which will be used for the coding process, which is a laptop Alienware 17 R5, Intel(R) Core (TM) i9-8950HK CPU@2.90GHz, 32 GB installed RAM, running on Windows 10 operating system version Home Single Language (20H2) 64-bit, x64-based processor. The code then deploys on the test machine. As most Ethereum-related software is initially designed for Linux OS, so Ubuntu was selected OS for the test machine. The test machine is where all Blockchain-related environment was deployed. A test machine is a virtual machine established within the main machine using Oracle VM VirtualBox. The virtual machine running on Linux Ubuntu (64-bit) version 18.10 with 8 GB RAM and 100 GB storage dynamically shared from the host main machine.

4.1.2 Go-Ethereum

Go-Ethereum or "Geth" client is the open sources software engine requiring to operate Ethereum Blockchain within each node. The client allows the user to issue commands to the node like initiate the Blockchain, start-stop mining/validating process for the Blockchain, and activate devp2p protocol to sync Blockchain data with other nodes. The client is available at [40]. Geth can be installed as standalone or included in

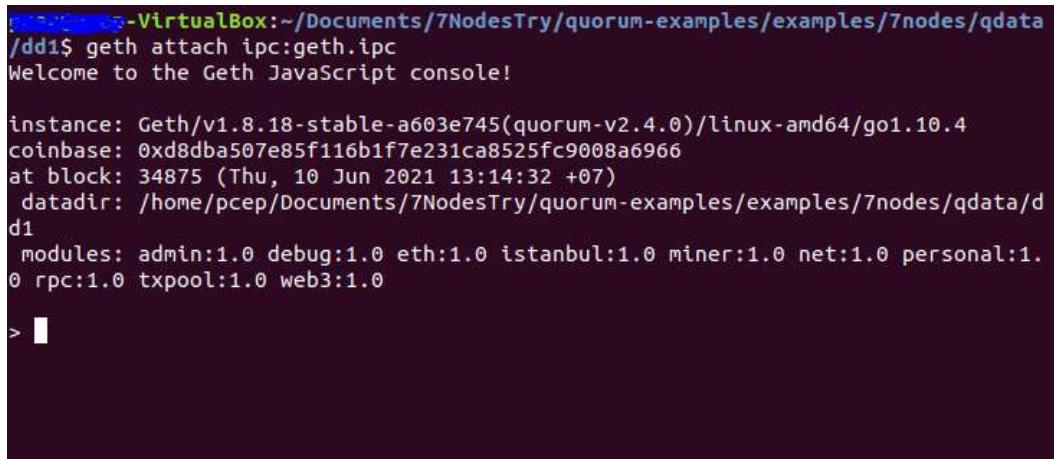
the installation package of the Ethereum platform variant or other kinds of service interacting with Ethereum Blockchain (i.e., Ethereum Wallet Client). Geth's interface was initially designed to operate on Linux OS and later extend compatibility to other OS via Linux console simulated platform or work under graphic user interface of another client. The Geth client has no specific system requirement as it only is a set of Golang scripts that has no restriction to any system but, as it is mostly integrated within another client, so it requires the machine to compatible with the main client for installation. In the implementation, the test machine has Geth globally installed by installing Quorum, so the client can be launched from anywhere regardless of environment path.

Geth can be installed as standalone for ready the machine for working with Ethereum Blockchain using Linux installation from source repository command i.e., “apt-get install ethereum” in Ubuntu. The installation instruction can be located at [41]. Figure 4-1 showing installation method for Ubuntu. All available command lines for Geth can be located at [42]. The most used command is "geth attach <IPC path or Link>" which required for accessing Geth console of each active node, as shown in Figure 4-2. The console is where the user can input the command line to directly control the behavior of each Ethereum Node.

```
sudo add-apt-repository -y ppa:ethereum/ethereum
#Enable launchpad repository for Ethereum

sudo apt-get update
sudo apt-get install ethereum
#Install Ethereum using apt-get|
```

Figure 4-1 Installation command-line for Go-Ethereum on Ubuntu [41]

A screenshot of a terminal window titled "VirtualBox: ~ /Documents/7NodesTry/quorum-examples/examples/7nodes/qdata". The window shows the output of the "geth attach ipc:geth.ipc" command. It displays the Geth version (v1.8.18-stable-a603e745), coinbase address (0xd8dba507e85f116b1f7e231ca8525fc9008a6966), current block number (34875, timestamp Thu, 10 Jun 2021 13:14:32 +07), data directory (/home/pcep/Documents/7NodesTry/quorum-examples/examples/7nodes/qdata/d1), and various module versions (admin:1.0, debug:1.0, eth:1.0, istanbul:1.0, miner:1.0, net:1.0, personal:1.0, rpc:1.0, txpool:1.0, web3:1.0). A prompt "> []" is visible at the bottom.

```
[root@pcep-VirtualBox:~/Documents/7NodesTry/quorum-examples/examples/7nodes/qdata] dd1$ geth attach ipc:geth.ipc
Welcome to the Geth JavaScript console!

instance: Geth/v1.8.18-stable-a603e745(quorum-v2.4.0)/linux-amd64/go1.10.4
coinbase: 0xd8dba507e85f116b1f7e231ca8525fc9008a6966
at block: 34875 (Thu, 10 Jun 2021 13:14:32 +07)
  datadir: /home/pcep/Documents/7NodesTry/quorum-examples/examples/7nodes/qdata/d1
modules: admin:1.0 debug:1.0 eth:1.0 istanbul:1.0 miner:1.0 net:1.0 personal:1.0
          rpc:1.0 txpool:1.0 web3:1.0

> [ ]
```

Figure 4-2 Geth console accessed using "geth attach" command

4.1.3 Quorum Installation

As mentioned in Section 2.3.4.2, Quorum is an Ethereum-forked that allows the Blockchain to adopt a consensus mechanism other than PoW and PoS which default to Ethereum Blockchain. Quorum's source code and installation package can be accessed at [31]. The installation method for the latest stable release is located at [43]. The platform was designed to specifically operate with a Linux-based interface and can be compatible with non-Linux OS with the aid of 3rd party software as a medium. Other than that, the platform has no specific system requirement for installation. However, from the test during the implementation, it is recommended that the machine running Quorum should have more than 6 GB of available RAM. Otherwise, there will be a performance issue that occurred during the run. In this implementation, as the test machine running on Ubuntu 18.10, there is no other 3rd party software required to operate Quorum. The Geth client was included in the Quorum installation package, which means a developer can immediately start their Quorum Blockchain development right after the installation.

Figure 4-3 showing the installation method for Quorum from its source which was used to install the latest stable Quorum released available at the time for the implementation. Some parts or functions used in the implementation may differ from the current released due to the version difference.

```
git clone https://github.com/ConsenSys/quorum.git  
#Clone Quorum from its source repository  
  
cd quorum  
make all  
#Make the cloned file as an installation  
  
make test  
#Check if the installation was successful
```

Figure 4-3 Installing Quorum directly from its source

Other than the Blockchain platform, Quorum also offers the "7-Nodes Example" for developers to locally deploy in their machine to test the functionality and performance of Smartcontract during the development. The source code can be cloned directly from its repository available in Github [33] as shown in Figure 4-4. The "7-Nodes" will simulate seven Blockchain nodes in the host machine in a similar fashion to a virtual machine using the required library called "Tessera" [44] and "Constellation" [45] included in the package as a running engine. The source code can be initiated, activated, and simultaneously controlled using the control script provided within the example. Each node can be accessed using the Geth client. For the implementation, the control script provided within the example was further modified to be compatible with our usage. The Blockchain initiation script was modified to be able to re-initiate the entire Blockchain by deleting the existing chain and replace with the empty one. This allows reset of published Blockchain during the development. The transaction publishing script was modified to run other specific code developed for XDS Document Registry Actor and its Smartcontract, allow testing and running of XDS Document registry-related code on the 7-Nodes. It must be noted that transaction-related scripts only operate on specified single nodes amongst the seven, not the entire set of the seven nodes. That means the activity of each node is independent.

```
git clone https://github.com/jpmorganchase/quorum-examples.git  
#Clone the 7-Nodes Example from its source repository
```

Figure 4-4 Cloning "7-Nodes" Quorum example from its repository available on Github

All initial configuration instructions are available at [46]. Primarily, it is required to configure the genesis Block for the Blockchain ledger and issue the initiation command using the script provided in the example as shown in Figure 4-5. Each script is specific for each consensus mechanism.

```
cd path/to/7nodes
#Navigate to the folder path where the cloned repository locate

./istanbul-init.sh
#Initiate the genesis block with IBFT as its consensus

./istanbul-start.sh
#Activate all seven nodes to start the Blockchain based on the genesis block
```

Figure 4-5 Initial configuration method for 7-Nodes example

In this implementation, we only use the script "istanbul-init.sh" (execute using Linux Bash syntax as shown in Figure 4-6) to initiate the genesis Block for the Blockchain ledger as we going to use IBFT as its consensus mechanism. The script will generate "istanbul-genesis.json" file as a configuration script for the genesis block which its content should be configured as shown in Figure 4-7. Then the activation of the IBFT Blockchain can be done using "istanbul-start.sh" script as shown in Figure 4-8 which will start the activation of all seven nodes and bring the 7-Nodes Blockchain network to become alive as shown in Figure 4-9 and Figure 4-10. It must be noted that this activation process may take several minutes.

./istanbul-init.sh

Figure 4-6 Executing "istanbul-init.sh" with Linux Bash syntax

```
{
  "alloc": {
    "0xed9d02e382b34818e88b88a309c7fe71e65f419d": {
      "balance": "10000000000000000000000000000000"
    },
    "0xca843569e3427144cead5e4d5999a3d0ccf92b8e": {
      "balance": "10000000000000000000000000000000"
    },
    "0x0fbdc686b912d7722dc86510934589e0aaf3b55a": {
      "balance": "10000000000000000000000000000000"
    },
    "0x9186eb3d20cbd1f5f992a950d808c4495153abd5": {
      "balance": "10000000000000000000000000000000"
    },
    "0x0638e1574728b6d862dd5d3a3e0942c3be47d996": {
      "balance": "10000000000000000000000000000000"
    }
  },
  "coinbase": "0x0000000000000000000000000000000000000000000000000000000000000000",
  "config": {
    "homesteadBlock": 0,
    "byzantiumBlock": 0,
    "constantinopleBlock": 0,
    "chainId": 10,
    "eip150Block": 0,
    "eip150Hash": "0x000000000000000000000000000000000000000000000000000000000000000",
    "eip155Block": 0,
    "eip158Block": 0,
    "isQuorum": true,
    "maxCodeSize": 35,
    "istanbul": {
      "epoch": 30000,
      "policy": 0,
      "cell2Nby3Block": 0
    }
  },
  "extraData": "0x000000000000000000000000000000000000000000000000000000000000000f897f893946571d977f340c8495b661a823f2c2145ca47d63c2948157d
  "gasLimit": "0xE0000000",
  "difficulty": "0x1",
  "mixHash": "0x63740963616c2062797a616e74696e65206661756c7420746f6c6572616e6365",
  "nonce": "0x0",
  "parentHash": "0x000000000000000000000000000000000000000000000000000000000000000",
  "timestamp": "0x0"
}
}
```

Figure 4-7 Content of "istanbul - genesis.json" file

```
./istanbul-start.sh tessera --tesseraOptions "--tesseraJar /home/[REDACTED]/
Documents/7NodesTry/tessera/tessera-dist/tessera-app/target/tessera-
app-0.11-SNAPSHOT-jdk11_app.jar"
```

Figure 4-8 IBFT 7-Nodes Blockchain activation script

```

    Found geth: "Quorum Version: 2.4.0"
[*] Starting Tessera nodes
Tessera version (extracted from manifest file): 0.11-SNAPSHOT
Config type -09-
[*] Starting 7 Tessera node(s)
java  -Xms128M -Xmx128M -jar /home/pcep/Documents/7NodesTry/tessera/tessera-di
st/tessera-app/target/tessera-app-0.11-SNAPSHOT-jdk11_app.jar -configfile qdata
/c1/tessera-config-09-1.json >> qdata/logs/tessera1.log 2>&1 &
java  -Xms128M -Xmx128M -jar /home/pcep/Documents/7NodesTry/tessera/tessera-di
st/tessera-app/target/tessera-app-0.11-SNAPSHOT-jdk11_app.jar -configfile qdata
/c2/tessera-config-09-2.json >> qdata/logs/tessera2.log 2>&1 &
java  -Xms128M -Xmx128M -jar /home/pcep/Documents/7NodesTry/tessera/tessera-di
st/tessera-app/target/tessera-app-0.11-SNAPSHOT-jdk11_app.jar -configfile qdata
/c3/tessera-config-09-3.json >> qdata/logs/tessera3.log 2>&1 &
java  -Xms128M -Xmx128M -jar /home/pcep/Documents/7NodesTry/tessera/tessera-di
st/tessera-app/target/tessera-app-0.11-SNAPSHOT-jdk11_app.jar -configfile qdata
/c4/tessera-config-09-4.json >> qdata/logs/tessera4.log 2>&1 &
java  -Xms128M -Xmx128M -jar /home/pcep/Documents/7NodesTry/tessera/tessera-di
st/tessera-app/target/tessera-app-0.11-SNAPSHOT-jdk11_app.jar -configfile qdata
/c5/tessera-config-09-5.json >> qdata/logs/tessera5.log 2>&1 &
java  -Xms128M -Xmx128M -jar /home/pcep/Documents/7NodesTry/tessera/tessera-di
st/tessera-app/target/tessera-app-0.11-SNAPSHOT-jdk11_app.jar -configfile qdata
/c6/tessera-config-09-6.json >> qdata/logs/tessera6.log 2>&1 &
java  -Xms128M -Xmx128M -jar /home/pcep/Documents/7NodesTry/tessera/tessera-di
st/tessera-app/target/tessera-app-0.11-SNAPSHOT-jdk11_app.jar -configfile qdata
/c7/tessera-config-09-7.json >> qdata/logs/tessera7.log 2>&1 &
Waiting until all Tessera nodes are running...
Node 1 is not yet listening on tm.ipc
Node 1 is not yet listening on http
Node 2 is not yet listening on tm.ipc
Node 2 is not yet listening on http
Node 3 is not yet listening on tm.ipc
Node 3 is not yet listening on http
Node 4 is not yet listening on tm.ipc
Node 4 is not yet listening on http
Node 5 is not yet listening on tm.ipc
Node 5 is not yet listening on http
Node 6 is not yet listening on tm.ipc
Node 6 is not yet listening on http
Node 7 is not yet listening on tm.ipc
Node 7 is not yet listening on http
Waiting until all Tessera nodes are running...

```

Figure 4-9 The activation script activating all seven Blockchain nodes

```

All Tessera nodes started
[*] Starting 7 Ethereum nodes with ChainID and NetworkId of 10
ARGS="--nodiscover --istanbul.blockperiod 5 --networkid $NETWORK_ID --syncmode
full --mine --minerthreads 1 --rpc --rpccorsdomain=* --rpcvhosts=* --rpcauth 0.
0.0.0 --rpccap admin,db,eth,debug,miner,net,shh,txpool,personal,web3,quorum,ist
anbul,quorumPermission --unlock 0 --password passwords.txt $QUORUM_GETH_ARGS"

basePort=21000
baseRpcPort=22000
for i in `seq 1 ${numNodes}`
do
  port=$((basePort + ${i} - 1))
  rpcPort=$((baseRpcPort + ${i} - 1))
  permissioned=
  if ! [[ -z "${STARTPERMISSION+x}" ]]; then
    permissioned="--${STARTPERMISSION}"
  fi

  PRIVATE_CONFIG=qdata/c${i}/tm.ipc nohup geth --datadir qdata/dd${i} ${ARGS}
  ${permissioned} --rpcport ${rpcPort} --port ${port} 2>>qdata/logs/${i}.log &
done

set +v

All nodes configured. See 'qdata/logs' for logs, and run e.g. 'geth attach qdat
a/dd1/geth.ipc' to attach to the first Geth node.

```

Figure 4-10 All seven Blockchain nodes successfully activated

For this implementation, we further created a script to reduce the complexity of the initiation and activation process of 7-Nodes Blockchain. The script "rebirth.sh" will delete all data of an existing set of 7-Nodes Blockchain and initiate a new genesis file to simplify the reset of the Blockchain during the development of the implementation as shown in Figure 4-11. The script "runmy7nodes.sh" will issue the whole command line required for activating the 7-Nodes Blockchain, simplify the Blockchain activation process as shown in Figure 4-12. These scripts will help reduce the complexity of command-line manipulation during the implementation.

```
#!/bin/bash
rm -R qdata/
mkdir qdata
./istanbul-init.sh
```

Figure 4-11 The content of "rebirth.sh" script

```
#!/bin/bash
./istanbul-start.sh tessera --tesseraOptions "--tesseraJar /home/pcep/
Documents/7NodesTry/tessera/tessera-dist/tessera-app/target/tessera-
app-0.11-SNAPSHOT-jdk11_app.jar"
```

Figure 4-12 The content of "runmy7nodes.sh" script

4.1.4 Compile and Deploy Smartcontract Solidity Code

For Smartcontract programming, Ethereum provides a web-based IDE for Solidity language that can compile, test, and deploy smart-contract to specific Ethereum node called “Remix” [47]. In the implementation, Remix was accessed using Google Chrome from the main machine and the session was saved locally using Remix client to avoid unexpected issues on the Solidity code. Each Smartcontract is validated, and test deployed within the IDE before actual implementation on the test machine. The Smartcontract ready for implementation will be compiled using the Solidity compiler provided by Remix community-based plugin. Each compiled solidity code gives ABI code and Binary code which will be used on Web3js code to interact with the Blockchain Smartcontract.

After successfully compiled the Solidity Smartcontract code, the ABI code and Byte code will be automatically generated by the IDE as shown in Figure 4-13. These codes can be copied and passed into Web3js code by assigning a variable to store the code as its value like the example shown in Figure 4-14 and Figure 4-15. Noted that Byte code defines the behavior of the Smartcontract and only required on the first deployment of the Smartcontract which required only once in this implementation, while ABI code define interface for communicating with the Smartcontract and always required every time the native program communicate with Smartcontract.

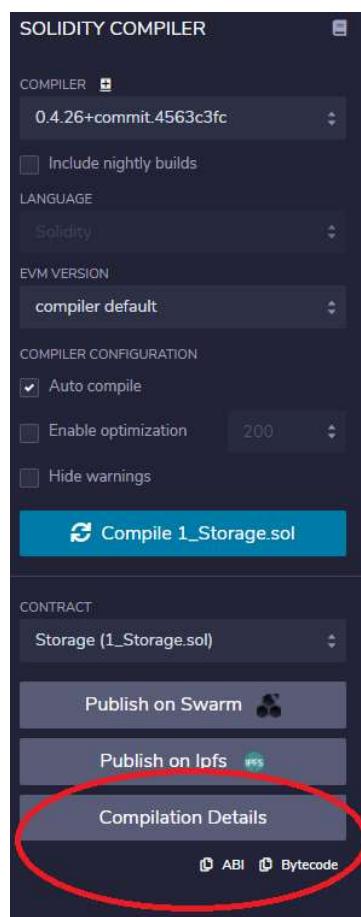


Figure 4-13 ABI Code and Byte code generated can be copied and passed directly
(From red circle) into Web3js code

```

var abi = [
  {
    "inputs": [],
    "name": "checkLastID",
    "outputs": [
      {
        "internalType": "uint256",
        "name": "",
        "type": "uint256"
      }
    ],
    "stateMutability": "view",
    "type": "function"
  },
  {
    "inputs": [
      {
        "internalType": "uint256",
        "name": "Docid",
        "type": "uint256"
      }
    ],
    "name": "retriveFull",
    "outputs": [
      {
        "internalType": "string",
        "name": "",
        "type": "string"
      }
    ],
    "stateMutability": "view",
    "type": "function"
  },
  {
    "inputs": [
      {
        "internalType": "uint256",
        "name": "Docid",
        "type": "uint256"
      }
    ],
    "name": "retriveSearch",
    "outputs": [
      {
        "internalType": "string",
        "name": "",
        "type": "string"
      }
    ],
    "stateMutability": "view",
    "type": "function"
  }
];

```

Figure 4-14 ABI code (brown color) assigned into variable "abi"

```

var bytecode =
"0x608060405234801561001057600080fd5b50612fdb806100206000396000f3fe608060405234801561
001057600080fd5b50600436106100625760003560e01c80636ca1115d14610067578063862723df1461
067c578063902a9f0814610eed5780639896e0c8146116c7578063d07d9f9b14611778578063f092186d1
4611b30575b600080fd5b61067a600480360361016081101561007e57600080fd5b81019080803590602
00190929190803590602001906401000000008111156100a557600080fd5b8201836020820111156100b
757600080fd5b80359060200191846001830284011164010000000831117156100d957600080fd5b919
08080601f016020809104026020016040519081016040528093929190818152602001838380828437600
081840152601f19601f8201169050808301925050505050919291929080359060200190640100000
00081111561013c57600080fd5b82018360208201111561014e57600080fd5b803590602001918460018
302840111640100000008311171561017057600080fd5b91908080601f0160208091040260200160405
19081016040528093929190818152602001838380828437600081840152601f19601f820116905080830
192505050505050919291929080359060200190640100000008111156101d357600080fd5b8201836
020820111156101e557600080fd5b8035906020019184600183028401116401000000008311171561020
757600080fd5b91908080601f01602080910402602001604051908101604052809392919081815260200
1838380828437600081840152601f19601f820116905080830192505050505091929192908035906
02001906401000000081111561026a57600080fd5b82018360208201111561027c57600080fd5b80359
0602001918460018302840111640100000008311171561029e57600080fd5b91908080601f016020809
104026020016040519081016040528093929190818152602001838380828437600081840152601f19601
f820116905080830192505050505091929192908035906020019064010000000811115610301576
00080fd5b82018360208201111561031357600080fd5b803590602001918460018302840111640100000
0008311171561033557600080fd5b91908080601f0160208091040260200160405190810160405280939
29190818152602001838380828437600081840152601f19601f82011690508083019250505050509
192919290803590602001906401000000081111561039857600080fd5b8201836020820111156103aa5
7600080fd5b80359060200191846001830284011164010000000831117156103cc57600080fd5b91908
080601f01602080910402602001604051908101604052809392919081815260200183838082843760008
1840152601f19601f820116905080830192505050505091929192908035906020019064010000000
081111561042f57600080fd5b82018360208201111561044157600080fd5b80359060200191846001830
2840111640100000008311171561046357600080fd5b91908080601f016020809104026020016040519
081016040528093929190818152602001838380828437600081840152601f19601f82011690508083019
2505050505050919291929080359060200190640100000008111156104c657600080fd5b820183602
0820111156104d857600080fd5b80359060200191846001830284011164010000000831117156104fa5
7600080fd5b91908080601f0160208091040260200160405190810160405280939291908181526020018
38380828437600081840152601f19601f82011690508083019250505050509192919290803590602
001906401000000081111561055d57600080fd5b82018360208201111561056f57600080fd5b8035906
02001918460018302840111640100000008311171561059157600080fd5b91908080601f01602080910
4026020016040519081016040528093929190818152602001838380828437600081840152601f19601f8
201169050808301925050505050919291929080359060200190640100000008111156105f457600
080fd5b82018360208201111561060657600080fd5b80359060200191846001830284011164010000000
08311171561062857600080fd5b91908080601f01602080910402602001604051908101604052809392";

```

Figure 4-15 Byte code (brown color) assigned into variable "bytecode"

4.1.5 Deploy Smartcontract into Blockchain

Before begin registering health documents metadata into Blockchain Smartcontract, the Smartcontract must be first deployed to act as a contract format for the entire Blockchain ledger for the implementation. Figure 4-16 show the Web3js script that simply deploys the Smartcontract into the Blockchain ledger. It required both the Byte code and ABI code received from the Solidity compiler to be completed. Once the Smartcontract is deployed, any later communication with Smartcontract will only need ABI code to act as an interface for the communication. This Smartcontract deployment process only required once at the initiation of the Blockchain ledger and no longer needs to be performed ever again for the rest of the Blockchain ledger life cycle.

```
a = eth.accounts[0]
web3.eth.defaultAccount = a;

// abi and bytecode generated from simplestorage.sol:
// > solcjs --bin --abi simplestorage.sol
/*var abi =
[{"constant":true,"inputs":[],"name":"storedData","outputs":[{"name":"","type":"uint256"}],"payable":false,"type":"function"}, {"constant":false,"inputs":[{"name":"x","type":"uint256"}],"name":"set","outputs":[],"payable":false,"type":"function"}, {"constant":true,"inputs":[],"name":"get","outputs":[{"name":"RetVal","type":"uint256"}],"payable":false,"type":"function"}, {"inputs":[{"name":"initVal","type":"uint256"}],"payable":false,"type":"constructor"}];*/

var abi = [...];

var bytecode = [...];

var simpleContract = web3.eth.contract(abi);
var simple = simpleContract.new(42, {from:web3.eth.accounts[0], data: bytecode, gas: 0x47b760},
function(e, contract) {
    if (e) {
        console.log("err creating contract", e);
    } else {
        if (!contract.address) {
            console.log("Contract transaction send: TransactionHash: " +
contract.transactionHash + " waiting to be mined...");
        } else {
            console.log("Contract mined! Address: " + contract.address);
            console.log(contract);
        }
    }
});
```

Figure 4-16 The Web3js script for Smartcontract deploy

4.1.6 Prepare NodeJS Coding Environment

For the coding process of all non-Blockchain native Javascript programs, the coding environment must be provided essential coding components. In this implementation, we use NodeJS as a compiler and coding environment for all Javascript programs. NodeJS is available at [48]. The essential coding components node module can be installed using Node Package Manager (NPM) which comes together with NodeJS [49]. The coding of program for native side of XDS Actor require node module name "Web3" (Web3js) [50], "xml2js" [51], "fs" [52], "net" [53], "util" [54], "moment" [55], and "crypt" [56] which can be installed using the command-line as shown in .

```
npm install (with no args, in package dir)
npm install [<@scope>/]<name>
npm install [<@scope>/]<name>@<tag>
npm install [<@scope>/]<name>@<version>
npm install [<@scope>/]<name>@<version range>
npm install <alias>@npm:<name>
npm install <git-host>:<git-user>/<repo-name>
npm install <git repo url>
npm install <tarball file>
npm install <tarball url>
npm install <folder>

aliases: npm i, npm add
common options: [-P|--save-prod|-D|--save-dev|-O|--save-optional|--save-peer] [-E|--save-exact] [-B|--save-bundle] [--no-save] [--dry-run]
```

Figure 4-17 "npm install" command-line

4.2 XDS Actors

As we have seen from HL7 and FHIR, current healthcare information exchanged related standards are mostly web-based protocol. Additionally, development of IT infrastructure to support healthcare operation require the capability to handle a huge amount of transaction in a limited amount of time so, it requires our system implementation to be able to handle multitask properly. With asynchronous nature and compatibility with website integration, Javascript is one of the best choices for our implementation of this work. In this implementation, we adopt the "Node.js" variant of Javascript as it was made to build scalable network applications that handle many connections concurrently. Furthermore, Node.js also providing simple access to community-made node modules which offer a wide variety of useful APIs for software development which may reduce difficulty in our implementation further.

All actors within IHE XDS Profile communicate with each other using XML message transaction. As we utilize Javascript as main programming language for the implementation, these XML messages need to be interpreted into programming object to allow simpler handling method within the program. Javascript Object Notation (JSON) is a lightweight data-interchange format of programming object which was invented to serve the purpose. It is easy for humans to read and write and easy for machines to parse or generate. That mean, all XML message transactions sent to XDS Document Registry actor program will be converted into JSON. For this implementation, we utilize NodeJS "xml2js" module for the task.

To connect our program to Ethereum smart contract, we can use Ethereum API tools which is Web3 [57] as a middle. Web3 allows smart contract control through preferred programming language and transitions logic and variables from the language to Solidity. Web3 provides a programming API for Javascript called "Web3JS" which allows the Javascript program to interact with Ethereum based smart-contract. The API can be accessed using the node module provided via Node.js.

4.2.1 XDS Document Repository Actor

4.2.1.1 Interpret IHE ITI-42 Transaction

Figure 4-18, showing XML language code snippet of Registry Document Set-b [ITI-42] transaction sample. The code composing of two main sections. The first section

labeled with “lcm:SubmitObjectRequest” is where XML schematic information are located and the label also act as marker which tell interpreter program to recognize it as ITI-42 transaction. The second section starts from label “rim:RegistryObjectList” following with “rim:ExtrinsicObject” contain all information regarding corresponding health document. This section is where all Metadata attributes of the document are located. If the Document Registry Actor successfully received the transaction, they must return response as shown in Figure 4-18. The response transaction included only XML schematic information, message UUID number, and status type “successful” as shown in Figure 4-19. This response will let the Repository finish its process and end messaging attempt. Figure 4-20 show the actual code snippet using for the implementation.

```
<lcm:SubmitObjectsRequest xmlns:xsi=..XML schematic information..>
<rim:RegistryObjectList>

    <rim:ExtrinsicObject id=..DocumentEntry identifier name or label..
        mimeType="text/xml"
        objectType="urn:uuid:7edca82f-054d-47f2-a032-9b2a5b5186c1">
        ...
        ..DocumentEntry META-data attributes object list..
        ...
    </rim:ExtrinsicObject>

    <rim:RegistryPackage id=..SubmissionSet identifier name or label..>
    ...
    ..SubmissionSet or Folder META-data attributes object list..
    ...
</rim:RegistryPackage>

    <rim:Classification id=..Classification identifier name or label..
        classifiedObject=..SubmissionSet ID which it belonged to..
        classificationNode="urn:uuid:a54d6aa5-d40d-43f9-88c5-b4633d873bdd"/>

    <rim:Association id=..Association identifier name or label..
        associationType=..Association Type..
        sourceObject=..SubmissionSet ID which it belonged to..
        targetObject=..Target Document Entry ID..>
    ...
    ..Association META-data attributes object list..
    ...
</rim:Association>
</rim:RegistryObjectList>
</lcm:SubmitObjectsRequest>
```

Figure 4-18 Pseudocode represents general format of Register Document Set-b [ITI - 42]

```
<rs:RegistryResponse xmlns:rs="urn:oasis:names:tc:ebxml-regrep:xsd:rs:3.0"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="urn:oasis:names:tc:ebxml-regrep:xsd:rs:3.0 ../..schema/ebRS/rs.xsd"
    status="urn:oasis:names:tc:ebxml-regrep:ResponseStatusType:Success"/>
```

Figure 4-19 XML Code snippet of Registry Document Set-b Response transaction sample

```
<lcm:SubmitObjectsRequest xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="urn:oasis:names:tc:ebxml-regrep:xsd:lcm:3.0 ../..schema/ebRS/lcm.xsd"
    xmlns:lcm="urn:oasis:names:tc:ebxml-regrep:xsd:lcm:3.0" xmlns:rim="urn:oasis:names:tc:ebxml-
    regrep:xsd:rim:3.0" xmlns:rs="urn:oasis:names:tc:ebxml-regrep:xsd:rs:3.0">
    <rim:RegistryObjectList>
        <rim:ExtrinsicObject id="Document01" mimeType="text/xml"
objectType="urn:uuid:7edca82f-054d-47f2-a032-9b2a5b5186c1">
            <rim:Slot name="creationTime">
                <rim:ValueList>
                    <rim:Value>20051224</rim:Value>
                </rim:ValueList>
            </rim:Slot>
            <rim:Slot name="languageCode">
                <rim:ValueList>
                    <rim:Value>en-us</rim:Value>
                </rim:ValueList>
            </rim:Slot>
            <rim:Slot name="serviceStartTime">
                <rim:ValueList>
                    <rim:Value>200412230800</rim:Value>
                </rim:ValueList>
            </rim:Slot>
            <rim:Slot name="serviceStopTime">
                <rim:ValueList>
                    <rim:Value>200412230801</rim:Value>
                </rim:ValueList>
            </rim:Slot>
            <rim:Slot name="sourcePatientId">
                <rim:ValueList>
                    <rim:Value>ST-
1000^^^&1.3.6.1.4.1.21367.2003.3.9&ISO</rim:Value>
                </rim:ValueList>
            </rim:Slot>
            <rim:Slot name="sourcePatientInfo">
                <rim:ValueList>
                    <rim:Value>PID-3|ST-
1000^^^&1.3.6.1.4.1.21367.2003.3.9&ISO</rim:Value>
                    <rim:Value>PID-5|Doe^John^^</rim:Value>
                    <rim:Value>PID-7|19560527</rim:Value>
                    <rim:Value>PID-8|M</rim:Value>
                    <rim:Value>PID-11|100 Main
St^^Metropolis^II^44130^USA</rim:Value>
                </rim:ValueList>
            </rim:Slot>
```

```
<rim:Name>
    <rim:LocalizedString value="Physical"/>
</rim:Name>
<rim:Description/>
<rim:Classification id="cl01" classificationScheme="urn:uuid:93606bcf-9494-
43ec-9b4e-a7748d1a838d" classifiedObject="Document01">
    <rim:Slot name="authorPerson">
        <rim:ValueList>
            <rim:Value>Gerald Smitty</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Slot name="authorInstitution">
        <rim:ValueList>
            <rim:Value>Cleveland Clinic</rim:Value>
            <rim:Value>Parma Community</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Slot name="authorRole">
        <rim:ValueList>
            <rim:Value>Attending</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Slot name="authorSpecialty">
        <rim:ValueList>
            <rim:Value>Orthopedic</rim:Value>
        </rim:ValueList>
    </rim:Slot>
</rim:Classification>
<rim:Classification id="cl02" classificationScheme="urn:uuid:41a5887f-8865-
4c09-adf7-e362475b143a" classifiedObject="Document01" nodeRepresentation="History and Physical">
    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>Connect-a-thon classCodes</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="History and Physical"/>
    </rim:Name>
</rim:Classification>
<rim:Classification id="cl03" classificationScheme="urn:uuid:f4f85eac-e6cb-
4883-b524-f2705394840f" classifiedObject="Document01"
nodeRepresentation="1.3.6.1.4.1.21367.2006.7.101">
```

```
<rim:Slot name="codingScheme">
    <rim:ValueList>
        <rim:Value>Connect-a-thon
    confidentialityCodes</rim:Value>
    </rim:ValueList>
</rim:Slot>
<rim:Name>
    <rim:LocalizedString value="Clinical-Staff"/>
</rim:Name>
</rim:Classification>
<rim:Classification id="cl04" classificationScheme="urn:uuid:a09d5840-386c-46f2-b5ad-9c3699a4309d" classifiedObject="Document01" nodeRepresentation="CDAR2/IHE 1.0">
    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>Connect-a-thon formatCodes</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="CDAR2/IHE 1.0"/>
    </rim:Name>
    </rim:Classification>
    <rim:Classification id="cl05" classificationScheme="urn:uuid:f33fb8ac-18af-42cc-ae0e-ed0b0bdb91e1" classifiedObject="Document01" nodeRepresentation="Outpatient">
        <rim:Slot name="codingScheme">
            <rim:ValueList>
                <rim:Value>Connect-a-thon
    healthcareFacilityTypeCodes</rim:Value>
            </rim:ValueList>
        </rim:Slot>
        <rim:Name>
            <rim:LocalizedString value="Outpatient"/>
        </rim:Name>
        </rim:Classification>
        <rim:Classification id="cl06" classificationScheme="urn:uuid:cccf5598-8b07-4b77-a05e-ae952c785ead" classifiedObject="Document01" nodeRepresentation="General Medicine">
            <rim:Slot name="codingScheme">
                <rim:ValueList>
                    <rim:Value>Connect-a-thon
    practiceSettingCodes</rim:Value>
                </rim:ValueList>
            </rim:Slot>
            <rim:Name>
                <rim:LocalizedString value="General Medicine"/>
            </rim:Name>
            </rim:Classification>
```

```
<rim:Classification id="cl07" classificationScheme="urn:uuid:f0306f51-975f-434e-a61c-c59651d33983" classifiedObject="Document01" nodeRepresentation="34108-1">
    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>LOINC</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="Outpatient Evaluation And Management"/>
    </rim:Name>
</rim:Classification>
<rim:ExternalIdentifier id="ei01" registryObject="Document01" identificationScheme="urn:uuid:58a6f841-87b3-4a3e-92fd-a8ffeff98427" value="SELF-5^^^&#13.6.1.4.1.21367.2005.3.7&ISO">
    <rim:Name>
        <rim:LocalizedString value="XDSDocumentEntry.patientId"/>
    </rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier id="ei02" registryObject="Document01" identificationScheme="urn:uuid:2e82c1f6-a085-4c72-9da3-8640a32e42ab" value="1.3.6.1.4.1.21367.2005.3.9999.32">
    <rim:Name>
        <rim:LocalizedString value="XDSDocumentEntry.uniqueId"/>
    </rim:Name>
</rim:ExternalIdentifier>
</rim:ExtrinsicObject>
<rim:RegistryPackage id="SubmissionSet01">
    <rim:Slot name="submissionTime">
        <rim:ValueList>
            <rim:Value>20041225235050</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="Physical"/>
    </rim:Name>
    <rim:Description>
        <rim:LocalizedString value="Annual physical"/>
    </rim:Description>
    <rim:Classification id="cl08" classificationScheme="urn:uuid:a7058bb9-b4e4-4307-ba5b-e3f0ab85e12d" classifiedObject="SubmissionSet01">
        <rim:Slot name="authorPerson">
            <rim:ValueList>
                <rim:Value>Sherry Dopplemeyer</rim:Value>
            </rim:ValueList>
```

```
</rim:Slot>
<rim:Slot name="authorInstitution">
    <rim:ValueList>
        <rim:Value>Cleveland Clinic</rim:Value>
        <rim:Value>Berea Community</rim:Value>
    </rim:ValueList>
</rim:Slot>
<rim:Slot name="authorRole">
    <rim:ValueList>
        <rim:Value>Primary Surgeon</rim:Value>
    </rim:ValueList>
</rim:Slot>
<rim:Slot name="authorSpecialty">
    <rim:ValueList>
        <rim:Value>Orthopedic</rim:Value>
    </rim:ValueList>
</rim:Slot>
</rim:Classification>
<rim:Classification id="cl09" classificationScheme="urn:uuid:aa543740-bdda-424e-8c96-df4873be8500" classifiedObject="SubmissionSet01" nodeRepresentation="History and Physical">
    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>Connect-a-thon</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="History and Physical"/>
    </rim:Name>
</rim:Classification>
<rim:ExternalIdentifier id="ei03" registryObject="SubmissionSet01" identificationScheme="urn:uuid:96fdda7c-d067-4183-912e-bf5ee74998a8" value="1.3.6.1.4.1.21367.2005.3.9999.33">
    <rim:Name>
        <rim:LocalizedString value="XDSSubmissionSet.uniqueId"/>
    </rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier id="ei04" registryObject="SubmissionSet01" identificationScheme="urn:uuid:554ac39e-e3fe-47fe-b233-965d2a147832" value="3670984664">
    <rim:Name>
        <rim:LocalizedString value="XDSSubmissionSet.sourceId"/>
    </rim:Name>
</rim:ExternalIdentifier>
```

```
<rim:ExternalIdentifier id="ei05" registryObject="SubmissionSet01"
identificationScheme="urn:uuid:6b5aea1a-874d-4603-a4bc-96a0a7b38446" value="SELF-
5^^&#13.6.1.4.1.21367.2005.3.&#13ISO">
<rim:Name>
<rim:LocalizedString value="XDSSubmissionSet.patientId"/>
</rim:Name>
</rim:ExternalIdentifier>
</rim:RegistryPackage>
<rim:Classification id="cl10" classifiedObject="SubmissionSet01"
classificationNode="urn:uuid:a54d6aa5-d40d-43f9-88c5-b4633d873bdd"/>
<rim:Association id="as01" associationType="HasMember"
sourceObject="SubmissionSet01" targetObject="Document01">
<rim:Slot name="SubmissionSetStatus">
<rim:ValueList>
<rim:Value>Original</rim:Value>
</rim:ValueList>
</rim:Slot>
</rim:Association>
</rim:RegistryObjectList>
</lcm:SubmitObjectsRequest>
```

Figure 4-20 XML Code snippet of Registry Document Set-b [ITI-42] transaction sample

4.2.1.2 XDS Document Repository Actor Simulating Program

For document registering, XDS Document Repository Actor register document Metadata attributes into XDS Document Registry Actor using IHE ITI-42 transaction. XDS Document Registry Actor then interprets the transaction into a programmable object before check if the transaction is ITI-42. Then, the actor proceeds to pass the retrieved object into Blockchain smart-contract and publish it into a Blockchain ledger. Figure 4-21 showing the Javascript code snippet for the native side of XDS Document Repository Actor.

```
var hrstart = null;
var net = require('net');
var fs = require("fs");
var util = require("util");
var xml2js = require('xml2js');

var parseString = xml2js.parseString;

var builder = new xml2js.Builder();
const readline = require("readline");
const rl = readline.createInterface({
  input: process.stdin,
  output: process.stdout
});
var HOST = '127.0.0.1';
var PORT = 65519;
var client = new net.Socket();
client.connect(PORT, HOST, function() {
  rl.question("Choose documents: ", function(docNum) {
    console.log('CONNECTED TO: ' + HOST + ':' + PORT);
    var docChosen = 'SingleDocumentEntry' + docNum + '.xml';
    fs.readFile(docChosen, function(err, buf) {
      if (err) console.log(err);
      var text = buf.toString();
      client.write(text);
      hrstart = process.hrtime();
      console.log('Sent: \n' + text + '\n');
    });
    rl.close();
  });
  client.on('data', function(data) {
    var hrend = process.hrtime(hrstart);
    console.log('=====');
    console.log('Respond received: ' + data);
    console.info('Execution time (hr): %ds %dms', hrend[0], hrend[1] / 1000000);
    console.log('=====');
    client.destroy();
  });
  client.on('close', function() {
    console.log('Connection closed');
  });
});
```

Figure 4-21 Javascript Code Snippet of XDS Document Repository Actor

4.2.2 XDS Document Consumer Actor

4.2.2.1 Interpret IHE ITI-18 Transaction

Figure 4-22, showing XML language code snippet of RegistryStoredQueryRequest [ITI-18] transaction sample. The code composing of 3 main sections. The first section labeled “query:AdhocQueryRequest” is where XML schematic information are located and the label also act as marker which tell interpreter program to recognize it as ITI-18 transaction. The second section labeled “query:ResponseOption” mark the expected format of query result that will return to Document Consumer. The third section start from label “rim:AdhocQuery” contain all search keywords issued by Document Consumer. These search keywords are selected Metadata attributes and its value. When Document Registry Actor received the transaction, they will use search keyword provided to search for registry with matched Metadata attributes value then return the result to Document Consumer Actor as response transaction following Figure 4-23 and Figure 4-24. With header labeled “query:AdhocQueryResponse”, the transaction contain search result depend on query type specified in ITI-18 transaction. If the query expected for “LeafClass” as result, the response would return Metadata attributes of all matched result in detailed as shown in Figure 4-23. Otherwise, if the query expected for “ObjectList”, the response would return object reference number of all matched result as shown in Figure 4-24. These two types of response specifically selected depend on search behavior of Document Consumer Actor’s user. The query which specified “LeafClass” as its search result must provide keyword which unique to its corresponding document, such as document unique ID or object reference UUID. At the same time, “ObjectList” are used to search for wide range of document with generic search keyword and value where discovery of document existent is the main goal. Figure 4-25 showing the actual ITI-18 transaction using in the implementation while Figure 4-26 showing its actual response transaction.

```
<query:AdhocQueryRequest xmlns:xsi=..XML schematic information..>
    <query:ResponseOption returnComposedObjects="true"
        returnType="(LeafClass or ObjectList)"/>
    <rim:AdhocQuery id=" urn:uuid:14d4debf-8f97-4251-9a74-a90016b0af0d ">
        ...
        <rim:Slot name="..Search keyword label of META-data attributes..">
            <rim:ValueList>
                <rim:Value>..META-data attributes value..</rim:Value>
            </rim:ValueList>
        </rim:Slot>
        ...
        ..List of search keywords from Document Consumer Actor..
        ...
    </rim:AdhocQuery>
</query:AdhocQueryRequest>
```

Figure 4-22 Pseudocode represents general format of Registry Stored Query Request [ITI - 18]

```
<query:AdhocQueryResponse xmlns:xsi=..XML information schematic..>
    <rim:RegistryObjectList>
        ...
        <rim:ObjectRef xmlns:q="urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0"
            xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0"
            id="..Object Reference UUID.."/>
        ...
        ..Object reference of all matched result..
        ...
    </rim:RegistryObjectList>
</query:AdhocQueryResponse>
```

Figure 4-23 Pseudocode represents general format of Query Response

included “Object Reference” of search results

```
<query:AdhocQueryResponse xmlns:xsi="..XML information schematic..">
    <rim:RegistryObjectList>
        <rim:ExtrinsicObject xmlns:q="urn: oasis:names:tc:ebxml-regrep:xsd:query:3.0"
            xmlns:rim="urn: oasis:names:tc:ebxml-regrep:xsd:rim:3.0"
            id="..Identification UUID.."
            isOpaque="false"
            mimeType="text/xml"
            objectType="..Object Type UUID.."
            status="urn: oasis:names:tc:ebxml-regrep:StatusType:Approved">
            ..
            //Document generic information META-data attributes
            <rim:Slot name="..META-data attributes type name..">
                <rim:ValueList>
                    <rim:Value>..META-data attributes value..</rim:Value>
                </rim:ValueList>
            </rim:Slot>
            ...
            //META-data attributes "title"
            <rim:Name>
                <rim:LocalizedString charset="UTF-8"
                    value="..META-data attributes value.." xml:lang="en-us"/>
            </rim:Name>
            ...
            //META-data attributes "comment"
            <rim:Description/>
            ...
            //Communication protocol-based META-data attributes
            <rim:Classification classificationScheme="..META-data attributes type UUID..">
                <classifiedObject="..Classified Object UUID.."
                    id="..Identification UUID.."
                    nodeRepresentation="..Representing Node.."
                    objectType="..Object Type UUID..">
                    <rim:Slot name="..META-data attributes type name..">
                        <rim:ValueList>
                            <rim:Value>..META-data attributes value..</rim:Value>
                        </rim:ValueList>
                    </rim:Slot>
                    <rim:Name>
                        <rim:LocalizedString charset="UTF-8"
                            value="..Representing Node Detail.." xml:lang="en-us"/>
                    </rim:Name>
                    <rim:Description/>
                </rim:Classification>
                ...
            
```

```
...
//External identifier-based META-data attributes
<rim:ExternalIdentifier id=".META-data attributes type UUID.." ...
    registryObject=".Registry Object UUID.."
    identificationScheme=".Identification scheme UUID.."
    objectType="ExternalIdentifier"
    value=".META-data attributes value..">
    <rim:Name>
        <rim:LocalizedString charset="UTF-8"
            value=".META-data attributes type name.."
            xml:lang="en-us"/>
    </rim:Name>
    <rim:Description/>
</rim:ExternalIdentifier>
...
..List of Document Entry META-data attributes of matched result..
...
</rim:ExtrinsicObject>
</rim:RegistryObjectList>
</query:AdhocQueryResponse>
```

Figure 4-24 Pseudocode represents general format of Query Response

included "Leaf Class" of search result

```
<query:AdhocQueryRequest xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0 ..../schema/ebRS/query.xsd"
xmlns:query="urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0" xmlns:rim="urn:oasis:names:tc:ebxml-
regrep:xsd:rim:3.0" xmlns:rs="urn:oasis:names:tc:ebxml-regrep:xsd:rs:3.0">
    <query:ResponseOption returnComposedObjects="true" returnType="LeafClass"/>
    <rim:AdhocQuery id="urn:uuid:14d4debf-8f97-4251-9a74-a90016b0af0d">
        <rim:Slot name="$XDSDocumentEntryPatientId">
            <rim:ValueList>

                <rim:Value>st3498702^^^&#13.6.1.4.1.21367.2005.3.7&#ISO</rim:Value>
            </rim:ValueList>
        </rim:Slot>
        <rim:Slot name="$XDSDocumentEntryStatus">
            <rim:ValueList>
                <rim:Value>('urn:oasis:names:tc:ebxml-
regrep:ResponseStatusType:Approved')</rim:Value>
            </rim:ValueList>
        </rim:Slot>
        <rim:Slot name="$XDSDocumentEntryCreationTimeFrom">
            <rim:ValueList>
                <rim:Value>200412252300</rim:Value>
            </rim:ValueList>
        </rim:Slot>
        <rim:Slot name="$XDSDocumentEntryCreationTimeTo">
            <rim:ValueList>
                <rim:Value>200501010800</rim:Value>
            </rim:ValueList>
        </rim:Slot>
        <rim:Slot name="$XDSDocumentEntryHealthcareFacilityTypeCode">
            <rim:ValueList>
                <rim:Value>('Emergency Department')</rim:Value>
            </rim:ValueList>
        </rim:Slot>
    </rim:AdhocQuery>
</query:AdhocQueryRequest>
```

Figure 4-25 XML Code Snippet of RegistryStoredQueryRequest [ITI-18] Transaction Sample

```
<query:AdhocQueryResponse xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0 ../..schema/ebRS/query.xsd"
xmlns:query="urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0" xmlns:rim="urn:oasis:names:tc:ebxml-
regrep:xsd:rim:3.0" status="Success">
    <rim:RegistryObjectList>
        <rim:ExtrinsicObject xmlns:q="urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0"
xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0" id="urn:uuid:08a15a6f-5b4a-42de-8f95-
89474f83abdf" isOpaque="false" mimeType="text/xml" objectType="urn:uuid:7edca82f-054d-47f2-
a032-9b2a5b5186c1" status="urn:oasis:names:tc:ebxml-regrep>StatusType:Approved">
            <rim:Slot name="URI">
                <rim:ValueList>
                    <rim:Value>http://localhost:8080/XDS/Repository/08a15a6f-
5b4a-42de-8f95-89474f83abdf.xml</rim:Value>
                </rim:ValueList>
            </rim:Slot>
            <rim:Slot name="authorInstitution">
                <rim:ValueList>
                    <rim:Value>Fairview Hospital</rim:Value>
                </rim:ValueList>
            </rim:Slot>
            <rim:Slot name="creationTime">
                <rim:ValueList>
                    <rim:Value>200412261119</rim:Value>
                </rim:ValueList>
            </rim:Slot>
            <rim:Slot name="hash">
                <rim:ValueList>
                    <rim:Value>4cf4f82d78b5e2aac35c31bca8cb79fe6bd6a41e</rim:Value>
                </rim:ValueList>
            </rim:Slot>
            <rim:Slot name="languageCode">
                <rim:ValueList>
                    <rim:Value>en-us</rim:Value>
                </rim:ValueList>
            </rim:Slot>
            <rim:Slot name="serviceStartTime">
                <rim:ValueList>
                    <rim:Value>200412230800</rim:Value>
                </rim:ValueList>
            </rim:Slot>
            <rim:Slot name="serviceStopTime">
                <rim:ValueList>
                    <rim:Value>200412230801</rim:Value>
                </rim:ValueList>
            </rim:Slot>
        </rim:ExtrinsicObject>
    </rim:RegistryObjectList>
</query:AdhocQueryResponse>
```

```
</rim:Slot>
<rim:Slot name="size">
    <rim:ValueList>
        <rim:Value>54449</rim:Value>
    </rim:ValueList>
</rim:Slot>
<rim:Slot name="sourcePatientId">
    <rim:ValueList>
        <rim:Value>jd12323^^^wsh</rim:Value>
    </rim:ValueList>
</rim:Slot>
<rim:Slot name="sourcePatientInfo">
    <rim:ValueList>
        <rim:Value>PID-3|pid1^^^domain</rim:Value>
        <rim:Value>PID-5|Doe^John^^</rim:Value>
        <rim:Value>PID-7|19560527</rim:Value>
        <rim:Value>PID-8|M</rim:Value>
        <rim:Value>PID-11|100 Main
St^^Metropolis||^44130^USA</rim:Value>
    </rim:ValueList>
</rim:Slot>
<rim:Name>
    <rim:LocalizedString charset="UTF-8" value="Sample document 1">
xml:lang="en-us"/>
</rim:Name>
<rim:Description/>
<rim:Classification classificationScheme="urn:uuid:41a5887f-8865-4c09-adf7-e362475b143a" classifiedObject="urn:uuid:08a15a6f-5b4a-42de-8f95-89474f83abdf" id="urn:uuid:ac872fc0-1c6e-439f-84d1-f76770a0ccdf" nodeRepresentation="Education" objectType="Urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification">
    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>Connect-a-thon classCodes</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString charset="UTF-8" value="Education">
xml:lang="en-us"/>
        </rim:Name>
        <rim:Description/>
    </rim:Classification>
    <rim:Classification classificationScheme="urn:uuid:f4f85eac-e6cb-4883-b524-f2705394840f" classifiedObject="urn:uuid:08a15a6f-5b4a-42de-8f95-89474f83abdf" id="urn:uuid:f1a8c8e4-3593-4777-b7e0-8b0773378705" nodeRepresentation="C" objectType="Urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification">
```

```
<rim:Slot name="codingScheme">
    <rim:ValueList>
        <rim:Value>Connect-a-thon
    confidentialityCodes</rim:Value>
    </rim:ValueList>
</rim:Slot>
<rim:Name>
    <rim:LocalizedString charset="UTF-8" value="Celebrity"
xml:lang="en-us"/>
</rim:Name>
<rim:Description/>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:a09d5840-386c-46f2-b5ad-
9c3699a4309d" classifiedObject="urn:uuid:08a15a6f-5b4a-42de-8f95-89474f83abdf"
id="urn:uuid:b6e49c73-96c8-4058-8c95-914d83bd262a" nodeRepresentation="CDAR2/IHE 1.0"
objectType="Urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification">
    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>Connect-a-thon formatCodes</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString charset="UTF-8" value="CDAR2/IHE 1.0"
xml:lang="en-us"/>
    </rim:Name>
    <rim:Description/>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:f33fb8ac-18af-42cc-ae0e-
ed0b0bdb91e1" classifiedObject="urn:uuid:08a15a6f-5b4a-42de-8f95-89474f83abdf"
id="urn:uuid:61e2b376-d74a-4984-ac21-dcd0b8890f9d" nodeRepresentation="Emergency Department"
objectType="Urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification">
    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>Connect-a-thon
    healthcareFacilityTypeCodes</rim:Value>
            </rim:ValueList>
        </rim:Slot>
        <rim:Name>
            <rim:LocalizedString charset="UTF-8" value="Assisted Living"
xml:lang="en-us"/>
        </rim:Name>
        <rim:Description/>
    </rim:Classification>
    <rim:Classification classificationScheme="urn:uuid:cccf5598-8b07-4b77-a05e-
ae952c785ead" classifiedObject="urn:uuid:08a15a6f-5b4a-42de-8f95-89474f83abdf"
```

```
id="urn:uuid:fb7677c5-c42f-485d-9010-dce0f3cd4ad5" nodeRepresentation="Cardiology"
objectType="Urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification">
    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>Connect-a-thon
practiceSettingCodes</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString charset="UTF-8" value="Cardiology"
xml:lang="en-us"/>
    </rim:Name>
    <rim:Description/>
    </rim:Classification>
    <rim:Classification classificationScheme="urn:uuid:f0306f51-975f-434e-a61c-
c59651d33983" classifiedObject="urn:uuid:08a15a6f-5b4a-42de-8f95-89474f83abdf"
id="urn:uuid:0a8a8ed9-8be5-4a63-9b68-a511adee8ed5" nodeRepresentation="34098-4"
objectType="Urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification">
        <rim:Slot name="codingScheme">
            <rim:ValueList>
                <rim:Value>LOINC</rim:Value>
            </rim:ValueList>
        </rim:Slot>
        <rim:Name>
            <rim:LocalizedString charset="UTF-8" value="Conference
Evaluation Note" xml:lang="en-us"/>
        </rim:Name>
        <rim:Description/>
        </rim:Classification>
        <rim:ExternalIdentifier id="urn:uuid:db9f4438-ffff-435f-9d34-d76190728637"
registryObject="urn:uuid:08a15a6f-5b4a-42de-8f95-89474f83abdf"
identificationScheme="urn:uuid:58a6f841-87b3-4a3e-92fd-a8ffeff98427"
objectType="ExternalIdentifier" value="st3498702^^^&1.3.6.1.4.1.21367.2005.3.7&ISO">
            <rim:Name>
                <rim:LocalizedString charset="UTF-8"
value="XDSDocumentEntry.patientId" xml:lang="en-us"/>
            </rim:Name>
            <rim:Description/>
        </rim:ExternalIdentifier>
        <rim:ExternalIdentifier id="urn:uuid:c3fcfb0e-9765-4f5b-abaa-b37ac8ff05a5"
registryObject="urn:uuid:08a15a6f-5b4a-42de-8f95-89474f83abdf"
identificationScheme="urn:uuid:2e82c1f6-a085-4c72-9da3-8640a32e42ab"
objectType="ExternalIdentifier" value="1.3.6.1.4.1.21367.2005.3.99.1.1010">
            <rim:Name>
                <rim:LocalizedString charset="UTF-8"
value="XDSDocumentEntry.uniqueId" xml:lang="en-us"/>
```

```
</rim:Name>
<rim:Description/>
</rim:ExternalIdentifier>
</rim:ExtrinsicObject>
<rim:ObjectRef xmlns:q="urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0"
xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0" id="urn:uuid:41a5887f-8865-4c09-adf7-
e362475b143a"/>
    <rim:ObjectRef xmlns:q="urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0"
xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0" id="urn:uuid:f4f85eac-e6cb-4883-b524-
f2705394840f"/>
        <rim:ObjectRef xmlns:q="urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0"
xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0" id="urn:uuid:a09d5840-386c-46f2-b5ad-
9c3699a4309d"/>
            <rim:ObjectRef xmlns:q="urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0"
xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0" id="urn:uuid:f33fb8ac-18af-42cc-ae0e-
ed0b0bdb91e1"/>
                <rim:ObjectRef xmlns:q="urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0"
xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0" id="urn:uuid:cccf5598-8b07-4b77-a05e-
ae952c785ead"/>
                    <rim:ObjectRef xmlns:q="urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0"
xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0" id="urn:uuid:f0306f51-975f-434e-a61c-
c59651d33983"/>
                        <rim:ObjectRef xmlns:q="urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0"
xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0" id="urn:uuid:58a6f841-87b3-4a3e-92fd-
a8ffeff98427"/>
                            <rim:ObjectRef xmlns:q="urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0"
xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0" id="urn:uuid:2e82c1f6-a085-4c72-9da3-
8640a32e42ab"/>
                        </rim:RegistryObjectList>
</query:AdhocQueryResponse>
```

Figure 4-26 XML Code Snippet of RegistryStoredQueryResponse Transaction Sample

4.2.2.2 XDS Document Consumer Actor Simulating Program

For document query, XDS Document Consumer query for document Metadata attributes stored within XDS Document Registry Blockchain providing search operation type and some Metadata attributes value as search keyword via ITI-18 transaction. XDS Document Registry will check if the transaction is ITI-18 before performing search operation matching specified search type using provided keyword Metadata attributes value. The search operation will be performed by consequently call for each registered smart-contracts until all contracts with matched attributes value were found. XDS Document Registry Actor then returns all query result in XML format following specification for ITI-18 responding. Upon receiving the query response, XDS Document Consumer then interprets the transaction and displays the result to the user in a human-understandable format.

Following IHE XDS Profile, XDS Document Consumer actor is where the user specifies search keyword values of Metadata attributes for the system to query for matching document exist within XDS Affinity Domain. For this implementation, we design that the user interface will take the form of a command-line program that can be run via Windows command prompt or Linux terminal. The program will prompt the user to specify search type, including META-attributes value, and specify the value. The actor then accepts these values to create an XML message following ITI-18 format before sending it to a local or accessible XDS Document Registry actor to query for matching document and start search operation. Figure 4-31 showing the Javascript code snippet for the native-side of the XDS Document Consumer Actor program.

The command-line interface of XDS Document Consumer begins with prompt the user to input registry query types (FindDocuments, FindSubmissionSets, FindFolders, GetAll, GetDocuments, GetFolders, GetAssociations, GetDocumentsAndAssociations, GetSubmissionSets, GetSubmissionSetAndContents, GetFolderAndContents, GetFoldersForDocument, GetRelatedDocuments, FindDocumentsByReferenceId, or choose to quit the program) as shown in Figure 4-27. The user will need to specify digit numbers corresponding to the choice. Then, the user will be prompt to input essential metadata attributes required for the query type (i.e., FindDocuments will require attributes included DocumentEntryPatientId and DocumentEntryStatus as shown in Figure 4-28) before prompt to input other metadata

attributes as optional depending on the information the user known as shown in Figure 4-29. When there are no more metadata attribute values to add, the user can choose to start a query for the document as shown in Figure 4-30. The XDS Document Consumer Actor program will then accept the input and assort it into the ITI-18 transaction before sending it to XDS Document Registry Actor.

```
=====
|| XDS Consumer Actor Interface ||
=====
Please select query type
1) FindDocuments
2) FindSubmissionSets
3) FindFolders
4) GetAll
5) GetDocuments
6) GetFolders
7) GetAssociations
8) GetDocumentsAndAssociations
9) GetSubmissionSets
10) GetSubmissionSetAndContents
11) GetFolderAndContents
12) GetFoldersForDocument
13) GetRelatedDocuments
14) FindDocumentsByReferenceId
#) Quit
(Specify number): 1
```

Figure 4-27 The program prompt user to input query type

```
Keywords require: XDSDocumentEntryPatientId
Value: 1234
Keywords require: XDSDocumentEntryStatus
Value: Approved
```

Figure 4-28 The program prompt user to input essential metadata attribute values

(In case of FindDocuments query type)

```
=====
Query type: FindDocuments
Query keywords:
$XDSDocumentEntryPatientId = 1234
$XDSDocumentEntryStatus = Approved
=====
Available optional keywords:
0) No more optional keywords
1) XDSDocumentEntryClassCode
2) XDSDocumentEntryTypeCode
3) XDSDocumentEntryPracticeSettingCode
4) XDSDocumentEntryCreationTime
5) XDSDocumentEntryServiceStartTime
6) XDSDocumentEntryServiceStopTime
7) XDSDocumentEntryHealthcareFacilityTypeCode
8) XDSDocumentEntryEventCodeList
9) XDSDocumentEntryConfidentialityCode
10) XDSDocumentEntryAuthorPerson
11) XDSDocumentEntryFormatCode
12) XDSDocumentEntryType
#) Quit
Select keywords (specify number): 10
Keyword: XDSDocumentEntryAuthorPerson
Value: Jennifer
```

Figure 4-29 The program prompt user to input optional metadata attributes

```
=====
Query type: FindDocuments
Query keywords:
$XDSDocumentEntryPatientId = 1234
$XDSDocumentEntryStatus = Approved
$XDSDocumentEntryAuthorPerson = Jennifer
=====
Available optional keywords:
0) No more optional keywords
1) XDSDocumentEntryClassCode
2) XDSDocumentEntryTypeCode
3) XDSDocumentEntryPracticeSettingCode
4) XDSDocumentEntryCreationTime
5) XDSDocumentEntryServiceStartTime
6) XDSDocumentEntryServiceStopTime
7) XDSDocumentEntryHealthcareFacilityTypeCode
8) XDSDocumentEntryEventCodeList
9) XDSDocumentEntryConfidentialityCode
10) XDSDocumentEntryAuthorPerson
11) XDSDocumentEntryFormatCode
12) XDSDocumentEntryType
#) Quit
Select keywords (specify number): 0
=====
All keywords set...
=====
Query type: FindDocuments
Query keywords:
$XDSDocumentEntryPatientId = 1234
$XDSDocumentEntryStatus = Approved
$XDSDocumentEntryAuthorPerson = Jennifer
=====
```

Figure 4-30 The user chooses to start the query after input all known attributes

After the query has been sent, the XDS Document Consumer will wait for the response from XDS Document Registry Actor. When the response is received, the XDS Document Consumer then shows the metadata attributes the value of the query result in the terminal or just terminates the program if there is no matched result registered.

```
var hrstart = null;
var hrend = null;
var net = require('net');
var fs = require("fs");
var util = require("util");
var xml2js = require('xml2js');
var parseString = xml2js.parseString;
var builder = new xml2js.Builder();

const readline = require("readline");
const rl = readline.createInterface({
    input: process.stdin,
    output: process.stdout
});

var HOST = '127.0.0.1';
var PORT = 65519;
var client = new net.Socket();

var prepXDSAtt = {
    DocumentEntry: {
        author: [
            {
                authorPerson: 'N/A',
                authorInstitution: [],
                authorRole: 'N/A',
                authorSpecialty: 'N/A'
            }
        ],
        availabilityStatus: 'N/A',
        classCode: {
            codingScheme: 'N/A',
            displayName: 'N/A'
        },
        comment: 'N/A',
        confidentialityCode: {
            codingScheme: 'N/A',
            displayName: 'N/A'
        },
        creationTime: 'N/A',
        entryUUID: 'N/A',
        eventCodeList: [],
        formatCode: {
            codingScheme: 'N/A',
            displayName: 'N/A'
        },
    }
},
```

```
hash: 'N/A',
healthcareFacilityTypeCode: {
  codingScheme: 'N/A',
  displayName: 'N/A'
},
homeCommunityId: 'N/A',
languageCode: 'N/A',
legalAuthenticator: 'N/A',
limitedMetadata: 'N/A',
mimeType: 'N/A',
objectType: 'N/A',
patientId: 'N/A',
practiceSettingCode: {
  codingScheme: 'N/A',
  displayName: 'N/A'
},
referenceIdList: 'N/A',
repositoryUniqueId: 'N/A',
serviceStartTime: 'N/A',
serviceStopTime: 'N/A',
size: 'N/A',
sourcePatientId: 'N/A',
sourcePatientInfo: [],
title: 'N/A',
typeCode: {
  codingScheme: 'N/A',
  displayName: 'N/A'
},
uniqueId: 'N/A',
URI: 'N/A'
}
}

var documentEntryUUID = {
  //----Document Entry-----
  DocumentEntry: 'urn:uuid:7edca82f-054d-47f2-a032-9b2a5b5186c1',
  author: 'urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d',
  classCode: 'urn:uuid:41a5887f-8865-4c09-adf7-e362475b143a',
  confidentialityCode: 'urn:uuid:f4f85eac-e6cb-4883-b524-f2705394840f',
  formatCode: 'urn:uuid:a09d5840-386c-46f2-b5ad-9c3699a4309d',
  healthcareFacilityTypeCode: 'urn:uuid:f33fb8ac-18af-42cc-ae0e-ed0b0bdb91e1',
  practiceSettingCode: 'urn:uuid:cccf5598-8b07-4b77-a05e-ae952c785ead',
  typeCode: 'urn:uuid:f0306f51-975f-434e-a61c-c59651d33983',
  patientId: 'urn:uuid:58a6f841-87b3-4a3e-92fd-a8ffeff98427',
  uniqueId: 'urn:uuid:2e82c1f6-a085-4c72-9da3-8640a32e42ab',
  eventCodeList: 'urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4'
}
```

```
var submissionSetUUID = {
    //----SubmissionSet Attributes-----
    author: 'urn:uuid:a7058bb9-b4e4-4307-ba5b-e3f0ab85e12d',
    contentTypeCodes: 'urn:uuid:aa543740-bdda-424e-8c96-df4873be8500',
    uniqueId: 'urn:uuid:96fdad7c-d067-4183-912e-bf5ee74998a8',
    sourceId: 'urn:uuid:554ac39e-e3fe-47fe-b233-965d2a147832',
    patientId: 'urn:uuid:6b5aea1a-874d-4603-a4bc-96a0a7b38446',
    limitedMetadata: 'urn:uuid:a54d6aa5-d40d-43f9-88c5-b4633d873bdd'
}

var queryType = null;
var requiredKeywords = [];
var optionalKeywords = [];
var inputKeywords = [];

var keywordCount = 0;

var queryTypeList = ['',
    'FindDocuments', 'FindSubmissionSets', 'FindFolders',
    'GetAll', 'GetDocuments', 'GetFolders', 'GetAssociations',
    'GetDocumentsAndAssociations', 'GetSubmissionSets',
    'GetSubmissionSetAndContents', 'GetFolderAndContents',
    'GetFoldersForDocument', 'GetRelatedDocuments',
    'FindDocumentsByReferenceld'];
var queryTypeUUID = {
    FindDocuments: 'urn:uuid:14d4debf-8f97-4251-9a74-a90016b0af0d',
    FindSubmissionSets: 'urn:uuid:f26abbcb-ac74-4422-8a30-edb644bbc1a9'
}

var timeKeyList = ['$XDSDocumentEntryCreationTimeFrom', '$XDSDocumentEntryCreationTimeTo',
    '$XDSDocumentEntryServiceStartTimeFrom',
    '$XDSDocumentEntryServiceStartTimeTo',
    '$XDSDocumentEntryServiceStopTimeFrom',
    '$XDSDocumentEntryServiceStopTimeTo'];
var availableKeywords = {
    FindDocuments: {
        required: ['XDSDocumentEntryPatientId', 'XDSDocumentEntryStatus'],
        optional: ['XDSDocumentEntryClassCode', 'XDSDocumentEntryTypeCode',
            'XDSDocumentEntryPracticeSettingCode', 'XDSDocumentEntryCreationTime',
            'XDSDocumentEntryServiceStartTime', 'XDSDocumentEntryServiceStopTime',
            'XDSDocumentEntryHealthcareFacilityTypeCode',
            'XDSDocumentEntryEventCodeList',
            'XDSDocumentEntryConfidentialityCode', 'XDSDocumentEntryAuthorPerson',
            'XDSDocumentEntryFormatCode', 'XDSDocumentEntryType']
    },
}
```

```

var queryXML = {
    "query:AdhocQueryRequest": {
        "$": {
            "xmlns:query": "urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0",
            "xmlns:rim": "urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0",
            "xmlns:rs": "urn:oasis:names:tc:ebxml-regrep:xsd:rs:3.0",
            "xmlns:xsi": "http://www.w3.org/2001/XMLSchema-instance",
            "xsi:schemaLocation": "urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0
..../schema/ebRS/query.xsd"
        },
        "query:ResponseOption": [
            {
                "$": {
                    "returnComposedObjects": "true",
                    "returnType": "LeafClass" //This should be determined by number of results
                }
            }
        ],
        "rim:AdhocQuery": [
            {
                "$": {
                    "id": "urn:uuid:14d4debf-8f97-4251-9a74-a90016b0af0d" //This is UUID of each query
type
                },
                "rim:Slot": [] //Query keyword
            }
        ]
    }
}

function Main () {
    console.log('\n=====');
    console.log('| XDS Consumer Actor Interface ||');
    console.log('=====');
    getQueryType();
}

function getQueryType () {
    console.log('Please select query type');
    console.log('1) FindDocuments');
    console.log('2) FindSubmissionSets');
    console.log('3) FindFolders');
    console.log('4) GetAll');
    console.log('5) GetDocuments');
    console.log('6) GetFolders');
    console.log('7) GetAssociations');
    console.log('8) GetDocumentsAndAssociations');
}

```

```
console.log('9) GetSubmissionSets');
console.log('10) GetSubmissionSetAndContents');
console.log('11) GetFolderAndContents';
console.log('12) GetFoldersForDocument';
console.log('13) GetRelatedDocuments';
console.log('14) FindDocumentsByReferenceId';
console.log('#) Quit');

rl.question("(Specify number): ", function(queryTypeInput) {
    var queryTypeInteger = parseInt(queryTypeInput, 10);
    if (queryTypeInput && queryTypeInteger){
        queryType = queryTypeList[queryTypeInteger];
        console.log('Query Type: ' + queryType + '\n');
        requiredKeywords = availableKeywords[queryType]['required'];
        optionalKeywords = availableKeywords[queryType]['optional'];
    }
    else if (queryTypeInput == '#' || queryTypeInput == 'quit' || queryTypeInput == 'Quit'){
        console.log('Quit...');
        process.exit();
    }
    else {
        console.log('Error');
        process.exit();
    }
    inputKeywords.push(queryType);
    keywordCount = 0;
    getRequiredKeywords();
});

function getRequiredKeywords () {
    console.log('Keywords require: ' + requiredKeywords[keywordCount]);
    var addedHeader = '$' + requiredKeywords[keywordCount];
    rl.question('Value: ', function(requireKeyInput) {
        inputKeywords.push([addedHeader, requireKeyInput]);
        keywordCount++;
        if (keywordCount >= requiredKeywords.length){
            showAllKeywords();
            getOptionalKeywords();
        }
        else {
            getRequiredKeywords();
        }
    });
}
```

```
function getOptionalKeywords () {
    console.log('Available optional keywords: ');
    console.log('0) No more optional keywords');
    for (i = 0; i < optionalKeywords.length; i++){ //Show all available optional keywords
        var count = i+1;
        console.log(count + ')' + optionalKeywords[i]);
    }
    console.log('#) Quit')
    rl.question('Select keywords (specify number): ', function(selectedOpt) { //Prompt user for
optional keyword by specifying number
        if (selectedOpt == '#'){ // '#' Mark as program terminate
            process.exit();
        }
        else if (selectedOpt == '0') { // '0' Mark as user approve that all known keywords included
            console.log('=====');
            console.log('All keywords set...');
            showAllKeywords();
            createXML();
            return rl.close();
        }
        else { //Otherwise
            var selectedOpt = parseInt(selectedOpt, 10);
            var optionMarker = selectedOpt - 1;
            console.log('Keyword: ' + optionalKeywords[optionMarker]);
            if (selectedOpt && optionMarker >= 0 && optionMarker <
optionalKeywords.length){ //Check if user input is a number and the number is in available range
                var selectedOptKeywords = '$' + optionalKeywords[optionMarker];
                var replicateCheck = null;
                var timeKeyCheck = null;
                for (j = 1; j < inputKeywords.length; j++){ //Check for any replicated
keyword specified
                    if (inputKeywords[j][0] == selectedOptKeywords ||

inputKeywords[j][0] == selectedOptKeywords + 'From'){
                        replicateCheck = 1;
                        var replicatedKeywordPos = j;
                    }
                    if (timeKeyList.includes(selectedOptKeywords + 'From')){
                        timeKeyCheck = 1;
                    }
                }
                if (replicateCheck && !timeKeyCheck){ //If found any replicated keyword
then ask if user want to replace the value && the keyword is not a time keyword
                    console.log('Query keywords set already contain ' +
selectedOptKeywords);
                    rl.question('Overwrite the keyword? (y/n): ',
function(overwriteConfirm) {
                    if (overwriteConfirm == 'y' || overwriteConfirm == 'Y' ||
overwriteConfirm == 'yes' || overwriteConfirm == 'Yes'){ //Ask for user to specify yes or else

```

```

function(optionalKeyInput) {
    rl.question('Replace with value: ',
        if
            (inputKeywords[replicatedKeywordPos][0] == selectedOptKeywords){ //Second check if the keyword
                really replicated

                    inputKeywords[replicatedKeywordPos][1] = optionalKeyInput;
                        showAllKeywords();
                        getOptionalKeywords();
                    }
                }
            else { //If user not confirm on overwrite the keyword,
                just skip overwriting
                    console.log('Overwrite cancelled...');

                    showAllKeywords();
                    getOptionalKeywords();
                }
            });
        }
    else if (replicateCheck && timeKeyCheck){ //If found any relicated
        keyword then ask if user want to replace the value && the keyword is a time keyword
            console.log('Query keywords set already contain ' +
            selectedOptKeywords);
            rl.question('Overwrite the keyword? (y/n): ',
        function(overwriteConfirm) {
            if (overwriteConfirm == 'y' || overwriteConfirm == 'Y' ||
            overwriteConfirm == 'yes' || overwriteConfirm == 'Yes'){ //Ask for user to specify yes or else
                rl.question('Replace time value from
                (YYYYMMDDhhmmss): ', function(optionalKeyInputFrom) {
                    rl.question('Replace time value to
                    (YYYYMMDDhhmmss): ', function(optionalKeyInputTo) {

                        inputKeywords[replicatedKeywordPos][1] = optionalKeyInputFrom;

                        inputKeywords[replicatedKeywordPos + 1][1] = optionalKeyInputTo;
                            showAllKeywords();
                            getOptionalKeywords();
                        });
                    });
                }
            else { //If user not confirm on overwrite the keyword,
                just skip overwriting
                    console.log('Overwrite cancelled...');

                    showAllKeywords();
                    getOptionalKeywords();
                }
            });
        });
    }
}

```

```

        }
        else if (!replicateCheck && timeKeyCheck){ //If non of any replicated
were found, then add more keyword into query set && the keyword is a time keyword
        rl.question('Time value from (YYYYMMDDhhmmss): ',
function(optionalKeyInputFrom) {
        rl.question('Time value to (YYYYMMDDhhmmss): ',
function(optionalKeyInputTo) {
        inputKeywords.push([selectedOptKeywords +
'From', optionalKeyInputFrom]);
        inputKeywords.push([selectedOptKeywords +
'To', optionalKeyInputTo]);
        showAllKeywords();
        getOptionalKeywords();
    });
}
else { //If non of any replicated were found, then add more keyword
into query set
        rl.question('Value: ', function(optionalKeyInput) {
        inputKeywords.push([selectedOptKeywords,
optionalKeyInput]);
        showAllKeywords();
        getOptionalKeywords();
    });
}
else { //If user try to input anything that not available, force to try again
        console.log('Error, try again...');
        getOptionalKeywords();
    }
}
});
}

function showAllKeywords () {
    console.log('=====');
    console.log('Query type: ' + inputKeywords[0]);
    console.log('Query keywords: ');
    for (i = 1; i < inputKeywords.length; i++){
        console.log(inputKeywords[i][0] + ' = ' + inputKeywords[i][1]);
    }
    console.log('=====');
}

function createXML () { //Assort keywords into ITI-18 XML format

    queryXML['query:AdhocQueryRequest']['rim:AdhocQuery'][0]['$']['id'] =
queryTypeUUID[inputKeywords[0]];
}

```

```
var slot = queryXML['query:AdhocQueryRequest']['rim:AdhocQuery'][0]['rim:Slot'];

for (i = 1; i < inputKeywords.length; i++){
    var rimSlot = {
        "$": {
            "name": inputKeywords[i][0]
        },
        "rim:ValueList": [
            {
                "rim:Value": [
                    inputKeywords[i][1]
                ]
            }
        ]
    }

    slot.push(rimSlot);
}

sendQuery();
}

function sendQuery () {
    client.connect(PORT, HOST, function() {
        console.log('CONNECTED TO: ' + HOST + ':' + PORT);
        // Write a message to the socket as soon as the client is connected, the server will receive it as
message from the client
        var queryXMLrebuilt = builder.buildObject(queryXML);
        hrstart = process.hrtime();
        client.write(queryXMLrebuilt);
        console.log('Query Sent...');
    });

    // Add a 'data' event handler for the client socket
    // data is what the server sent to this socket
    client.on('data', function(data) {
        // Close the client socket completely
        if (data.includes('ACK from ')){
            console.log('Respond received: ' + data);
            hrend = process.hrtime(hrstart);
            console.info('Execution time (hr): %ds %dms', hrend[0], hrend[1] / 1000000);
        }
        else {
            console.log('=====\\nQuery response received: ');
            var dataIn = data.toString();
            parseString(dataIn, function (err, result) {
                var eventCodeListCount = 0;
                if (err) throw err;
            });
        }
    });
}
```

```

var bodyExtrinsicObject =
result['query:AdhocQueryResponse']['rim:RegistryObjectList'][0]['rim:ExtrinsicObject'][0];
if (bodyExtrinsicObject['$']['objectType'] == documentEntryUUID.DocumentEntry){
    //Scanning object within DocumentEntry "Classification"
    if (bodyExtrinsicObject['$']['id']){
        prepXDSAtt.DocumentEntry.entryUUID = bodyExtrinsicObject['$']['id'];
    }
    if (bodyExtrinsicObject['$']['mimeType']){
        prepXDSAtt.DocumentEntry.mimeType = bodyExtrinsicObject['$']['mimeType'];
    }
    if (bodyExtrinsicObject['$']['objectType']){
        prepXDSAtt.DocumentEntry.objectType = bodyExtrinsicObject['$']['objectType'];
    }
    if (bodyExtrinsicObject['$']['status']){
        prepXDSAtt.DocumentEntry.availabilityStatus =
bodyExtrinsicObject['$']['status'];
    }
    for (var i = 0; i < bodyExtrinsicObject['rim:Classification'].length; i++){
        //Detect DocumentEntry > author (Set)
        if (bodyExtrinsicObject['rim:Classification'][i]['$']['classificationScheme'] ==
documentEntryUUID.author){
            if (i != 0) { //If there are more than one author for the Doc, add more author object into
array
                prepXDSAtt.DocumentEntry.author.push({
                    authorPerson: 'N/A',
                    authorInstitution: [],
                    authorRole: 'N/A',
                    authorSpecialty: 'N/A'
                });
            }
            //Assign each element of the author
            for (var j = 0; j < bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'].length; j++){
                if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][j]['$']['name'] ==
'authorPerson'){
                    prepXDSAtt.DocumentEntry.author[i].authorPerson =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][j]['rim:ValueList'][0]['rim:Value'][0];
                }
                if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][j]['$']['name'] ==
'authorInstitution'){
                    prepXDSAtt.DocumentEntry.author[i].authorInstitution =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][j]['rim:ValueList'][0]['rim:Value'];
                }
                if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][j]['$']['name'] == 'authorRole'){
                    prepXDSAtt.DocumentEntry.author[i].authorRole =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][j]['rim:ValueList'][0]['rim:Value'][0];
                }
                if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][j]['$']['name'] ==
'authorSpecialty'){

```

```

        prepXDSAtt.DocumentEntry.author[i].authorSpecialty =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][j]['rim:ValueList'][0]['rim:Value'][0];
    }
}
//Detect DocumentEntry > classCode
if (bodyExtrinsicObject['rim:Classification'][i]['$']['classificationScheme'] ==
documentEntryUUID.classCode){
    prepXDSAtt.DocumentEntry.classCode.displayName =
bodyExtrinsicObject['rim:Classification'][i]['rim:Name'][0]['rim:LocalizedString'][0]['$']['value'];
    if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['$']['name'] ==
'codingScheme'){
        prepXDSAtt.DocumentEntry.classCode.codingScheme =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['rim:ValueList'][0]['rim:Value'][0];
    }
}
//Detect DocumentEntry > confidentialityCode
if (bodyExtrinsicObject['rim:Classification'][i]['$']['classificationScheme'] ==
documentEntryUUID.confidentialityCode){
    prepXDSAtt.DocumentEntry.confidentialityCode.displayName =
bodyExtrinsicObject['rim:Classification'][i]['rim:Name'][0]['rim:LocalizedString'][0]['$']['value'];
    if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['$']['name'] ==
'codingScheme'){
        prepXDSAtt.DocumentEntry.confidentialityCode.codingScheme =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['rim:ValueList'][0]['rim:Value'][0];
    }
}
//Detect DocumentEntry > formatCode
if (bodyExtrinsicObject['rim:Classification'][i]['$']['classificationScheme'] ==
documentEntryUUID.formatCode){
    prepXDSAtt.DocumentEntry.formatCode.displayName =
bodyExtrinsicObject['rim:Classification'][i]['rim:Name'][0]['rim:LocalizedString'][0]['$']['value'];
    if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['$']['name'] ==
'codingScheme'){
        prepXDSAtt.DocumentEntry.formatCode.codingScheme =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['rim:ValueList'][0]['rim:Value'][0];
    }
}
//Detect DocumentEntry > healthcareFacilityTypeCode
if (bodyExtrinsicObject['rim:Classification'][i]['$']['classificationScheme'] ==
documentEntryUUID.healthcareFacilityTypeCode){
    prepXDSAtt.DocumentEntry.healthcareFacilityTypeCode.displayName =
bodyExtrinsicObject['rim:Classification'][i]['rim:Name'][0]['rim:LocalizedString'][0]['$']['value'];
    if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['$']['name'] ==
'codingScheme'){
        prepXDSAtt.DocumentEntry.healthcareFacilityTypeCode.codingScheme =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['rim:ValueList'][0]['rim:Value'][0];
    }
}

```

```

    }
    //Detect DocumentEntry > practiceSettingCode
    if (bodyExtrinsicObject['rim:Classification'][i]['$']['classificationScheme'] ==
documentEntryUUID.practiceSettingCode){
        prepXDSAtt.DocumentEntry.practiceSettingCode.displayName =
bodyExtrinsicObject['rim:Classification'][i]['rim:Name'][0]['rim:LocalizedString'][0]['$']['value'];
        if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['$']['name'] ==
'codingScheme'){
            prepXDSAtt.DocumentEntry.practiceSettingCode.codingScheme =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['rim:ValueList'][0]['rim:Value'][0];
        }
    }
    //Detect DocumentEntry > eventCode
    if (bodyExtrinsicObject['rim:Classification'][i]['$']['classificationScheme'] ==
documentEntryUUID.eventCodeList){
        prepXDSAtt.DocumentEntry.eventCodeList.push({
            codingScheme: 'N/A',
            displayName: 'N/A'
        });
        prepXDSAtt.DocumentEntry.eventCodeList[eventCodeListCount].displayName =
bodyExtrinsicObject['rim:Classification'][i]['rim:Name'][0]['rim:LocalizedString'][0]['$']['value'];
        if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['$']['name'] ==
'codingScheme'){
            prepXDSAtt.DocumentEntry.eventCodeList[eventCodeListCount].codingScheme =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['rim:ValueList'][0]['rim:Value'][0];
        }
        eventCodeListCount++;
    }
    //Detect DocumentEntry > TypeCode
    if (bodyExtrinsicObject['rim:Classification'][i]['$']['classificationScheme'] ==
documentEntryUUID.typeCode){
        prepXDSAtt.DocumentEntry.typeCode.displayName =
bodyExtrinsicObject['rim:Classification'][i]['rim:Name'][0]['rim:LocalizedString'][0]['$']['value'];
        if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['$']['name'] ==
'codingScheme'){
            prepXDSAtt.DocumentEntry.typeCode.codingScheme =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['rim:ValueList'][0]['rim:Value'][0];
        }
    }
    //Scanning object within DocumentEntry "Descriptor" which usually be "comment"
    for (var i = 0; i < bodyExtrinsicObject['rim:Description'].length; i++){
        prepXDSAtt.DocumentEntry.comment = bodyExtrinsicObject['rim:Description'][i];
    }
    for (var i = 0; i < bodyExtrinsicObject['rim:Name'].length; i++){
        prepXDSAtt.DocumentEntry.title =
bodyExtrinsicObject['rim:Name'][i]['rim:LocalizedString'][0]['$']['value'];
    }
}

```

```

//Scanning object within DocumentEntry "ExternalIdentifier"
for (var i = 0; i < bodyExtrinsicObject['rim:ExternalIdentifier'].length; i++){
    //Detect DocumentEntry > patientId
    if (bodyExtrinsicObject['rim:ExternalIdentifier'][i]['$']['identificationScheme'] ==
documentEntryUUID.patientId){
        prepXDSAtt.DocumentEntry.patientId =
(bodyExtrinsicObject['rim:ExternalIdentifier'][i]['$']['value']);
    }
    if (bodyExtrinsicObject['rim:ExternalIdentifier'][i]['$']['identificationScheme'] ==
documentEntryUUID.uniqueId){
        prepXDSAtt.DocumentEntry.uniqueId =
(bodyExtrinsicObject['rim:ExternalIdentifier'][i]['$']['value']);
    }
}
//Scannig object within DocumentEntry "Slot"
for (var i = 0; i < bodyExtrinsicObject['rim:Slot'].length; i++){
    if (bodyExtrinsicObject['rim:Slot'][i]['$']['name'] == 'size'){
        prepXDSAtt.DocumentEntry.size =
bodyExtrinsicObject['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'][0];
    }
    if (bodyExtrinsicObject['rim:Slot'][i]['$']['name'] == 'repositoryUniqueId'){
        prepXDSAtt.DocumentEntry.repositoryUniqueId =
bodyExtrinsicObject['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'][0];
    }
    if (bodyExtrinsicObject['rim:Slot'][i]['$']['name'] == 'hash'){
        prepXDSAtt.DocumentEntry.hash =
bodyExtrinsicObject['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'][0];
    }
    if (bodyExtrinsicObject['rim:Slot'][i]['$']['name'] == 'creationTime'){
        prepXDSAtt.DocumentEntry.creationTime =
bodyExtrinsicObject['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'][0];
    }
    if (bodyExtrinsicObject['rim:Slot'][i]['$']['name'] == 'languageCode'){
        prepXDSAtt.DocumentEntry.languageCode =
bodyExtrinsicObject['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'][0];
    }
    if (bodyExtrinsicObject['rim:Slot'][i]['$']['name'] == 'serviceStartTime'){
        prepXDSAtt.DocumentEntry.serviceStartTime =
bodyExtrinsicObject['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'][0];
    }
    if (bodyExtrinsicObject['rim:Slot'][i]['$']['name'] == 'serviceStopTime'){
        prepXDSAtt.DocumentEntry.serviceStopTime =
bodyExtrinsicObject['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'][0];
    }
    if (bodyExtrinsicObject['rim:Slot'][i]['$']['name'] == 'sourcePatientId'){
        prepXDSAtt.DocumentEntry.sourcePatientId =
bodyExtrinsicObject['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'][0];
    }
}

```

```
        if (bodyExtrinsicObject['rim:Slot'][i]['$']['name'] == 'sourcePatientInfo'){
            prepXDSAtt.DocumentEntry.sourcePatientInfo =
bodyExtrinsicObject['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'];
        }
    }
    console.log(util.inspect(prepXDSAtt));
    hrend = process.hrtime(hrstart);
    console.log('=====');
    console.info('Execution time (hr): %ds %dms', hrend[0], hrend[1] / 1000000);
    console.log('=====');
};

client.destroy();
rl.close();
}
});

// Add a 'close' event handler for the client socket
client.on('close', function() {
    console.log('Connection closed');
});
}

Main();
```

Figure 4-31 Javascript Code Snippet of XDS Document Consumer Actor

4.2.3 XDS Document Registry Actor

Following Section 3.5.1, the XDS Document Registry Actor program must be able to communicate with the simulated XDS Document Repository actor and XDS Document Consumer actor. At the same time, the software will need to act as the middle between the local XDS system and the Blockchain ledger. The completed process flow of the XDS Document Registry Actor is shown in pseudocode Figure 4-32. The Actor will wait until receiving the XML message transaction and react differently to ITI-42 and ITI-18 transactions.

```
Main() {
    while (True) {
        var ReceivedMessage = Wait_For_XMLMessage();
        if (ReceivedMessage == "ITI-42"){
            //Section 4.2.3.1
            var SmartcontractCompatible = Received_ITI_42(XMLMessage)
            //Section 4.2.3.1.1
            var registerStatus = DocumentRegistering_Into_Blockchain(SmartcontractCompatible);
            //Section 4.2.3.1.2
            Send_Response_To_XDSDocumentRepositoryActor(registerStatus);
        }
        else if (ReceivedMessage == "ITI-18"){
            //Section 4.2.3.2
            var SearchKeywords = Received_ITI_18(XMLMessage);
            //Section 4.2.3.2.1
            var SearchResult = DocumentSearch_Within_Blockchain(SearchKeywords);
            //Section 4.2.3.2.2
            var ITI_18_Response = SortResult_Into_ITI18ResponseFormat(SearchResult);
            Send_Response_To_XDSDocumentConsumerActor(ITI_18_Response);
        }
    }
}
```

Figure 4-32 Pseudocode showing the process flow of the XDS Document Registry Actor

Unlike the XDS Document Repository Actor and XDS Document Consumer Actor, the XDS Document Registry was made to act as the medium between the native system and the Blockchain Smartcontract. This section will break down the component of the XDS Document Registry Actor in a pattern different from the rest where it separated by its main function interacting with health document metadata which included Document Registering and Document Search. Each section will break down into Javascript native program part and Smartcontract part.

4.2.3.1 Implementing Document Register Function

4.2.3.1.1 Native-Side Javascript Program

For this implementation, the XDS Document Registry Actor will open a TCP connection to receive the transaction on a specified port. Upon receiving the ITI-42 transaction, the Actor then converts the XML message into JSON using xml2js. When ITI-42 was interpreted into JSON, the actor then assorts the object and sorts it into the Smartcontract compatible format. Figure 4-33 is the pseudocode showing the process flow for the Javascript program handling the ITI-42 transaction until converted into the Smartcontract compatible format. Figure 4-34 to Figure 4-39 showing the Javascript code snippet of XDS Document Registry which is the part dealing with ITI-42 transaction and Document Registering Function.

```
var Received_ITI_42(XMLMessage){
    var JSON_attributes = InterpretXMLtoJSON(XMLMessage);
    var Assorted_JSON = AssortMetadataAttributes(JSON_attributes);
    var SmartcontractCompatible = SortInto_SmartcontractCompatibleFormat(Assorted_JSON);
    return SmartcontractCompatible;
}
```

Figure 4-33 The pseudocode showing the process flow of XDS Document Registry Actor for Document Registering Function

```
var hrstart = null;
var hrend = null;
var fs = require("fs");
var net = require('net');
var util = require("util");
var xml2js = require('xml2js');
var parseString = xml2js.parseString;
var builder = new xml2js.Builder();
var moment = require('moment');
const Cryptr = require('cryptr');
const cryptr = new Cryptr('XDSDomainSharedSecretKey');

var Web3 = require('web3');
var web3 = new Web3("qdata/dd1/geth.ipc", net);

var HOST = '127.0.0.1';
var PORT = 65519;

var netServer = null;
var netSocket = null;

//Net socket wait for any messages=====
netServer = net.createServer(function(sock) {
    netSocket = sock;
    // We have a connection - a socket object is assigned to the connection automatically
    console.log('CONNECTED: ' + sock.remoteAddress + ':' + sock.remotePort);

    // Add a 'data' event handler to this instance of socket
    sock.on('data', function(data) {
        console.log('Received data....');
        hrstart = process.hrtime();
        sock.write('ACK from ' + sock.remoteAddress + '\n'); //Write ACK back to sender
        processData(data); //converting XML to JSON based on Module "xml-js"
        //console.log(result); // show the result of xml to js conversion
    });
    // Add a 'close' event handler to this instance of socket
    sock.on('close', function(data) {
        console.log('CLOSED: ' + sock.remoteAddress + ' ' + sock.remotePort);
    });
}).listen(PORT, HOST);
console.log('XDS Document Registry Actor listening on ' + HOST + ':' + PORT);
```

Figure 4-34 Javascript Code Snippet of XDS Document Registry Actor

Node Module import declaration and TCP Socket message receiver section

```
//ProcessData interprete any xmlMessages came through Netsocket =====
function processData (dataIn) {
    console.log('XML:\n' + dataIn);
    parseString(dataIn, function (err, result) {
        if (err) throw err;
        console.log('\nConverted to object: ');
        console.log('-----\n' + util.inspect(result) + '\n-----');
        /*
        fs.writeFile("queryReceived.json", stringXDSAttrib, function(err, data) {
            if (err) console.log(err);
            console.log("Successfully Written to File. ");
        });
        */
        if (Object.keys(result)[0] == 'query:AdhocQueryRequest') {
            console.log('Query requested...');
            documentQuery(result);
        }
        else{
            if (Object.keys(result)[0] == 'soapenv:Envelope'){
                if (result['soapenv:Envelope']['soapenv:Header'][0]['wsa:Action'][0]['_'] == 'urn:ihe:iti:2007:RegisterDocumentSet-b'){
                    console.log('RegisterDocumentSet-b...');
                    registerDocumentSetb(result);
                }
            }
        });
    });
}
```

Figure 4-35 XDS Document Registry Actor

This section checks if receiving message is ITI-42 or ITI-18 identified by its header

```
//RegisterDocumentSet-b
//-----
//Declare main object to store all META-data attributes essential for search operation
function registerDocumentSetb (inputAttributes) {
    var prepXDSAtt = {
        DocumentEntry: {
            author: [
                {
                    authorPerson: 'N/A',
                    authorInstitution: [],
                    authorRole: 'N/A',
                    authorSpecialty: 'N/A'
                }],
            availabilityStatus: 'N/A',
            classCode: {
                codingScheme: 'N/A',
                displayName: 'N/A'
            },
            comment: 'N/A',
            confidentialityCode: {
                codingScheme: 'N/A',
                displayName: 'N/A'
            },
            creationTime: 'N/A',
            entryUUID: 'N/A',
            eventCodeList: [],
            formatCode: {
                codingScheme: 'N/A',
                displayName: 'N/A'
            },
            hash: 'N/A',
            healthcareFacilityTypeCode: {
                codingScheme: 'N/A',
                displayName: 'N/A'
            },
            homeCommunityId: 'N/A',
            languageCode: 'N/A',
            legalAuthenticator: 'N/A',
            limitedMetadata: 'N/A',
            mimeType: 'N/A',
            objectType: 'N/A',
            patientId: 'N/A',
            practiceSettingCode: {
                codingScheme: 'N/A',
                displayName: 'N/A'
            },
        }
    }
}
```

```

referenceIdList: 'N/A',
repositoryUniqueId: 'N/A',
serviceStartTime: 'N/A',
serviceStopTime: 'N/A',
size: 'N/A',
sourcePatientId: 'N/A',
sourcePatientInfo: [],
title: 'N/A',
typeCode: {
  codingScheme: 'N/A',
  displayName: 'N/A'
},
uniqueId: 'N/A',
URI: 'N/A'
},
SubmissionSet: {
author: [
  {
    authorPerson: 'N/A',
    authorInstitution: [],
    authorRole: 'N/A',
    authorSpecialty: 'N/A'
  }
],
availabilityStatus: 'N/A',
comments: 'N/A',
contentTypeCodes: {
  codingScheme: 'N/A',
  displayName: 'N/A'
},
entryUUID: 'N/A',
homeCommunityId: 'N/A',
intendedRecipient: 'N/A',
limitedMetadata: 0,
patientId: 'N/A',
sourceId: 'N/A',
submissionTime: 'N/A',
title: 'N/A',
uniqueId: 'N/A'
},
Folder: {
  availabilityStatus: 'N/A',
  codeList: 'N/A',
  comments: 'N/A',
  entryUUID: 'N/A',
  homeCommunityId: 'N/A',
  lastUpdateTime: 'N/A',
  limitedMetadata: 'N/A',
  patientId: 'N/A',
  title: 'N/A',
  uniqueId: 'N/A'
},
Association: {
  associationType: 'N/A',
  sourceObject: 'N/A',
  targetObject: 'N/A',
  SubmissionSetStatus: 'N/A'
}
}

```

Figure 4-36 XDS Document Registry Actor

Declaration of JSON variable to store all Metadata attributes by its position in the format

```
//Define UUID number of each META-data attributes
var documentEntryUUID = {
    //----Document Entry-----
    DocumentEntry: 'urn:uuid:7edca82f-054d-47f2-a032-9b2a5b5186c1',
    author: 'urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d',
    classCode: 'urn:uuid:41a5887f-8865-4c09-adf7-e362475b143a',
    confidentialityCode: 'urn:uuid:f4f85eac-e6cb-4883-b524-f2705394840f',
    formatCode: 'urn:uuid:a09d5840-386c-46f2-b5ad-9c3699a4309d',
    healthcareFacilityTypeCode: 'urn:uuid:f33fb8ac-18af-42cc-ae0e-ed0b0bdb91e1',
    practiceSettingCode: 'urn:uuid:cccf5598-8b07-4b77-a05e-ae952c785ead',
    typeCode: 'urn:uuid:f0306f51-975f-434e-a61c-c59651d33983',
    patientId: 'urn:uuid:58a6f841-87b3-4a3e-92fd-a8ffeff98427',
    uniqueId: 'urn:uuid:2e82c1f6-a085-4c72-9da3-8640a32e42ab',
    eventCodeList: 'urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4'
}

var submissionSetUUID = {
    //----SubmissionSet Attributes-----
    author: 'urn:uuid:a7058bb9-b4e4-4307-ba5b-e3f0ab85e12d',
    contentTypeCodes: 'urn:uuid:aa543740-bdda-424e-8c96-df4873be8500',
    uniqueId: 'urn:uuid:96fdda7c-d067-4183-912e-bf5ee74998a8',
    sourceId: 'urn:uuid:554ac39e-e3fe-47fe-b233-965d2a147832',
    patientId: 'urn:uuid:6b5aea1a-874d-4603-a4bc-96a0a7b38446',
    limitedMetadata: 'urn:uuid:a54d6aa5-d40d-43f9-88c5-b4633d873bdd'
}
```

Figure 4-37 XDS Document Registry Actor

Define variable of each Metadata attribute UUID label following IHE ITI Framework

```

function assignAll (rXDSAttribute, myCallback) {
    //Define variable for shorter object accessing
    var sEnvelope = rXDSAttribute['soapenv:Envelope'];
    //inside Envelope
    var s$ = sEnvelope['$'];
    var sBody = sEnvelope['soapenv:Body'][0];
    var sHeader = sEnvelope['soapenv:Header'][0];
    //inside Envelope>Header
    var wsaTo = sHeader['wsa:To'];
    var wsaMessageID = sHeader['wsaMessageID'];
    var wsaAction = sHeader['wsaAction'];
    //inside Envelope>Body
    var lcmSubmitObjectsRequest = sBody['lcm:SubmitObjectsRequest'][0];
    //inside Envelope>Body>lcm:SubmitObjectsRequest
    var bodyRegistryObjectList = lcmSubmitObjectsRequest['rim:RegistryObjectList'][0];
    //inside Envelope>Body>lcm:SubmitObjectsRequest>rim:RegistryObjectList
    var bodyExtrinsicObject = bodyRegistryObjectList['rim:ExtrinsicObject'][0];
    var bodyRegistryPackage = bodyRegistryObjectList['rim:RegistryPackage'][0];
    var bodyClassification = bodyRegistryObjectList['rim:Classification'][0];
    var bodyAssociation = bodyRegistryObjectList['rim:Association'][0];

    var eventCodeListCount = 0; //Document may have more than one eventCodeList, so it need
counter

    //Detect DocumentEntry
    if (bodyExtrinsicObject['$']['objectType'] == documentEntryUUID.DocumentEntry){
        //Scanning object within DocumentEntry "Classification"
        if (bodyExtrinsicObject['$']['id']){
            prepXDSAtt.DocumentEntry.entryUUID = bodyExtrinsicObject['$']['id'];
        }
        if (bodyExtrinsicObject['$']['mimeType']){
            prepXDSAtt.DocumentEntry.mimeType = bodyExtrinsicObject['$']['mimeType'];
        }
        if (bodyExtrinsicObject['$']['objectType']){
            prepXDSAtt.DocumentEntry.objectType = bodyExtrinsicObject['$']['objectType'];
        }
        if (bodyExtrinsicObject['$']['status']){
            prepXDSAtt.DocumentEntry.availabilityStatus = bodyExtrinsicObject['$']['status'];
        }
    }
}

```

```

        for (var i = 0; i < bodyExtrinsicObject['rim:Classification'].length; i++){
            //Detect DocumentEntry > author (Set)
            if (bodyExtrinsicObject['rim:Classification'][i]['$']['classificationScheme'] ==
documentEntryUUID.author){
                if (i != 0) { //If there are more than one author for the Doc, add more author object into
array
                    prepXDSAtt.DocumentEntry.author.push({
                        authorPerson: 'N/A',
                        authorInstitution: [],
                        authorRole: 'N/A',
                        authorSpecialty: 'N/A'
                    });
                }
                //Assign each element of the author
                for (var j = 0; j < bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'].length; j++){
                    if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][j]['$']['name'] ==
'authorPerson'){
                        prepXDSAtt.DocumentEntry.author[i].authorPerson =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][j]['rim:ValueList'][0]['rim:Value'][0];
                    }
                    if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][j]['$']['name'] ==
'authorInstitution'){
                        prepXDSAtt.DocumentEntry.author[i].authorInstitution =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][j]['rim:ValueList'][0]['rim:Value'];
                    }
                    if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][j]['$']['name'] == 'authorRole'){
                        prepXDSAtt.DocumentEntry.author[i].authorRole =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][j]['rim:ValueList'][0]['rim:Value'][0];
                    }

                    if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][j]['$']['name'] ==
'authorSpecialty'){
                        prepXDSAtt.DocumentEntry.author[i].authorSpecialty =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][j]['rim:ValueList'][0]['rim:Value'][0];
                    }
                }
            //Detect DocumentEntry > classCode
            if (bodyExtrinsicObject['rim:Classification'][i]['$']['classificationScheme'] ==
documentEntryUUID.classCode){
                prepXDSAtt.DocumentEntry.classCode.displayName =
bodyExtrinsicObject['rim:Classification'][i]['rim:Name'][0]['rim:LocalizedString'][0]['$']['value'];
                if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['$']['name'] ==
'codingScheme'){
                    prepXDSAtt.DocumentEntry.classCode.codingScheme =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['rim:ValueList'][0]['rim:Value'][0];
                }
            }
        }
    }
}

```

```

//Detect DocumentEntry > confidentialityCode
if (bodyExtrinsicObject['rim:Classification'][i]['$']['classificationScheme'] ==
documentEntryUUID.confidentialityCode){
    prepXDSAtt.DocumentEntry.confidentialityCode.displayName =
bodyExtrinsicObject['rim:Classification'][i]['rim:Name'][0]['rim:LocalizedString'][0]['$']['value'];
    if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['$']['name'] ==
'codingScheme'){
        prepXDSAtt.DocumentEntry.confidentialityCode.codingScheme =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['rim:ValueList'][0]['rim:Value'][0];
    }
}
//Detect DocumentEntry > formatCode
if (bodyExtrinsicObject['rim:Classification'][i]['$']['classificationScheme'] ==
documentEntryUUID.formatCode){
    prepXDSAtt.DocumentEntry.formatCode.displayName =
bodyExtrinsicObject['rim:Classification'][i]['rim:Name'][0]['rim:LocalizedString'][0]['$']['value'];
    if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['$']['name'] ==
'codingScheme'){
        prepXDSAtt.DocumentEntry.formatCode.codingScheme =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['rim:ValueList'][0]['rim:Value'][0];
    }
}
//Detect DocumentEntry > healthcareFacilityTypeCode
if (bodyExtrinsicObject['rim:Classification'][i]['$']['classificationScheme'] ==
documentEntryUUID.healthcareFacilityTypeCode){
    prepXDSAtt.DocumentEntry.healthcareFacilityTypeCode.displayName =
bodyExtrinsicObject['rim:Classification'][i]['rim:Name'][0]['rim:LocalizedString'][0]['$']['value'];
    if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['$']['name'] ==
'codingScheme'){
        prepXDSAtt.DocumentEntry.healthcareFacilityTypeCode.codingScheme =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['rim:ValueList'][0]['rim:Value'][0];
    }
}
//Detect DocumentEntry > practiceSettingCode
if (bodyExtrinsicObject['rim:Classification'][i]['$']['classificationScheme'] ==
documentEntryUUID.practiceSettingCode){
    prepXDSAtt.DocumentEntry.practiceSettingCode.displayName =
bodyExtrinsicObject['rim:Classification'][i]['rim:Name'][0]['rim:LocalizedString'][0]['$']['value'];
    if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['$']['name'] ==
'codingScheme'){
        prepXDSAtt.DocumentEntry.practiceSettingCode.codingScheme =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['rim:ValueList'][0]['rim:Value'][0];
    }
}

```

```
//Detect DocumentEntry > eventCode
if (bodyExtrinsicObject['rim:Classification'][i]['$']['classificationScheme'] ==
documentEntryUUID.eventCodeList){
    prepXDSAtt.DocumentEntry.eventCodeList.push({
        codingScheme: 'N/A',
        displayName: 'N/A'
    });
    prepXDSAtt.DocumentEntry.eventCodeList[eventCodeListCount].displayName =
bodyExtrinsicObject['rim:Classification'][i]['rim:Name'][0]['rim:LocalizedString'][0]['$']['value'];
    if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['$']['name'] ==
'codingScheme'){
        prepXDSAtt.DocumentEntry.eventCodeList[eventCodeListCount].codingScheme =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['rim:ValueList'][0]['rim:Value'][0];
    }
    eventCodeListCount++;
}
//Detect DocumentEntry > TypeCode
if (bodyExtrinsicObject['rim:Classification'][i]['$']['classificationScheme'] ==
documentEntryUUID.typeCode){
    prepXDSAtt.DocumentEntry.typeCode.displayName =
bodyExtrinsicObject['rim:Classification'][i]['rim:Name'][0]['rim:LocalizedString'][0]['$']['value'];
    if (bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['$']['name'] ==
'codingScheme'){
        prepXDSAtt.DocumentEntry.typeCode.codingScheme =
bodyExtrinsicObject['rim:Classification'][i]['rim:Slot'][0]['rim:ValueList'][0]['rim:Value'][0];
    }
}
//Scanning object within DocumentEntry "Descriptor" which usually be "comment"
for (var i = 0; i < bodyExtrinsicObject['rim:Description'].length; i++){
    prepXDSAtt.DocumentEntry.comment = bodyExtrinsicObject['rim:Description'][i];
}

for (var i = 0; i < bodyExtrinsicObject['rim:Name'].length; i++){
    prepXDSAtt.DocumentEntry.title =
bodyExtrinsicObject['rim:Name'][i]['rim:LocalizedString'][0]['$']['value'];
}
```

```

//Scanning object within DocumentEntry "ExternalIdentifier"
for (var i = 0; i < bodyExtrinsicObject['rim:ExternalIdentifier'].length; i++){
    //Detect DocumentEntry > patientId
    if (bodyExtrinsicObject['rim:ExternalIdentifier'][i]['$']['identificationScheme'] ==
documentEntryUUID.patientId){
        prepXDSAtt.DocumentEntry.patientId =
(bodyExtrinsicObject['rim:ExternalIdentifier'][i]['$']['value']);
    }
    if (bodyExtrinsicObject['rim:ExternalIdentifier'][i]['$']['identificationScheme'] ==
documentEntryUUID.uniqueId){
        prepXDSAtt.DocumentEntry.uniqueId =
(bodyExtrinsicObject['rim:ExternalIdentifier'][i]['$']['value']);
    }
}
//Scannig object within DocumentEntry "Slot"
for (var i = 0; i < bodyExtrinsicObject['rim:Slot'].length; i++){
    if (bodyExtrinsicObject['rim:Slot'][i]['$']['name'] == 'size'){
        prepXDSAtt.DocumentEntry.size =
bodyExtrinsicObject['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'][0];
    }
    if (bodyExtrinsicObject['rim:Slot'][i]['$']['name'] == 'repositoryUniqueId'){
        prepXDSAtt.DocumentEntry.repositoryUniqueId =
bodyExtrinsicObject['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'][0];
    }
    if (bodyExtrinsicObject['rim:Slot'][i]['$']['name'] == 'hash'){
        prepXDSAtt.DocumentEntry.hash =
bodyExtrinsicObject['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'][0];
    }
    if (bodyExtrinsicObject['rim:Slot'][i]['$']['name'] == 'creationTime'){
        prepXDSAtt.DocumentEntry.creationTime =
bodyExtrinsicObject['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'][0];
    }
    if (bodyExtrinsicObject['rim:Slot'][i]['$']['name'] == 'languageCode'){
        prepXDSAtt.DocumentEntry.languageCode =
bodyExtrinsicObject['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'][0];
    }
    if (bodyExtrinsicObject['rim:Slot'][i]['$']['name'] == 'serviceStartTime'){
        prepXDSAtt.DocumentEntry.serviceStartTime =
bodyExtrinsicObject['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'][0];
    }
    if (bodyExtrinsicObject['rim:Slot'][i]['$']['name'] == 'serviceStopTime'){
        prepXDSAtt.DocumentEntry.serviceStopTime =
bodyExtrinsicObject['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'][0];
    }
}

```

```

        if (bodyExtrinsicObject['rim:Slot'][i]['$']['name'] == 'sourcePatientId'){
            prepXDSAtt.DocumentEntry.sourcePatientId =
bodyExtrinsicObject['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'][0];
        }
        if (bodyExtrinsicObject['rim:Slot'][i]['$']['name'] == 'sourcePatientInfo'){
            var plaintext = bodyExtrinsicObject['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'];
            var encryptedString = cryptr.encrypt(plaintext);
            prepXDSAtt.DocumentEntry.sourcePatientInfo = 'Anonymized';
            //Also replace the attributes within full XDSAAttributes object with encrypted attribute

            rXDSAtribut['soapenv:Envelope']['soapenv:Body'][0]['lcm:SubmitObjectsRequest'][0]['rim:Regi
stryObjectList'][0]['rim:ExtrinsicObject'][0]['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'] = encryptedString;
        }
    }

    if (bodyRegistryPackage){
        for (var i = 0; i < bodyRegistryPackage['rim:Classification'].length; i++){
            if (bodyRegistryPackage['rim:Classification'][i]['$']['classificationScheme'] ==
submissionSetUUID.author){
                if (i != 0) { //If there are more than one author for the Doc, add more author object into
array
                    prepXDSAtt.SubmissionSet.author.push({
                        authorPerson: 'N/A',
                        authorInstitution: [],
                        authorRole: 'N/A',
                        authorSpecialty: 'N/A'
                    });
                }
                //Assign each element of the author
                for (var j = 0; j < bodyRegistryPackage['rim:Classification'][i]['rim:Slot'].length; j++){
                    if (bodyRegistryPackage['rim:Classification'][i]['rim:Slot'][j]['$']['name'] ==
'authorPerson'){
                        prepXDSAtt.SubmissionSet.author[i].authorPerson =
bodyRegistryPackage['rim:Classification'][i]['rim:Slot'][j]['rim:ValueList'][0]['rim:Value'][0];
                    }

                    if (bodyRegistryPackage['rim:Classification'][i]['rim:Slot'][j]['$']['name'] ==
'authorInstitution'){
                        prepXDSAtt.SubmissionSet.author[i].authorInstitution =
bodyRegistryPackage['rim:Classification'][i]['rim:Slot'][j]['rim:ValueList'][0]['rim:Value'];
                    }
                }
            }
        }
    }
}

```

```

        if (bodyRegistryPackage['rim:Classification'][i]['rim:Slot'][j]['$']['name'] ==
'authorRole'){
            prepXDSAtt.SubmissionSet.author[i].authorRole =
bodyRegistryPackage['rim:Classification'][i]['rim:Slot'][j]['rim:ValueList'][0]['rim:Value'][0];
        }
        if (bodyRegistryPackage['rim:Classification'][i]['rim:Slot'][j]['$']['name'] ==
'authorSpecialty'){
            prepXDSAtt.SubmissionSet.author[i].authorSpecialty =
bodyRegistryPackage['rim:Classification'][i]['rim:Slot'][j]['rim:ValueList'][0]['rim:Value'][0];
        }
    }

    if (bodyRegistryPackage['rim:Classification'][i]['$']['classificationScheme'] ==
submissionSetUUID.contentTypeCodes){
        prepXDSAtt.SubmissionSet.contentTypeCodes.displayName =
bodyRegistryPackage['rim:Classification'][i]['rim:Name'][0]['rim:LocalizedString'][0]['$']['value'];
        if (bodyRegistryPackage['rim:Classification'][i]['rim:Slot'][0]['$']['name'] ==
'codingScheme'){
            prepXDSAtt.SubmissionSet.contentTypeCodes.codingScheme =
bodyRegistryPackage['rim:Classification'][i]['rim:Slot'][0]['rim:ValueList'][0]['rim:Value'][0];
        }
    }

    for (var i = 0; i < bodyRegistryPackage['rim:Description'].length; i++){
        prepXDSAtt.SubmissionSet.comment =
bodyRegistryPackage['rim:Description'][i]['rim:LocalizedString'][0]['$']['value'];
    }

    for (var i = 0; i < bodyRegistryPackage['rim:Name'].length; i++){
        prepXDSAtt.SubmissionSet.title =
bodyRegistryPackage['rim:Name'][i]['rim:LocalizedString'][0]['$']['value'];
    }

    for (var i = 0; i < bodyRegistryPackage['rim:ExternalIdentifier'].length; i++){
        if (bodyRegistryPackage['rim:ExternalIdentifier'][i]['$']['identificationScheme'] ==
submissionSetUUID.uniqueId){
            prepXDSAtt.SubmissionSet.uniqueId =
bodyRegistryPackage['rim:ExternalIdentifier'][i]['$']['value'];
        }
        if (bodyRegistryPackage['rim:ExternalIdentifier'][i]['$']['identificationScheme'] ==
submissionSetUUID.sourceId){
            prepXDSAtt.SubmissionSet.sourceId =
bodyRegistryPackage['rim:ExternalIdentifier'][i]['$']['value'];
        }
    }
}

```

```
        if (bodyRegistryPackage['rim:ExternalIdentifier'][i]['$']['identificationScheme'] ==  
submissionSetUUID.patientId){  
            prepXDSAtt.SubmissionSet.patientId =  
bodyRegistryPackage['rim:ExternalIdentifier'][i]['$']['value'];  
        }  
    }  
  
    for (var i = 0; i < bodyRegistryPackage['rim:Slot'].length; i++){  
        if (bodyRegistryPackage['rim:Slot'][i]['$']['name'] == 'submissionTime'){  
            prepXDSAtt.SubmissionSet.submissionTime =  
bodyRegistryPackage['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'][0];  
        }  
    }  
    console.log('-----');  
    console.log(prepXDSAtt);  
    //fs.writeFileSync("extractedObject", util.inspect(prepXDSAtt));  
    myCallback(prepXDSAtt, rXDSAtribut);  
}  
  
assignAll(inputAttributes, invokeContract);  
}
```

Figure 4-38 XDS Document Registry Actor

This section interprets and assort Metadata attribute value from ITI-42 to JSON

```
//-----Smartcontract interact function
async function invokeContract(XDSMETADATAAttributes, rawXDSAttr){
    //web3.eth.defaultAccount = web3.eth.personal.getAccounts().then(console.log);
    let acc = await web3.eth.personal.getAccounts();
    if (acc.err) {console.log(acc.err);}
    else {console.log('Accounts available on this node:\n' + acc);}

    console.log('-----');
    var deployerAccount = acc[0];
    console.log('Deploying with account:' + deployerAccount);
    var abi =
    [
        {
            "inputs": [],
            "name": "checkLastID",
            "outputs": [
                {
                    "internalType": "uint256",
                    "name": "",
                    "type": "uint256"
                }
            ],
            "stateMutability": "view",
            "type": "function"
        },
        {
            "inputs": [
                {
                    "internalType": "uint256",
                    "name": "Docid",
                    "type": "uint256"
                }
            ],
            "name": "retreiveFull",
            "outputs": [
                {
                    "internalType": "string",
                    "name": "",
                    "type": "string"
                }
            ],
            "stateMutability": "view",
            "type": "function"
        }
    ],
    XDSMETADATAAttributes,
    rawXDSAttr
}
```

```
{  
    "inputs": [  
        {  
            "internalType": "uint256",  
            "name": "Docid",  
            "type": "uint256"  
        }  
    ],  
    "name": "retreiveSearch",  
    "outputs": [  
        {  
            "internalType": "string",  
            "name": "",  
            "type": "string"  
        }  
    ],  
    "stateMutability": "view",  
    "type": "function"  
},  
{  
    "inputs": [  
        {  
            "internalType": "uint256",  
            "name": "Docid",  
            "type": "uint256"  
        },  
        {  
            "internalType": "string",  
            "name": "searchJSON",  
            "type": "string"  
        },  
        {  
            "internalType": "string",  
            "name": "fullJSON",  
            "type": "string"  
        }  
    ],  
    "name": "store",  
    "outputs": [],  
    "stateMutability": "nonpayable",  
    "type": "function"  
}  
];  
  
var contractAddress = require('./contractAddress.js');  
console.log('Contract Address: ' + contractAddress);
```

```
var myContract = new web3.eth.Contract(abi, contractAddress, {  
    from: deployerAccount,  
    gas: 30000000  
});  
  
var Docid = 0;  
var inputSearch = JSON.stringify(XDSMETADATAAttributes);  
var inputFull = JSON.stringify(rawXDSAttr);  
  
myContract.methods.store(Docid, inputSearch, inputFull).send({  
    from: deployerAccount  
}).then(function(receipt){  
    console.log(receipt);  
    console.log('=====\\nTransaction success...');  
    hrend = process.hrtime(hrstart);  
    console.info('Execution time (hr): %ds %dms', hrend[0], hrend[1] / 1000000);  
    console.log('=====');  
});  
}
```

Figure 4-39 XDS Document Registry Actor

This section passes JSON into Smart Contract as single string variable

4.2.3.1.2 Smartcontract

In the implementation, Smartcontract was designed to store string values and will return the stored value when called by the corresponding Smartcontract function. The prepared JSON must be converted into a string variable before entering Smartcontract. This is due to the limit of the Ethereum Smartcontract which can cover a limited number of programming variables so, we simplify our program to avoid that limit by storing the whole JSON in string form as a single variable. As the Ethereum Blockchain requires a certain amount of gas to execute the Smartcontract, the length of the variable may cause an error in the process if there was not enough gas supplied. That means, we need to increase the limit amount of gas for executing Smartcontract from the default value as shown in Figure 4-40. Although this change may not affect the implementation, it may affect the network where its member prefers to use actual cryptocurrency like Ether to maintain Blockchain where an increase in required gas may accelerate the depletion of currency circulating in the network and severely reduce the maintainability of the Blockchain. Figure 4-41 showing the process flow of Smartcontract function related to Document Registering.

```
var myContract = new web3.eth.Contract(abi, contractAddress, {
  from: deployerAccount,
  gas: 3000000
});
```

Figure 4-40 Specified gas value applying Ethereum Smartcontract execution

```
var DocumentRegistering_Into_Blockchain() {
  var lastID = Invoke_CheckLastID_SmartcontractFunction();
  var NewID = lastID + 1;
  Invoke_DocumentRegister_SmartcontractFunction(NewID);
  var registerStatus
  if (not Error) {
    registerStatus = "Success";
  }
  return registerStatus;
}
```

Figure 4-41 The pseudocode showing the process flow of Document Register Smartcontract

By these Smartcontract design, XDS Document Registry actors can keep Metadata attributes of each document by storing them as JSON string variable inside Blockchain using one Smartcontract per document. At the same time, the actor can perform search operation by sequentially call upon each published Smartcontract one-by-one until the result was found or until the last in the case which no matching result. It must be noted that publishing of Smartcontract always requires gas to execute the task while calling for the variable value stored in the Smartcontract is not consuming any Blockchain resource. Figure 4-42 showing the Solidity code snippet highlighting (green color) the part relating to Document Registering Function.

```

pragma solidity >=0.4.22 <0.7.0; // SPDX-License-Identifier: UNLICENSED

contract Storage {

    struct Document_Registry {
        string searchAttributes; // Storing META-Data Attributes for search operation
        string fullAttributes; // Storing META-Data Attributes for return result
    }
    uint DocID = 0; // This variable is for selecting Document ID, always reset to 0
    uint lastDoc; // This variable keep track for the latest Document ID being used
    mapping (uint => Document_Registry) docreg;
    // Assign variable "documentregist" to map value of struct Document_Registry
    // Constructor Document_Registry store JSON string for search and for return as full response

    // Store string JSON
    function store(uint Docid, string memory searchJSON, string memory fullJSON) public {
        if (Docid > 0){
            DocID = Docid; // If Docid was specified (not 0) replacing string JSON of existing Docid
            // This probably require some kind of authentication
        }
        else{
            lastDoc++; // If Docid was not specified, create new ID
            DocID = lastDoc;
        }
        docreg[DocID].searchAttributes = searchJSON;
        docreg[DocID].fullAttributes = fullJSON;
    }

    // Check the lastest ID being used
    function checkLastID() public view returns (uint) {
        return lastDoc;
    }

    // Call for string JSON for Search Program
    function retrieveSearch(uint Docid) public view returns (string memory) {
        return docreg[Docid].searchAttributes;
    }

    // Call for string JSON for Result Return Program
    function retrieveFull(uint Docid) public view returns (string memory) {
        return docreg[Docid].fullAttributes;
    }
}

```

Figure 4-42 Solidity Code Snippet of Smart Contract
(Highlight - green color) related to Document Registering Function

4.2.3.2 Implementing Document Search Function

4.2.3.2.1 Native-Side Javascript Program

Like IHE ITI-42 transaction handling, the XDS Document Registry actors also wait for ITI-18 on the TCP channel. The received transaction will be converted into JSON while matching UUID with its corresponding metadata attributes as declared in Figure 4-43. The transaction is specified with the header “QueryResponse” and compose of Metadata attributes value input by Document Consumer. These values will be used in search operation which will seek for the Smartcontract with matching metadata attribute values. After the result was found, the actor then proceeds to create a response XML message following the ITI-18 format. Figure 4-44 showing the pseudocode describing the process flow for the native-side Javascript program related to Document Search. Figure 4-45 to Figure 4-49 show the Javascript code snippet for native-side of XDS Document Registry handling ITI-18 transaction and Document Search function.

```
//DocumentQuery=====
function documentQuery (inputAttributes) {
    var requestUUID = {
        FindDocuments: 'urn:uuid:14d4debf-8f97-4251-9a74-a90016b0af0d',
        FindSubmissionSets: 'urn:uuid:f26abbcb-ac74-4422-8a30-edb644bbc1a9',
        FindFolders: 'urn:uuid:958f3006-baad-4929-a4de-ff1114824431',
        GetAll: 'urn:uuid:10b545ea-725c-446d-9b95-8aeb444edd93',
        GetDocuments: 'urn:uuid:5c4f972b-d56b-40ac-a5fc-c8ca9b40b9d4',
        GetFolders: 'urn:uuid:5737b14c-8a1a-4539-b659-e03a34a5e1e4',
        GetAssociations: 'urn:uuid:a7ae438b-4bc2-4642-93e9-be891f7bb155',
        GetDocumentsAndAssociations: 'urn:uuid:bab9529a-4a10-40b3-a01f-f68a615d247a',
        GetSubmissionSets: 'urn:uuid:51224314-5390-4169-9b91-b1980040715a',
        GetSubmissionSetAndContents: 'urn:uuid:e8e3cb2c-e39c-46b9-99e4-c12f57260b83',
        GetFolderAndContents: 'urn:uuid:b909a503-523d-4517-8acf-8e5834dfc4c7',
        GetFoldersForDocument: 'urn:uuid:10cae35a-c7f9-4cf5-b61e-fc3278ffb578',
        GetRelatedDocuments: 'urn:uuid:d90e5407-b356-4d91-a89f-873917b4b0e6',
        FindDocumentsByReferenceId: 'urn:uuid:12941a89-e02e-4be5-967c-ce4bfc8fe492'
    }
}
```

Figure 4-43 XDS Document Registry Actor

Define variable of query request type UUID label following IHE ITI Framework

```
var Received_ITI_18(XMLMessage){
    var JSON_attributes = InterpretXMLtoJSON(XMLMessage);
    var Assorte_JSON = AssortMetadataAttributes(JSON_attributes);
    var SearchKeywords = SortInto_SearchKeywordsFormat(Assorted_JSON);
    return SearchKeywords;
}
```

Figure 4-44 The process flow for the native-side Javascript program

related Document Search Function

```

function specifyRequestType (requestedJSON, myCallback) {
    //Specify responseOption
    console.log('Specify responseOption');
    var responseOption = '';
    if
(requestedJSON['query:AdhocQueryRequest'][0]['query:ResponseOption'][0]['$']['returnComposedObjects']
] == 'true'){
    console.log('returnComposedObjects = true');
    if (requestedJSON['query:AdhocQueryRequest'][0]['query:ResponseOption'][0]['$']['returnType']
== 'LeafClass') {
        responseOption = 'LeafClass';
        console.log('Request response as ' + responseOption + '...');
    }
    else if
(requestedJSON['query:AdhocQueryRequest'][0]['query:ResponseOption'][0]['$']['returnType'] ==
'ObjectRef'){
        responseOption = 'ObjectRef';
        console.log('Request response as ObjectRef...');

    }
}
//Specify queryType -> revert UUID to human understandable word
console.log(requestedJSON['query:AdhocQueryRequest'][0]['rim:AdhocQuery'][0]['$']['id']);
for (i = 0; i < Object.entries(requestUUID).length; i++){ //Cycle through requestUUID object to
check request types
    if (requestedJSON['query:AdhocQueryRequest'][0]['rim:AdhocQuery'][0]['$']['id'] ==
Object.entries(requestUUID)[i][1]){
        var requestType = Object.keys(requestUUID)[i];
        console.log('Query Type: ' + requestType);
    }
}
//Define search keyword array to meet specification of each request type
var searchKeyword = [];
if (requestType == 'FindDocuments'){
    var rimSlot = requestedJSON['query:AdhocQueryRequest'][0]['rim:AdhocQuery'][0]['rim:Slot'];
    console.log(util.inspect(rimSlot));
    for (i = 0; i < rimSlot.length; i++){ //Assign attributes in rim:Slot to search keyword array
        if (rimSlot[i]['$']['name'] == '$XDSDocumentEntryPatientId'){
            searchKeyword.push(['DocumentEntry', 'patientId',
rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]]);
        }
        else if (rimSlot[i]['$']['name'] == '$XDSDocumentEntryClassCode'){
            searchKeyword.push(['DocumentEntry', ['classCode', 'displayName'],
rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]]);
        }
        else if (rimSlot[i]['$']['name'] == '$XDSDocumentEntryTypeCode'){
            searchKeyword.push(['DocumentEntry', ['typeCode', 'displayName'],
rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]]);
        }
    }
}

```

```

else if (rimSlot[i]['$']['name'] == '$XDSDocumentEntryPracticeSettingCode'){
    searchKeyword.push(['DocumentEntry', 'practiceSettingCode', 'displayName'],
    rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]);
}
else if (rimSlot[i]['$']['name'] == '$XDSDocumentEntryCreationTimeFrom'){
    searchKeyword.push(['DocumentEntry', 'creationTime', 'From'],
    rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]);
}
else if (rimSlot[i]['$']['name'] == '$XDSDocumentEntryCreationTimeTo'){
    searchKeyword.push(['DocumentEntry', 'creationTime', 'To'],
    rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]);
}
else if (rimSlot[i]['$']['name'] == '$XDSDocumentEntryServiceStartTimeFrom'){
    searchKeyword.push(['DocumentEntry', 'serviceStartTime', 'From'],
    rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]);
}
else if (rimSlot[i]['$']['name'] == '$XDSDocumentEntryServiceStartTimeTo'){
    searchKeyword.push(['DocumentEntry', 'serviceStartTime', 'To'],
    rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]);
}
else if (rimSlot[i]['$']['name'] == '$XDSDocumentEntryServiceStopTimeFrom'){
    searchKeyword.push(['DocumentEntry', 'serviceStopTime', 'From'],
    rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]);
}
else if (rimSlot[i]['$']['name'] == '$XDSDocumentEntryServiceStopTimeTo'){
    searchKeyword.push(['DocumentEntry', 'serviceStopTime', 'To'],
    rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]);
}
else if (rimSlot[i]['$']['name'] == '$XDSDocumentEntryHealthcareFacilityTypeCode'){
    searchKeyword.push(['DocumentEntry', 'healthcareFacilityTypeCode', 'displayName'],
    rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]);
}
else if (rimSlot[i]['$']['name'] == '$XDSDocumentEntryEventCodeList'){
    searchKeyword.push(['DocumentEntry', 'eventCodeList'],
    rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]);
}
else if (rimSlot[i]['$']['name'] == '$XDSDocumentEntryConfidentialityCode'){
    searchKeyword.push(['DocumentEntry', 'confidentialityCode', 'displayName'],
    rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]);
}
else if (rimSlot[i]['$']['name'] == '$XDSDocumentEntryAuthorPerson'){
    searchKeyword.push(['DocumentEntry', 'author', 'authorPerson'],
    rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]);
}
else if (rimSlot[i]['$']['name'] == '$XDSDocumentEntryFormatCode'){
    searchKeyword.push(['DocumentEntry', 'formatCode', 'displayName'],
    rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]); }

```

```

        else if (rimSlot[i]['$']['name'] == '$XDSDocumentEntryStatus'){
            searchKeyword.push(['DocumentEntry', 'availabilityStatus',
                rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]]);
        }
        else if (rimSlot[i]['$']['name'] == '$XDSDocumentEntryType'){
            searchKeyword.push(['DocumentEntry', 'objectType',
                rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]]);
        } }
        else if (requestType == 'FindSubmissionSets'){ //Need to add case in DocSearch***
            var rimSlot =
requestedJSON['query:AdhocQueryRequest']['rim:AdhocQuery'][0]['rim:Slot'];
            console.log(util.inspect(rimSlot));
            for (i = 0; i < rimSlot.length; i++){
                if (rimSlot[i]['$']['name'] == '$XDSSubmissionSetPatientId'){
                    searchKeyword.push(['SubmissionSet', 'patientId',
                        rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]]);
                }
                else if (rimSlot[i]['$']['name'] == '$XDSSubmissionSetSourceId'){
                    searchKeyword.push(['SubmissionSet', 'sourceId',
                        rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]]);
                }
                else if (rimSlot[i]['$']['name'] == '$XDSSubmissionSetSubmissionTimeFrom'){ //***
                    searchKeyword.push(['SubmissionSet', 'submissionTime', 'From'],
                        rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]);
                }
                else if (rimSlot[i]['$']['name'] == '$XDSSubmissionSetSubmissionTimeTo'){ //***
                    searchKeyword.push(['SubmissionSet', 'submissionTime', 'To'],
                        rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]);
                }
                else if (rimSlot[i]['$']['name'] == '$XDSSubmissionSetAuthorPerson'){ //***
                    searchKeyword.push(['SubmissionSet', 'author', 'authorPerson'],
                        rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]));
                }
                else if (rimSlot[i]['$']['name'] == '$XDSSubmissionSetContentType'){
                    searchKeyword.push(['SubmissionSet', 'contentTypeCodes', 'displayName'],
                        rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]);
                }
                else if (rimSlot[i]['$']['name'] == '$XDSSubmissionSetStatus'){
                    searchKeyword.push(['SubmissionSet', 'availabilityStatus',
                        rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]]);
                }
            }
        }
        else if (requestType == 'FindFolders'){
            var rimSlot =
requestedJSON['query:AdhocQueryRequest']['rim:AdhocQuery'][0]['rim:Slot'];
            console.log(util.inspect(rimSlot));
        }
    }
}

```

```

        for (i = 0; i < rimSlot.length; i++){
            if (rimSlot[i]['$']['name'] == '$XDSFolderPatientId'){
                searchKeyword.push(['Folder', 'patientId',
                    rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]]);
            }
            else if (rimSlot[i]['$']['name'] == '$XDSFolderLastUpdateTimeFrom'){ //***
                searchKeyword.push(['Folder', ['lastUpdateTime', 'From'],
                    rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]]);
            }
            else if (rimSlot[i]['$']['name'] == '$XDSFolderLastUpdateTimeTo'){ //***
                searchKeyword.push(['Folder', ['lastUpdateTime', 'To'],
                    rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]]);
            }
            else if (rimSlot[i]['$']['name'] == '$XDSFolderCodeList'){ //***
                searchKeyword.push(['Folder', 'codeList',
                    rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]]);
            }
            else if (rimSlot[i]['$']['name'] == '$XDSFolderStatus'){
                searchKeyword.push(['Folder', 'availabilityStatus',
                    rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]]);
            }
        }
    }
    else if (requestType == 'GetAll'){
        var rimSlot =
requestedJSON['query:AdhocQueryRequest']['rim:AdhocQuery'][0]['rim:Slot'];
        console.log(util.inspect(rimSlot));
        for (i = 0; i < rimSlot.length; i++){
            if (rimSlot[i]['$']['name'] == '$patientId'){
                searchKeyword.push(['DocumentEntry', 'patientId',
                    rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]]);
                searchKeyword.push(['SubmissionSet', 'patientId',
                    rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]]);
                searchKeyword.push(['Folder', 'patientId',
                    rimSlot[i]['rim:ValueList'][0]['rim:Value'][0]]);
            }
        }
        searchKeyword.push([requestType, responseOption]);
        console.log(searchKeyword);
        myCallback(searchKeyword, invokeContract);
    }
    specifyRequestType(inputAttributes, checkLastID);
}

```

Figure 4-45 XDS Document Registry Actor

Identify query request type following received ITI-18 header and assort search keyword

```
async function checkLastID (sK, myCallback) {
    //web3.eth.defaultAccount = web3.eth.personal.getAccounts().then(console.log);
    console.log('Checking for latest ID...');

    let acc = await web3.eth.personal.getAccounts();
    if (acc.err) {console.log(acc.err);}
    else {console.log('Accounts available on this node:\n' + acc);}

    var deployerAccount = acc[0];
    console.log('Originally deployed with account:' + deployerAccount);
    var abi =
    [
        {
            "inputs": [],
            "name": "checkLastID",
            "outputs": [
                {
                    "internalType": "uint256",
                    "name": "",
                    "type": "uint256"
                }
            ],
            "stateMutability": "view",
            "type": "function"
        },
        {
            "inputs": [
                {
                    "internalType": "uint256",
                    "name": "Docid",
                    "type": "uint256"
                }
            ],
            "name": "retreiveFull",
            "outputs": [
                {
                    "internalType": "string",
                    "name": "",
                    "type": "string"
                }
            ],
            "stateMutability": "view",
            "type": "function"
        }
    ];
}
```

```
{  
  "inputs": [  
    {  
      "internalType": "uint256",  
      "name": "Docid",  
      "type": "uint256"  
    }  
  ],  
  "name": "retreiveSearch",  
  "outputs": [  
    {  
      "internalType": "string",  
      "name": "",  
      "type": "string"  
    }  
  ],  
  "stateMutability": "view",  
  "type": "function"  
},  
{  
  "inputs": [  
    {  
      "internalType": "uint256",  
      "name": "Docid",  
      "type": "uint256"  
    },  
    {  
      "internalType": "string",  
      "name": "searchJSON",  
      "type": "string"  
    },  
    {  
      "internalType": "string",  
      "name": "fullJSON",  
      "type": "string"  
    }  
  ],  
  "name": "store",  
  "outputs": [],  
  "stateMutability": "nonpayable",  
  "type": "function"  
}  
];  
  
var contractAddress = require('./contractAddress.js');  
console.log('Contract Address: ' + contractAddress);
```

```
var myContract = new web3.eth.Contract(abi, contractAddress, {  
    from: deployerAccount,  
    gas: 30000000  
});  
  
console.log('Calling contract...');  
myContract.methods.checkLastID().call({  
    from: deployerAccount  
}, (err,res) => {  
    if (err) {  
        console.log(err);  
    }else{  
        console.log('Found, the lastest document ID is ' + res);  
        console.log('-----');  
        myCallback(sK, res, matchMaker);  
    }  
});  
}
```

Figure 4-46 XDS Document Registry Actor

Check for the latest document ID published in Blockchain before beginning search operation

```
//Invoke each contract for keyword search
async function invokeContract(sK, maxDoc, myCallback){
    //web3.eth.defaultAccount = web3.eth.personal.getAccounts().then(console.log);
    console.log('Search keywords received...\nMoving on to search function...');

    let acc = await web3.eth.personal.getAccounts();
    if (acc.err) {console.log(acc.err);}
    else {console.log('Accounts available on this node:\n' + acc);}

    var deployerAccount = acc[0];
    console.log('Originally deployed with account:' + deployerAccount);
    var abi =
    [
        {
            "inputs": [],
            "name": "checkLastID",
            "outputs": [
                {
                    "internalType": "uint256",
                    "name": "",
                    "type": "uint256"
                }
            ],
            "stateMutability": "view",
            "type": "function"
        },
        {
            "inputs": [
                {
                    "internalType": "uint256",
                    "name": "Docid",
                    "type": "uint256"
                }
            ],
            "name": "retreiveFull",
            "outputs": [
                {
                    "internalType": "string",
                    "name": "",
                    "type": "string"
                }
            ],
            "stateMutability": "view",
            "type": "function"
        }
    ];
}
```

```
{
  "inputs": [
    {
      "internalType": "uint256",
      "name": "Docid",
      "type": "uint256"
    }
  ],
  "name": "retreiveSearch",
  "outputs": [
    {
      "internalType": "string",
      "name": "",
      "type": "string"
    }
  ],
  "stateMutability": "view",
  "type": "function"
},
{
  "inputs": [
    {
      "internalType": "uint256",
      "name": "Docid",
      "type": "uint256"
    },
    {
      "internalType": "string",
      "name": "searchJSON",
      "type": "string"
    },
    {
      "internalType": "string",
      "name": "fullJSON",
      "type": "string"
    }
  ],
  "name": "store",
  "outputs": [],
  "stateMutability": "nonpayable",
  "type": "function"
}
];

var contractAddress = require('./contractAddress.js');
console.log('Contract Address: ' + contractAddress);
```

```
var myContract = new web3.eth.Contract(abi, contractAddress, {  
    from: deployerAccount,  
    gas: 30000000  
});  
  
console.log('The latest document ID is no.: ' + maxDoc);  
//callRegSearch while run along Docid from 1 to latest (known using checkID)  
console.log('Begin contract search...');  
var traceDocid = 0;  
for (Docid = 1; Docid <= maxDoc; Docid++) {  
    traceDocid++;  
    myContract.methods.retreiveSearch(Docid).call({  
        from: deployerAccount  
    }, (err, res) => {  
        if (err) {  
            console.log(err);  
        } else {  
            var XDSattributes = JSON.parse(res);  
            myCallback(XDSattributes, sK, traceDocid, fullContract);  
        }  
    });  
}  
}
```

Figure 4-47 XDS Document Registry Actor
Begin search operation by sequentially check each published contract one-by-one

```

//Compare keyword with JSON called from smartcontract
function matchMaker (searchXDSAtt, sK, Docid, myCallback){
    //searchXDSAtt = XDS Object called from smartcontract
    //sK = search keyword received from ITI-18
    console.log('-----\nSmartcontract called...');

    var matchedCount = 0;
    var timeAttributes = {
        creationTime: {
            From: null,
            To: null
        },
        serviceStartTime: {
            From: null,
            To: null
        },
        serviceStopTime: {
            From: null,
            To: null
        }
    }

    for (i = 0; i < sK.length - 1; i++){
        var keyCount = i+1;
        if (Array.isArray(sK[i][1])){ //check if attributes have sub-attributes i.e. author, classCode, etc.
            if (sK[i][1][0] == 'author') { //author specific case
                if (searchXDSAtt[sK[i][0]][sK[i][1][0]][0][sK[i][1][1]] == sK[i][2]){
                    matchedCount++;
                    console.log('Keyword ' + keyCount + ' matched...');
                }
                else {
                    console.log('Keyword ' + keyCount + ' unmatched...');
                    break;
                }
            }
            else if (sK[i][1][0] == 'creationTime') {
                timeAttributes[sK[i][1][0]][sK[i][1][1]] = sK[i][2];
                if (timeAttributes[sK[i][1][0]]['From'] && timeAttributes[sK[i][1][0]]['To']){
                    var dateFrom = moment.utc(timeAttributes[sK[i][1][0]]['From'],
'YYYYMMDDHHmmss');
                    var dateTo = moment.utc(timeAttributes[sK[i][1][0]]['To'], 'YYYYMMDDHHmmss');
                    var dateTarget = moment.utc(searchXDSAtt[sK[i][0]][sK[i][1][0]],
'YYYYMMDDHHmmss');
                }
            }
        }
    }
}

```

```

        if (moment(dateTimeTarget).isBetween(dateTimeFrom, dateTimeTo, undefined, '[]')){
            matchedCount++; //match count 2 times due to the attributes require 2 search keywords
            matchedCount++;
            console.log(sK[i][1][0] + ' at Keyword ' + keyCount + ' matched...');
        }
    }
}
else if (sK[i][1][0] == 'serviceStartTime' || sK[i][1][0] == 'serviceStopTime') {
    if (searchXDSAtt[sK[i][0]][sK[i][1][0]] != 'N/A'){ //check if current Document have
        serviceTime attributes present
        timeAttributes[sK[i][1][0]][sK[i][1][1]] = sK[i][2];
        if (timeAttributes[sK[i][1][0]]['From'] && timeAttributes[sK[i][1][0]]['To']){
            var dateTimeFrom = moment.utc(timeAttributes[sK[i][1][0]]['From'],
'YYYYMMDDHHmmss');
            var dateTimeTo = moment.utc(timeAttributes[sK[i][1][0]]['To'], 'YYYYMMDDHHmmss');
            var dateTimeTarget = moment.utc(searchXDSAtt[sK[i][0]][sK[i][1][0]],
'YYYYMMDDHHmmss');
            if (moment(dateTimeTarget).isBetween(dateTimeFrom, dateTimeTo, undefined, '[]')){
                matchedCount++; //match count 2 times due to the attributes require 2 search
                keywords
                matchedCount++;
                console.log(sK[i][1][0] + ' at Keyword ' + keyCount + ' matched...');
            }
        }
    }
}
else {
    if (searchXDSAtt[sK[i][0]][sK[i][1][0]][sK[i][1][1]] == sK[i][2]){
        matchedCount++;
        console.log('Keyword ' + keyCount + ' matched...');
    }
    else {
        console.log('Keyword ' + keyCount + ' unmatched...');
        break;
    }
}
}
else {
    if (Array.isArray(sK[i][2])){
        if (searchXDSAtt[sK[i][0]][sK[i][1]][0] == sK[i][2][0]){
            matchedCount++;
            console.log('Keyword ' + keyCount + ' matched...');
        }
        else if (searchXDSAtt[sK[i][0]][sK[i][1]][0] != sK[i][2][0]) {
            console.log('Keyword ' + keyCount + ' unmatched...');
            break;
        }
    }
}

```

```

        else {
            if (searchXDSAtt[sK[i][0]][sK[i][1]] == sK[i][2]){
                matchedCount++;
                console.log('Keyword ' + keyCount + ' matched...');
            }
            else {
                console.log('Keyword ' + keyCount + ' unmatched...');
                break;
            }
        }
    }

    if (matchedCount == sK.length - 1){
        console.log('All matched, successfully... \nReturn document as search
result:\n=====');
        console.log(searchXDSAtt.DocumentEntry);
        console.log('=====');
        myCallback(Docid, sK, responseToUser);
    }
    else {
        console.log('Unmatched...');
    }
}

async function fullContract (Docid, sK, myCallback){
    //web3.eth.defaultAccount = web3.eth.personal.getAccounts().then(console.log);
    console.log('Calling for full document...');
    let acc = await web3.eth.personal.getAccounts();
    if (acc.err) {console.log(acc.err);}
    else {console.log('Accounts available on this node:\n' + acc);}

    var deployerAccount = acc[0];
    console.log('Originally deployed with account:' + deployerAccount);
    var abi =
    [
        {
            "inputs": [],
            "name": "checkLastID",
            "outputs": [
                {
                    "internalType": "uint256",
                    "name": "",
                    "type": "uint256"
                }
            ],
        }
    ];
}

```

```
"stateMutability": "view",
"type": "function"
},
{
"inputs": [
{
"internalType": "uint256",
"name": "Docid",
"type": "uint256"
}
],
"name": "retreiveFull",
"outputs": [
{
"internalType": "string",
"name": "",
"type": "string"
}
],
"stateMutability": "view",
"type": "function"
},
{
"inputs": [
{
"internalType": "uint256",
"name": "Docid",
"type": "uint256"
}
],
"name": "retreiveSearch",
"outputs": [
{
"internalType": "string",
"name": "",
"type": "string"
}
],
"stateMutability": "view",
"type": "function"
},
{
"inputs": [
{
"internalType": "uint256",
"name": "Docid",
"type": "uint256"
}
],
```

```
{
  "internalType": "string",
  "name": "searchJSON",
  "type": "string"
},
{
  "internalType": "string",
  "name": "fullJSON",
  "type": "string"
},
],
"name": "store",
"outputs": [],
"stateMutability": "nonpayable",
"type": "function"
};
};

var contractAddress = require('./contractAddress.js');
console.log('Contract Address: ' + contractAddress);

var myContract = new web3.eth.Contract(abi, contractAddress, {
  from: deployerAccount,
  gas: 30000000
});

console.log('Returning document: ' + Docid);
myContract.methods.retreiveFull(Docid).call({
  from: deployerAccount
}, (err,res) => {
  if (err) {
    console.log(err);
  } else {
    var XDSattributes = JSON.parse(res);
    myCallback(XDSattributes, sk);
  }
});
}
```

Figure 4-48 XDS Document Registry Actor

Check if value of Metadata attributes in each publish contract matched with search keyword before summarize search result.

```

function responseToUser (rXDSattribute, sK) {
    //Define variable for shorter object accessing
    var sEnvelope = rXDSattribute['soapenv:Envelope'];
    //inside Envelope
    var s$ = sEnvelope['$'];
    var sBody = sEnvelope['soapenv:Body'][0];
    var sHeader = sEnvelope['soapenv:Header'][0];
    //inside Envelope>Header
    var wsaTo = sHeader['wsa:To'];
    var wsaMessageID = sHeader['wsaMessageID'];
    var wsaAction = sHeader['wsaAction'];
    //inside Envelope>Body
    var lcmSubmitObjectsRequest = sBody['lcm:SubmitObjectsRequest'][0];
    //inside Envelope>Body>lcm:SubmitObjectsRequest
    var bodyRegistryObjectList = lcmSubmitObjectsRequest['rim:RegistryObjectList'][0];
    //inside Envelope>Body>lcm:SubmitObjectsRequest>rim:RegistryObjectList
    var bodyExtrinsicObject = bodyRegistryObjectList['rim:ExtrinsicObject'][0];
    var bodyRegistryPackage = bodyRegistryObjectList['rim:RegistryPackage'][0];
    var bodyClassification = bodyRegistryObjectList['rim:Classification'][0];
    var bodyAssociation = bodyRegistryObjectList['rim:Association'][0];
    //Decrypt sourcePatientInfo -> So encryption just prevent those who look directly into
contract to read the attribute
    //Alternatively, this can be left encrypted while require Document Consumer to decrypt
by themselves
    for (var i = 0; i < bodyExtrinsicObject['rim:Slot'].length; i++) {
        if (bodyExtrinsicObject['rim:Slot'][i]['$']['name'] == 'sourcePatientInfo') {
            var encryptedString =
bodyExtrinsicObject['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'];
            var plaintext = cryptr.decrypt(encryptedString);
            //Also replace the attributes within full XDSAttributes object with encrypted attribute
            bodyExtrinsicObject['rim:Slot'][i]['rim:ValueList'][0]['rim:Value'] = plaintext.split(',');
        }
    }
    console.log('=====\\nReturn type: ' +
sK[sK.length-1] + '\\n=====');
    var responseJSON = {
        "query:AdhocQueryResponse": {
            "$": {
                "status": "Success",
                "xmlns:query": "urn:oasis:names:tc:ebxml-
repreg:xsd:query:3.0",
                "xmlns:rim": "urn:oasis:names:tc:ebxml-repreg:xsd:rim:3.0",
                "xmlns:xsi": "http://www.w3.org/2001/XMLSchema-instance",
                "xsi:schemaLocation": "urn:oasis:names:tc:ebxml-
repreg:xsd:query:3.0 ../../schema/ebRS/query.xsd"
            },
        }
    }
}

```

```
        {
          "rim:ExtrinsicObject": [bodyExtrinsicObject]
        }
      ]
    }
  }
  console.log(util.inspect(responseJSON));

  if (netServer && netSocket) {
    console.log('Responding query result:');
    var responseXML = builder.buildObject(responseJSON);
    //var regex = /\r?\n|\r/g;
    //var responseXML = responseXML.replace(regex,'');
    netSocket.write(responseXML);
    console.log('-----');
    console.log(responseXML);
  }
  console.log('=====\\nDone!');
  hrend = process.hrtime(hrstart);
  console.info('Execution time (hr): %ds %dms', hrend[0], hrend[1] / 1000000);
  console.log('=====');
}
```

Figure 4-49 XDS Document Registry

Gather search result and response back to Document Consumer Actor

4.2.3.2.2 Smartcontract

Like the Document Register function, the XDS Document Registry Actor must be able to respond to the Document Search query from the Document Consumer by returning the metadata attributes of the registered document matched with the query to the consumer. In a traditional database, this can be done by utilizing a query of a relational (SQL) database. However, for Blockchain, the structure of stored data is different from relational databases but similar to NoSQL. That means search operation will need to rely on a sequential search algorithm. The program will need to take a look at all published transactions one-by-one from the first until the result was found. Each transaction will require the program to call on smart-contract for reviewing the stored value before comparing it with the specified value used for search. When all of the values called from the Smartcontract are matched with the value specified for search, the value called will be marked as a search result which will be returned to XDS Document Consumer Actor via ITI-18 format. Figure 4-50 showing the pseudocode describing the process flow for the Smartcontract function related to Document Search. Figure 4-51 showing the Solidity code snippet highlighting (green color) the part relating to Document Search Function.

```
var DocumentSearch_Within_Blockchain(SearchKeywords) {
    var SearchResult;
    var lastID = Invoke_CheckLastID_SmartcontractFunction();
    for (i = 0; i < lastID; i++) {
        var StoredValue = Invoke_ReadStoredValue_SmartcontractFunction(i);
        if (SearchKeywords == StoredValue) {
            SearchResult = StoredValue;
        }
    }
    return SearchResult;
}
```

Figure 4-50 The pseudocode showing the process flow of Smartcontract function related to Document Search

```

pragma solidity >=0.4.22 <0.7.0; // SPDX-License-Identifier: UNLICENSED

contract Storage {

    struct Document_Registry {
        string searchAttributes; //Storing META-Data Attributes for search operation
        string fullAttributes; //Storing META-Data Attributes for return result
    }

    uint DocID = 0; //This variable is for selecting Document ID, always reset to 0
    uint lastDoc; //This variable keep track for the latest Document ID being used
    mapping (uint => Document_Registry) docreg;
    //Assign variable "documentregist" to map value of struct Document_Registry
    //Constructor Document_Registry store JSON string for search and for return as full response

    //Store string JSON
    function store(uint Docid, string memory searchJSON, string memory fullJSON) public {
        if (Docid > 0){
            DocID = Docid; //If Docid was specified (not 0) replacing string JSON of existing Docid
            //This probably require some kind of authentication
        }
        else{
            lastDoc++; //If Docid was not specified, create new ID
            DocID = lastDoc;
        }
        docreg[DocID].searchAttributes = searchJSON;
        docreg[DocID].fullAttributes = fullJSON;
    }

    //Check the lastest ID being used
    function checkLastID() public view returns (uint) {
        return lastDoc;
    }

    //Call for string JSON for Search Program
    function retreiveSearch(uint Docid) public view returns (string memory) {
        return docreg[Docid].searchAttributes;
    }

    //Call for string JSON for Result Return Program
    function retreiveFull(uint Docid) public view returns (string memory) {
        return docreg[Docid].fullAttributes;
    }
}

```

Figure 4-51 Solidity Code Snippet of Smartcontract
(Highlight - green color) related to Document Search Function

4.3 Implementation Result

As mentioned in Section 4.1.1, the environment of the test machine is running on Linux Ubuntu (64-bit) version 18.10 with 8 GB RAM and 100 GB storage dynamically shared from the host machine.

As mentioned in Section 4.1.3, the Blockchain network environment for the implementation will be demonstrated using the 7-Nodes Example Blockchain. That means there will be seven IBFT Blockchain nodes simulated within the environment of the test machine. The test sample will be monitored from node number one (which would later refer as “1st Node”).

To indicate that the implementation has the compatibility to operate with XDS Actors in a common XDS system, we created transaction samples based on the example provided by the IHE ITI framework. Transaction samples provided by the framework are including ITI-42 Register Document Set-b transaction, ITI-18 Registry Stored Query transaction and its corresponding response transaction. However, there is much more specification provided in the framework that far exceeds the element provided within the example so, there may consist of an element that differs from the transaction used in the actual system which may cause an error and need further adjustment in the actual deployment.

The main group of XDS Actors in the implementation are XDS Document Registry Actor, XDS Document Repository Actor, and XDS Document Consumer Actor as shown in Figure 4-52. All files corresponding to the implementation must be included within the directory that contains the 7-Node Examples as shown in Figure 4-52 in the bottom right window. As mentioned in Section 4.2.3 that the XDS Document Registry Actor is the actor that acts as the medium between the XDS system and the Blockchain network. At the same time, the main function and process triggered in the implementation including Document Register and Document Search (Document Query) are centered around the XDS Document Registry. The XDS Document Registry will always active and standby for incoming transactions as shown in Figure 4-52 top left terminal and Figure 4-53.

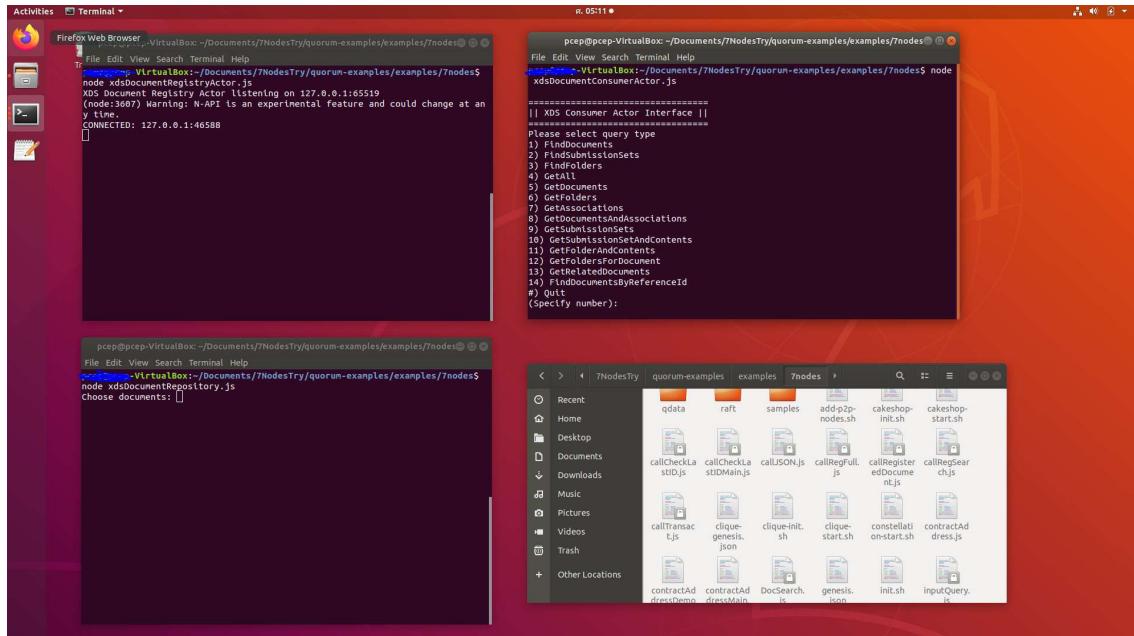


Figure 4-52 All XDS Actors activated via its terminal
 (Top Left) XDS Document Registry Actor
 (Top Right) XDS Document Consumer Actor
 (Bottom Left) XDS Document Repository Actor
 (Bottom Right) The folder containing all files related to the XDS Blockchain

```
node xdsDocumentRegistryActor.js
XDS Document Registry Actor listening on 127.0.0.1:65519
(node:3553) Warning: N-API is an experimental feature and could change at any time.
```

Figure 4-53 XDS Document Registry Actor standby and wait for incoming XML Messages.

As mentioned in Section 4.2.1 that the XDS Document Repository Actor is the actor that triggers the Document Register function registering new health document metadata attributes set into the Blockchain ledger. The Document Register function is triggered once the XDS Document Repository Actor program was called to register new health document metadata set into the XDS Affinity Domain network as shown in Figure 4-54 and Figure 4-55. The XDS Document Registry Actor then received the Document Register transaction and proceeds to broadcast the transaction into the Blockchain network publishing the transaction into the Blockchain ledger through a Block validation process as shown in Figure 4-56. After the transaction was successfully published into the Blockchain ledger, the XDS Document Registry Actor response back to the Document Repository Actor to report that the process was completed as shown in Figure 4-57 which terminating the XDS Document Repository Actor program.


```
=====
Respond received: ACK from 127.0.0.1
Execution time (hr): 0s 4.232416ms
=====
Connection closed
```

Figure 4-57 XDS Document Repository received response from XDS Document Registry
then terminate

As mentioned in Section 4.2.2 that the XDS Document Consumer Actor is the actor that triggers the Document Query function receiving user input search keyword values and asks the XDS Document Registry Actor to search for an existing registered document with the matching metadata attributes value as specified in the search keywords. Once called, the XDS Document Consumer Actor program will prompt the user for document query type (Figure 4-58) then prompt for essential search keyword values (Figure 4-59) and followed by the addition of optional search keyword values (Figure 4-60). After all search keyword values from the user were set, the XDS Document Consumer Actor program then proceeds to assort the input into the ITI-18 transaction format and send it to the XDS Document Registry Actor as shown in Figure 4-61. Upon receiving the transaction, the XDS Document Registry Actor program then uses the provided search keywords to search the Blockchain ledger for the metadata set with a matching value as shown in Figure 4-62 and Figure 4-63. Whether the matching result was found or not, after searching on all registered metadata set, the XDS Document Registry Actor then response search result to the XDS Document Consumer Actor as shown in Figure 4-64. The XDS Document Consumer Actor then interprets the response and displays the search result to the user as shown in Figure 4-65.

```
=====
|| XDS Consumer Actor Interface ||
=====

Please select query type
1) FindDocuments
2) FindSubmissionSets
3) FindFolders
4) GetAll
5) GetDocuments
6) GetFolders
7) GetAssociations
8) GetDocumentsAndAssociations
9) GetSubmissionSets
10) GetSubmissionSetAndContents
11) GetFolderAndContents
12) GetFoldersForDocument
13) GetRelatedDocuments
14) FindDocumentsByReferenceId
#) Quit
(Specify number): ■
```

Figure 4-58 XDS Document consumer Actor prompt the user for input

```
(Specify number): 1
Query Type: FindDocuments

Keywords require: XDSDocumentEntryPatientId
Value: IHEBLUE-2736^^^&1.3.6.1.4.1.27829.13.20.3000&ISO
Keywords require: XDSDocumentEntryStatus
Value: urn:oasis:names:tc:ebxml-regrep>StatusType:Approved■
```

Figure 4-59 XDS Document Consumer Actor prompt for essential search keyword values

```
=====
Query type: FindDocuments
Query keywords:
$XDSDocumentEntryPatientId = IHEBLUE-2736^^^&1.3.6.1.4.1.27829.13.20.3000&ISO
$XDSDocumentEntryStatus = urn:oasis:names:tc:ebxml-regrep>StatusType:Approved
=====
Available optional keywords:
0) No more optional keywords
1) XDSDocumentEntryClassCode
2) XDSDocumentEntryTypeCode
3) XDSDocumentEntryPracticeSettingCode
4) XDSDocumentEntryCreationTime
5) XDSDocumentEntryServiceStartTime
6) XDSDocumentEntryServiceStopTime
7) XDSDocumentEntryHealthcareFacilityTypeCode
8) XDSDocumentEntryEventCodeList
9) XDSDocumentEntryConfidentialityCode
10) XDSDocumentEntryAuthorPerson
11) XDSDocumentEntryFormatCode
12) XDSDocumentEntryType
#) Quit
Select keywords (specify number):
```

Figure 4-60 XDS Document Consumer Actor prompt for optional search keyword values

```
=====
All keywords set...
=====
Query type: FindDocuments
Query keywords:
$XDSDocumentEntryPatientId = IHEBLUE-2736^^^&1.3.6.1.4.1.21367.13.20.3000&am
p;ISO
$XDSDocumentEntryStatus = urn:oasis:names:tc:ebxml-regrep>StatusType:Approved
=====
CONNECTED TO: 127.0.0.1:65519
Query Sent...
Respond received: ACK from 127.0.0.1
Execution time (hr): 0s 10.777685ms
```

Figure 4-61 XDS Document Consumer Actor sent ITI-18 transaction

to XDS Document Registry and wait for response

```
Received data....
XML:
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<query:AdhocQueryRequest xmlns:query="urn:oasis:names:tc:ebxml-regrep:xsd:qu
ery:3.0" xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0" xmlns:rs="u
rn:oasis:names:tc:ebxml-regrep:xsd:rs:3.0" xmlns:xsi="http://www.w3.org/2001
/XMLSchema-instance" xsi:schemaLocation="urn:oasis:names:tc:ebxml-regrep:xsd
:query:3.0 ../../schema/ebRS/query.xsd">
  <query:ResponseOption returnComposedObjects="true" returnType="LeafClass"/>
  <rim:AdhocQuery id="urn:uuid:14d4debf-8f97-4251-9a74-a90016b0af0d">
    <rim:Slot name="$XDSDocumentEntryPatientId">
      <rim:ValueList>
        <rim:Value>IHEBLUE-2736^^^&1.3.6.1.4.1.21367.13.20.3000&am
p;ISO</rim:Value>
      </rim:ValueList>
    </rim:Slot>
    <rim:Slot name="$XDSDocumentEntryStatus">
      <rim:ValueList>
        <rim:Value>urn:oasis:names:tc:ebxml-regrep>StatusType:Approved</rim:
Value>
      </rim:ValueList>
    </rim:Slot>
  </rim:AdhocQuery>
</query:AdhocQueryRequest>

Converted to object:
-----
{ 'query:AdhocQueryRequest':
  { '$':
    { 'xmlns:query': 'urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0',
      'xmlns:rim': 'urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0',
      'xmlns:rs': 'urn:oasis:names:tc:ebxml-regrep:xsd:rs:3.0',
      'xmlns:xsi': 'http://www.w3.org/2001/XMLSchema-instance',
      'xsi:schemaLocation': 'urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0
../../../../schema/ebRS/query.xsd' },
    'query:ResponseOption': [ [Object] ],
    'rim:AdhocQuery': [ [Object] ] } }
```

Query requested...
Specify responseOption
returnComposedObjects = true
Request response as LeafClass...
urn:uuid:14d4debf-8f97-4251-9a74-a90016b0af0d
Query Type: FindDocuments
[{ '\$': { name: '\$XDSDocumentEntryPatientId' },
 'rim:ValueList': [[Object]] },
 { '\$': { name: '\$XDSDocumentEntryStatus' },
=====

Figure 4-62 XDS Document Registry received ITI-18 transaction then interpret the message


```

-----
Search keywords received...
Moving on to search function...
Accounts available on this node:
0xed9d02e382b34818e88B88a309c7fe71E65f419d
Originally deployed with account:0xed9d02e382b34818e88B88a309c7fe71E65f419d
Contract Address: 0x1932c48b2bF8102Ba33B4A6B545C32236e342f34
The latest document ID is no.:2
Begin contract search...
-----
Smartcontract called...
Keyword 1 unmatched...
Unmatched...
-----
Smartcontract called...
Keyword 1 matched...
Keyword 2 matched...
All matched, successfully...
Return document as search result:
=====
{ author:
  [ { authorPerson: '^Tymoteusz^McCabe^^',
      authorInstitution: [Array],
      authorRole: 'Attending',
      authorSpecialty: 'Neurology' },
    { authorPerson: '^Stevie^Lamb^^',
      authorInstitution: [Array],
      authorRole: 'Neurologist',
      authorSpecialty: 'Neurology' } ],
  availabilityStatus: 'urn:oasis:names:tc:ebxml-regrep>StatusType:Approved',
  classCode:
    { codingScheme: '1.3.6.1.4.1.19376.1.2.6.1',
      displayName: 'Treatment Plan or Protocol' },
  comment: '',
  confidentialityCode:
    { codingScheme: '2.16.840.1.113883.5.25',
      displayName: 'Restricted' },
  creationTime: '20070101',
  entryUUID: 'Document02',
  eventCodeList:
    [ { codingScheme: '1.3.6.1.4.1.21367.2017.3',
        displayName: 'Foundational Connectathon Read-Access Policy' },
      { codingScheme: '1.3.6.1.4.1.21367.2017.3',
        displayName: 'FULL ACCESS TO ALL POLICY' } ],
  formatCode:
    { codingScheme: '1.3.6.1.4.1.19376.1.2.3',
      displayName: 'urn:ihe:iti:bppc:2007' },
  hash: '8cd7c25aa2526918fef504fea46b79a3ebf123db',
  healthcareFacilityTypeCode:
    { codingScheme: '2.16.840.1.113883.6.96',
      displayName: 'Hospital-trauma center' },
  homeCommunityId: 'N/A',
  languageCode: 'en-us',
}

```

Figure 4-63 XDS Document Registry then begin search operation over Smartcontract

If the matching result were found, it will be response back to XDS Document Consumer.

```

Keyword 1 matched...
Keyword 2 matched...
All matched, successfully...
Return document as search result:
=====
{ author:
  [ { authorPerson: '^Tymoteusz^McCabe^^',
      authorInstitution: [Array],
      authorRole: 'Attending',
      authorSpecialty: 'Neurology' },
    { authorPerson: '^Stevie^Lamb^^',
      authorInstitution: [Array],
      authorRole: 'Neurologist',
      authorSpecialty: 'Neurology' } ],
  availabilityStatus: 'urn:oasis:names:tc:ebxml-regrep>StatusType:Approved',
  classCode:
  { codingScheme: '1.3.6.1.4.1.19376.1.2.6.1',
    displayName: 'Treatment Plan or Protocol' },
  comment: '',
  confidentialityCode:
  { codingScheme: '2.16.840.1.113883.5.25',
    displayName: 'Restricted' },
  creationTime: '20070101',
  entryUUID: 'Document02',
  eventCodeList:
  [ { codingScheme: '1.3.6.1.4.1.21367.2017.3',
      displayName: 'Foundational Connectathon Read-Access Policy' },
    { codingScheme: '1.3.6.1.4.1.21367.2017.3',
      displayName: 'FULL ACCESS TO ALL POLICY' } ],
=====

Calling for full document...
Accounts available on this node:
0xed9d02e382b34818e88B88a309c7fe71E65f419d
Originally deployed with account:0xed9d02e382b34818e88B88a309c7fe71E65f419d
Contract Address: 0x1932c48b2fb8102Ba33B4A6B545C32236e342f34
Returning document: 2
=====
Return type: FindDocuments,LeafClass
=====
{ 'query:AdhocQueryResponse':
  { '$':
    { status: 'Success',
      'xmlns:query': 'urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0',
      'xmlns:rim': 'urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0',
      'xmlns:xsi': 'http://www.w3.org/2001/XMLSchema-instance',
      'xsi:schemaLocation': 'urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0 ../../schema/ebRS/query.xsd',
      'rim:RegistryObjectList': [ [Object] ] } }
  Responding query result:
  -----
  <?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<query:AdhocQueryResponse status="Success" xmlns:query="urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0" xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="urn:oasis:names:tc:ebxml-regrep:xsd:query:3.0 ../../schema/ebRS/query.xsd">
  <rim:RegistryObjectList>
    <rim:ExtrinsicObject id="Document02" mimeType="text/plain" objectType="urn:uuid:7edca82f-054d-47f2-a032-9b2a5b5186c1" status="urn:oasis:names:tc:ebxml-regrep>StatusType:Approved">
  </rim:RegistryObjectList>
</query:AdhocQueryResponse>
=====

Done!
Execution time (hr): 0s 445.282259ms
=====
CLOSED: 127.0.0.1 41192

```

Figure 4-64 XDS Document Registry responding search result back to XDS Document Consumer

```

Query response received:
{
  DocumentEntry:
    {
      author: [ [Object], [Object] ],
      availabilityStatus: 'urn:oasis:names:tc:ebxml-regrep>StatusType:Approved',
      classCode:
        {
          codingScheme: '1.3.6.1.4.1.19376.1.2.6.1',
          displayName: 'Treatment Plan or Protocol' },
      comment: '',
      confidentialityCode:
        {
          codingScheme: '2.16.840.1.113883.5.25',
          displayName: 'Restricted' },
      creationTime: '20070101',
      entryUUID: 'Document02',
      eventCodeList: [ [Object], [Object] ],
      formatCode:
        {
          codingScheme: '1.3.6.1.4.1.19376.1.2.3',
          displayName: 'urn:ihe:iti:bppc:2007' },
      hash: '8cd7c25aa2526918fef504fea46b79a3ebf123db',
      healthcareFacilityTypeCode:
        {
          codingScheme: '2.16.840.1.113883.6.96',
          displayName: 'Hospital-trauma center' },
      homeCommunityId: 'N/A',
      languageCode: 'en-us',
      legalAuthenticator: 'N/A',
      limitedMetadata: 'N/A',
      mimeType: 'text/plain',
      objectType: 'urn:uuid:7edca82f-054d-47f2-a032-9b2a5b5186c1',
      patientId: 'IHEBLUE-2736^^&1.3.6.1.4.1.27829.13.20.3000&ISO',
      practiceSettingCode:
        {
          codingScheme: '1.3.6.1.4.1.21367.2017.3',
          displayName: 'Neurology' },
      referenceIdList: 'N/A',
      repositoryUniqueId: '1.19.6.24.110.42.1',
      serviceStartTime: '200701011800',
      serviceStopTime: '200701011900',
      size: '4',
      sourcePatientId: '6b12add33^^&1.3.4.5&ISO',
      sourcePatientInfo:
        [
          'PID-3|pid1^^&1.2.3&ISO',
          'PID-5|Emile^Sheehan^^',
          'PID-7|19560527',
          'PID-8|M',
          'PID-11|3094 Glen St^^Paducah^KY^42003^USA' ],
      title: 'DocB',
      typeCode:
        {
          codingScheme: '2.16.840.1.113883.6.1',
          displayName: 'LABORATORY REPORT.TOTAL' },
      uniqueId: '1.2.42.17115670011797.30',
      URI: 'N/A' } }
=====

Execution time (hr): 0s 497.036633ms
=====

Connection closed

```

Figure 4-65 XDS Document Consumer received search result and display it to the user

4.4 Evaluation

The goal of the evaluation is to test the functionalities and the performance of the implemented system. This including the Document Register function and Document Query function. The evaluation will indicate the compatibility of the implemented system to an actual healthcare operation environment. The implemented system should be able to sustain a huge amount of data that continuously flows through the system without a failure. Each setup will be tested with the mockup transactions and measure the processing time required for the system to complete the specific process.

There are ten transactions created for the experiment as test samples. Figure 4-66 and Figure 4-67 show an example of the mockup transaction created for the experiment and its full content can be further inspected in the Appendix Section. In each transaction have its metadata attributes named "DocumentEntry.patientId", "DocumentEntry.availabilityStatus" and some other attributes modified varied in each transaction for the test. All experiments will be tested with these transaction samples resulting as 10 times test for each setup ("transaction number #n" will be referred to as "Tx#n").

```
<?xml version='1.0' encoding='UTF-8'?>
<soapenv:Envelope xmlns:soapenv="http://www.w3.org/2003/05/soap-envelope">
  <soapenv:Header xmlns:wsa="http://www.w3.org/2005/08/addressing">
    <wsa:To soapenv:mustUnderstand="true">http://127.0.0.1:6969/</wsa:To>
    <wsa:MessageID soapenv:mustUnderstand="true">urn:uuid:2311B77C122650C7B91554413514373</wsa:MessageID>
    <wsa:Action soapenv:mustUnderstand="true">urn:htt:2007:RegisterDocumentSet-b</wsa:Action>
  </soapenv:Header>
  <soapenv:Body>
    <lcm:SubmitObjectsRequest xmlns:lcm="urn:oasis:names:tc:ebxml-regrep:xsd:lcm:3.0">
      <rmi:RegistryObjectList xmlns:rmi="urn:oasis:names:tc:ebxml-regrep:xsd:rmi:3.0">
        <rmi:ExtrinsicObject id="Document01" mimeType="text/plain" objectType="urn:uuid:7edca82f-054d-47f2-a032-9b2a5b5186c1" status="urn:oasis:names:tc:ebxml-regrep:StatusType:Approved">
          <rmi:Slot name="size">
            <rmi:ValueList>
              <rmi:Value>4</rmi:Value>
            </rmi:ValueList>
          </rmi:Slot>
          <rmi:Slot name="repositoryUniqueId">
            <rmi:ValueList>
              <rmi:Value>1.19.6.24.109.42.1</rmi:Value>
            </rmi:ValueList>
          </rmi:Slot>
          <rmi:Slot name="hash">
            <rmi:ValueList>
              <rmi:Value>e543712c0e10501972de13a5bfcbe826c49feb75</rmi:Value>
            </rmi:ValueList>
          </rmi:Slot>
          <rmi:Slot name="creationTime">
            <rmi:ValueList>
              <rmi:Value>20061224</rmi:Value>
            </rmi:ValueList>
          </rmi:Slot>
          <rmi:Slot name="languageCode">
            <rmi:ValueList>
              <rmi:Value>en-us</rmi:Value>
            </rmi:ValueList>
          </rmi:Slot>
          <rmi:Slot name="serviceStartTime">
            <rmi:ValueList>
              <rmi:Value>200612230800</rmi:Value>
            </rmi:ValueList>
          </rmi:Slot>
          <rmi:Slot name="serviceStopTime">
            <rmi:ValueList>
              <rmi:Value>200612230900</rmi:Value>
            </rmi:ValueList>
          </rmi:Slot>
        </rmi:ExtrinsicObject>
      </rmi:RegistryObjectList>
    </lcm:SubmitObjectsRequest>
  </soapenv:Body>
</soapenv:Envelope>
```

Figure 4-66 Part of transaction samples content



Figure 4-67 Ten of mockup transactions generated for the experiment

4.4.1 Functionalities Test

On the hypothesis that a changed number of active nodes may cause a change in the functionalities of the XDS Blockchain, to test the functionalities, the experiment performs by varying the number of nodes and test if the system could perform any function. Start from the setup with seven active nodes as the reference, followed by six, five, four, three, two, and one active node for the variation.

To create a situation where there are fewer than seven active nodes, the 7-Nodes Example configuration must be modified to meet the situation. In Quorum 7-Nodes Example, the number of active nodes was defined in the "permissioned-nodes.json" file as shown in Figure 4-54. Each active node represents by its "enode" identifier number together with its communicating TCP port number as shown in Figure 4-55. The node will become inactive if its enode number was excluded from the file. That means, in each setup for a specific number of nodes, enode number of inactive nodes must be excluded from the file before initiate the 7-Nodes Blockchain network. At the same time, the "numNodes" variable value in the "istanbul-init.sh" file must be set to the specific number of active nodes (i.e., numNodes = 6 for six active nodes) as shown in Figure 4-56 to declare that there will be file directory prepared for the specified number of nodes at the initiation of the 7-Node Blockchain network.

After the configuration was modified, the 7-Nodes Example will automatically generate Blockchain nodes to meet with the specified number upon the initiation of the Blockchain ledger. That means every time the configuration file was modified for a new setup, the Blockchain network must be reset and re-initiated to ensure that there is no conflict with another setup which could affect the accuracy of the experiment result.

```

[{"enode": "enode://ac6b1096ca56b9f6d004b779ae3728bf83f8e2245@127.0.0.1:21000?discport=0&raftport=50401", "enode": "enode://0ba6b9f606a43a95edc6247cdb1c1e105145817be@127.0.0.1:21001?discport=0&raftport=50402", "enode": "enode://579f786d4e2830bbcc02815a27e8a9bacccc9605d@127.0.0.1:21002?discport=0&raftport=50403", "enode": "enode://3d9ca5956b38557aba991e31cf510d4df641dce9c@127.0.0.1:21003?discport=0&raftport=50404", "enode": "enode://3701f007bfa4cb26512d7df18e6bbd202e8484a6e@127.0.0.1:21004?discport=0&raftport=50405", "enode": "enode://eaca74c4b0e7a9e12d2fe5fee6595eda841d6d99@127.0.0.1:21005?discport=0&raftport=50406", "enode": "enode://239c1f044a2b03b6c4713109af036b775c5418fe4@127.0.0.1:21006?discport=0&raftport=50407"}]

```

Figure 4-68 Content of "permissioned-nodes.json" file define active nodes

(node ids truncated for simpler explanation)

```
"enode://ac6b1096ca56b9f6d004b779ae3728bf83f8e2245@127.0.0.1:21000?discport=0&raftport=50401",
```

Figure 4-69 Single node id represent single active node

```

#!/bin/bash
set -u
set -e

function usage() {
    echo ""
    echo "Usage:"
    echo "$0 [--istanbulTools] [--numNodes numberOfNodes]"
    echo ""
    echo "Where:"
    echo "  --istanbulTools will perform initialisation from data generated using"
    echo "  istanbul-tools (note that permissioned-node.json and istanbul-genesis.json"
    echo "  files will be overwritten)"
    echo "  numberOfNodes is the number of nodes to initialise (default = $numNodes)"
    echo ""
    exit -1
}

istanbulTools="false"
numNodes=6
while (( $# )); do
    case "$1" in
        --istanbulTools)
            istanbulTools="true"
            shift
            ;;
        --numNodes)
            re='^[0-9]+$'
            if ! [[ $2 =~ $re ]] ; then
                echo "ERROR: numberOfNodes value must be a number"
                usage
            fi
            numNodes=$2
            shift 2
            ;;
    esac
done

```

Figure 4-70 "numNodes" variable in "istanbul-init.sh" file reassigned with new value

Table 4-1 shows that the system result from the implementation can function normally with 7, 6, and 5 active nodes. The system stops functioning when there are active nodes lesser than 5.

Table 1 Functionalities experiment result

	7 Nodes	6 Nodes	5 Nodes	4 Nodes	3 Nodes	2 Nodes	1 Nodes
Smartcontract Deployment	✓	✓	✓	✗	✗	✗	✗
Document Register	✓	✓	✓	✗	✗	✗	✗
Document Query	✓	✓	✓	✗	✗	✗	✗

After looking into the root cause of the result, it is turn out that the 7-Nodes Example cannot resolve the Block validation process cycle in a situation with fewer than 5 active nodes. Figure 4-71 shows the content of the log file monitoring the 7-Nodes example process where the upper red rectangle shows the beginning of the network while the lower red rectangle shows the process stopped at the initiation of the first Block validation process. The log shows that the Block validation process cycle which would repeat continuously and endlessly simply stopped at the first Block and there is no further upcoming process appeared in the log or none of any error notification appeared.

Noteworthy, this is not even related to the condition of IBFT consensus where it requires at least 2/3 of all nodes to vote for the same Block version to complete the validation process. The system should be able to operate normally without error even there are fewer than 5 active nodes when all active nodes agreeing on the same Block version and there is no "bad actor node" present in the system to propose a falsified Block version that interrupts the vote

We think that a possible reason could be that the 7-Nodes example may not be developed for the situation with 4,3,2, or 1 active node as it was only built to aid Smartcontract developers to easily deploy and test their Smartcontract in the proper 7 active nodes simulated environment closely similar to the actual Blockchain network.

```

Open ▾ 1.log -/Documents/7NodesTry/quorum-examples/examples/7nodes/qdata/logs Save ⌂ ⌓
nohup: appending output to 'nohup.out'
INFO [07-07|14:26:31.914] Maximum peer count
INFO [07-07|14:26:31.915] Starting peer-to-peer node
INFO [07-07|14:26:31.915] Allocated cache and file handles
qdata/dd1/geth/chaindata cache=768 handles=2048
INFO [07-07|14:26:32.001] Initialised chain configuration
EIP155: 0 Byzantium: 0 IsQuorum: true Constantinople: 0 ETHER=25 LES=0 total=25
INFO [07-07|14:26:32.001] Starting Ethereum protocol instance=Geth/v1.8.18-stable-a603e745(quorum-v2.4.0)/linux-amd64/go1.10.4
INFO [07-07|14:26:32.002] Loaded most recent local header database=/home/pcep/Documents/7NodesTry/quorum-examples/examples/7nodes/
INFO [07-07|14:26:32.002] Loaded most recent local full block config="[ChainID: 10 Homestead: 0 DAO: <nil> DAOSupport: false EIP150: 0
INFO [07-07|14:26:32.002] Loaded most recent local fast block versions="[63 62]" network=10
INFO [07-07|14:26:32.002] Regenerated local transaction journal number=0 hash=85c72c..e7aec8 td=1 age=52y3mo5d
INFO [07-07|14:26:32.002] IPC endpoint opened number=0 hash=85c72c..e7aec8 td=1 age=52y3mo5d
INFO [07-07|14:26:32.042] IPC endpoint opened transactions=0 accounts=0
INFO [07-07|14:26:32.042] HTTP endpoint opened url=http://
dd1/geth.ipc
INFO [07-07|14:26:32.043] HTTP endpoint opened url=http://
0.0.0.0:2000
WARN [07-07|14:26:32.043] -----
WARN [07-07|14:26:32.043] Referring to accounts by order in the keystore Folder is dangerous!
WARN [07-07|14:26:32.043] This functionality is deprecated and will be removed in the future!
WARN [07-07|14:26:32.043] Please use explicit addresses! (can search via `geth account list`)
WARN [07-07|14:26:32.043] -----
INFO [07-07|14:26:32.058] New local node record seq=1 id=577115fd9184a27 ip=127.0.0.1 udp=0 tcp=21000
INFO [07-07|14:26:32.058] Started P2P networking self="enode://
ac6b1096ca56b9f6d004b779ae3728bf83f8e22453404cc3cef16a3d9b96608bc6/c4b30d088e0a5a6c6390213f7acbe1153fffd23ce57380104288ae19373ef@127.0.0.1:21000
discover=0"
WARN [07-07|14:26:32.058] Removing static dial candidate id=0x8c5d60
INFO [07-07|14:26:35.605] Unlocked account addr=127.0.0.1:21000 err="is self"
INFO [07-07|14:26:35.605] Transaction pool price threshold updated address=0xed9d02e382b34818e88b88a309c7fe71e65f419d
INFO [07-07|14:26:35.605] Transaction pool price threshold updated price=1000000000
INFO [07-07|14:26:35.605] Commit new mining work number=1 sealhash=013766..01880d uncles=0 txs=0 gas=0 fees=0
elapsed=67.609us
INFO [07-07|14:28:22.279] Setting new local account address=0xed9d02e382b34818e88b88a309c7fe71e65f419d
INFO [07-07|14:28:22.279] Submitted contract creation fullhash=0x047145f40bd5476d3fc7a6fd6cad9ac9306254d81e7b074d77d6261ad7ffab75 to=0x1932c48b2bF8102Ba33B4A6B545C32236e342f34
INFO [07-07|14:28:23.617] Commit new mining work | number=1 sealhash=36eb9a..e89085 uncles=0 txs=1 gas=459309 fees=0
elapsed=384.074us

```

Plain Text ▾ Tab Width: 8 ▾ Ln 27, Col 53 ▾ INS

Figure 4-71 The 7-Node Example system log

It also must be noted that it is possible for the case that contains an even number of nodes may cause failure in Block validation attempt due to the majority of Block approval from nodes not meet the least requirement of 2/3 of all nodes in the network. For example, if ten nodes are participating, five nodes proposed Block named 'ABC' while another five nodes proposed Block named 'CBA'. This example will result in failed Block validation attempt. If this happened, the network was expected to try another attempt until the majority meet the least requirement of 2/3 and all the remaining transactions were successfully added into the valid Block and published into the Blockchain ledger. However, the evaluation of the implementation will not cover the case due to complications in creating the "bad actor" node. We assume that the feature was not directly included with Ethereum, Quorum, or its 7-Nodes Example as it was not created for a malicious purpose so, it is too difficult for us to create the situation that half of the participate nodes attempt to propose falsified Block for the evaluation.

4.4.2 Performance Test

On the hypothesis that a changed number of active nodes or change in the amount of XDS transactions entering the system may cause a change in the performance of the XDS Blockchain, the performance test will be performed by triggering the Document Register function and/or the Document Query function depends on the setup. The prepared transaction samples will be tested on the setup with a specific number of nodes then measure the time the system took to complete the process. Additionally, to increase the accuracy of experiment results and reduce the effect from other factors outside the consideration, the experiment will be repeated ten times on each transaction sample. The final performance result of each transaction will be derived from the average values of these ten times repeated.

As mentioned in Section 4.4.1 that the 7-Nodes example only functions normally with 7, 6, and 5 active nodes, so the performance test with a varied node number only possible for the case with the specified active nodes.

4.4.2.1 Test if the number of search keywords would cause a change in performance of Document Query function.

This setup is performed by trigger the XDS Document Consumer Actor to start the Document Query function which prompts for input from the user. The user then inputs metadata attributes values of each transaction sample (Tx1 – Tx10) into the program. The program then proceeds to query for the matching metadata set registered in the Blockchain ledger from the XDS Document Registry Actor in the 1st Node (only one active node received the query). The processing time since the moment the XDS Document Consumer Actor sent the ITI-18 transaction to the XDS Document Registry Actor until the XDS Document Consumer received the search result from the XDS Document Registry will be measured for the experiment result. The "minimum" search keywords will include only two attribute values while the "maximum" search keywords will include fourteen attribute values. Both will be performing the "FindDocument" query type which is the only stable query type available in the current version of the implementation.

The Document Query with minimum keywords took an average process time of 302.5096151 milliseconds to complete the function. The Document Query with maximum keywords took an average process time of 298.9329658 milliseconds to complete the function. Figure 4-72 show no significant difference between the Document Query with maximum search keywords compared to the Document Query with minimum search keywords. That means the amount of search keywords input is not affecting the performance of the Document Query function. A full version of the experiment result can be further inspected in the Appendix section.

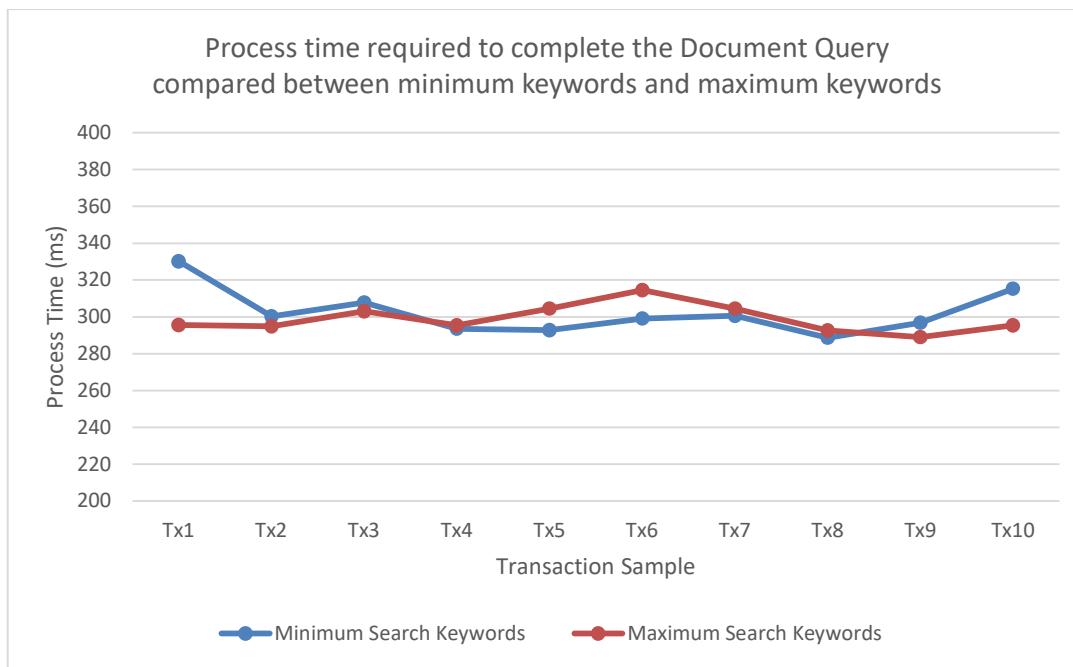


Figure 4-72 Process time required to complete the Document Query
compared between minimum keywords and maximum keywords

4.4.2.2 Test if number of active nodes would cause change in performance of Document Register function

This setup is performed by trigger the XDS Document Repository Actor to start the Document Register function which will send the ITI-42 transaction containing metadata attributes set of the selected document (Tx1 - Tx10) to the XDS Document Registry Actor of the 1st Node (only one active node received the register). The processing time the XDS Document Registry took to complete the process publishing the metadata attributes set into the Blockchain ledger will be measured for the experiment result.

With 7 active nodes, the 1st Node XDS Document Registry Actor took an average processing time of 3.65415466 seconds with the maximum processing time at 4.172552233 seconds and the minimum processing time at 2.880175005 seconds.

With 6 active nodes, the 1st Node XDS Document Registry Actor took an average processing time of 4.573630153 seconds with the maximum processing time at 5.391518249 seconds and the minimum processing time at 4.245366876 seconds.

With 5 active nodes, the 1st Node XDS Document Registry Actor took an average processing time of 5.954575049 seconds with the maximum processing time at 6.37163004 seconds and the minimum processing time at 5.273704735 seconds.

Figure 4-73 compares the processing times the system took to complete the Document Register function which shows that there is a slight difference in performance between each node number variation setup. The lesser number of active nodes, given longer processing time. This means the variation in node number is affecting the performance of the system.

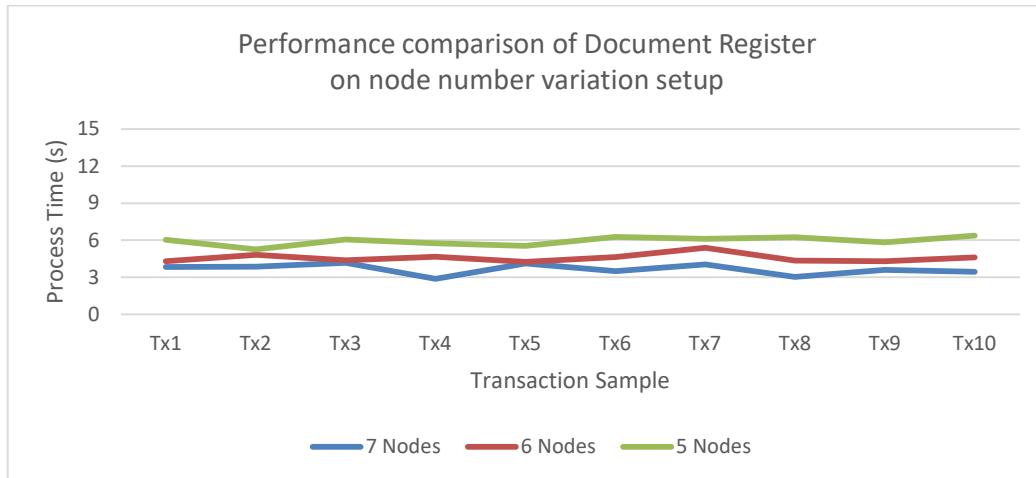


Figure 4-73 Performance comparison of Document Register on node number variation setup

4.4.2.3 Test if each active node has the same performance on performing the Document Register function when all active nodes perform the Document Register function at the same time.

This setup is performed by trigger the XDS Document Repository Actor to start the Document Register function which will send the ITI-42 transaction containing metadata attributes set of the selected document (Tx1 - Tx10) to the XDS Document Registry Actor of all active nodes (all active nodes received the register). The processing time the XDS Document Registry took to complete the process publishing the metadata attributes set into the Blockchain ledger in each active node will be measured for the experiment result. The experiment was further performed by varied active nodes number to check if there are any differences in the experiment result which is further explained in Section 4.4.2.4.

With 7 active nodes, to complete the Document Register function, the 1st Node took an average processing time of 6.694740502 seconds. The 2nd Node took an average processing time of 6.64481847 seconds. The 3rd Node took an average processing time of 6.697508806 seconds. The 4th Node took an average processing time of 6.892059017 seconds. The 5th Node took an average processing time of 7.026599076 seconds. The 6th Node took an average processing time of 6.695705492 seconds. The 7th Node took an average processing time of 6.631355668 seconds. All active nodes show no significant difference in performance to complete the function as shown in Figure 4-74.

With 6 active nodes, to complete the Document Register function, the 1st Node took an average processing time of 7.261896542 seconds. The 2nd Node took an average processing time of 7.03144854 seconds. The 3rd Node took an average processing time of 7.14090967 seconds. The 4th Node took an average processing time of 7.137407174 seconds. The 5th Node took an average processing time of 7.05559841 seconds. The 6th Node took an average processing time of 7.087177031 seconds. All active nodes show no significant difference in performance to complete the function as shown in Figure 4-75.

With 5 active nodes, to complete the Document Register function, the 1st Node took an average processing time of 7.289964378 seconds. The 2nd Node took an average processing time of 7.232330579 seconds. The 3rd Node took an average processing time of 7.27142245 seconds. The 4th Node took an average processing time of 7.150316791 seconds. The 5th Node took an average processing time of 7.146553912 seconds. All active nodes show no significant difference in performance to complete the function as shown in Figure 4-76.

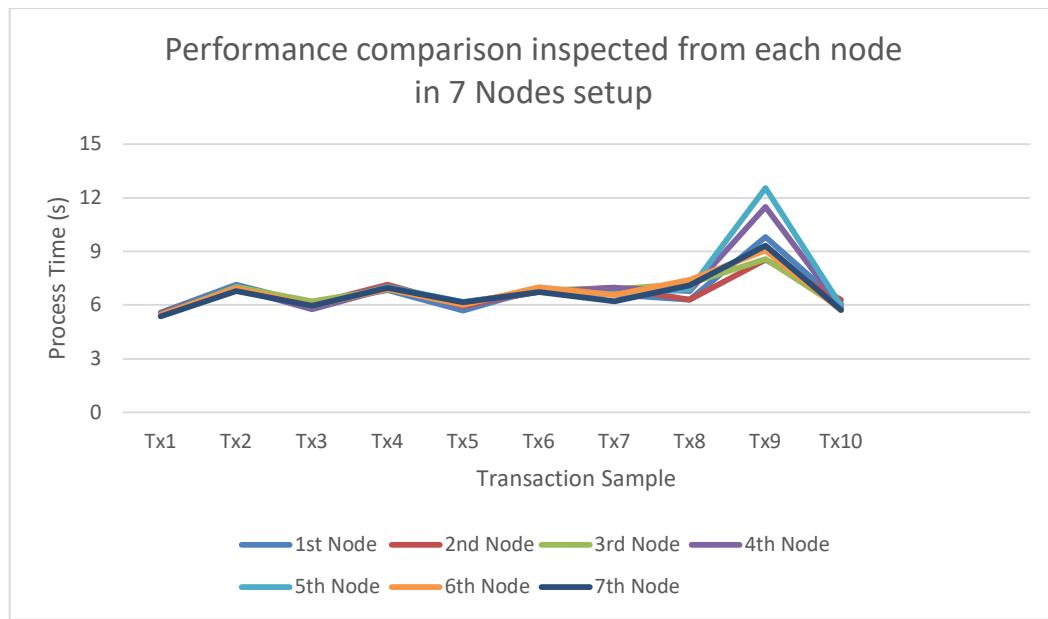


Figure 4-74 Performance comparison inspected from each node in 7 Nodes setup

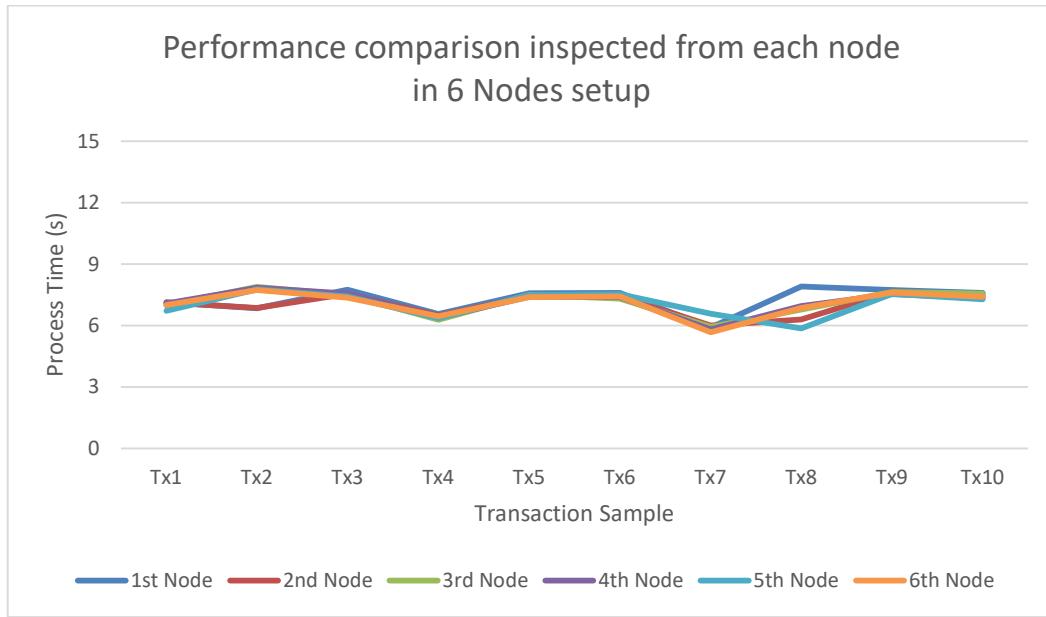


Figure 4-75 Performance comparison inspected from each node in 6 Nodes setup

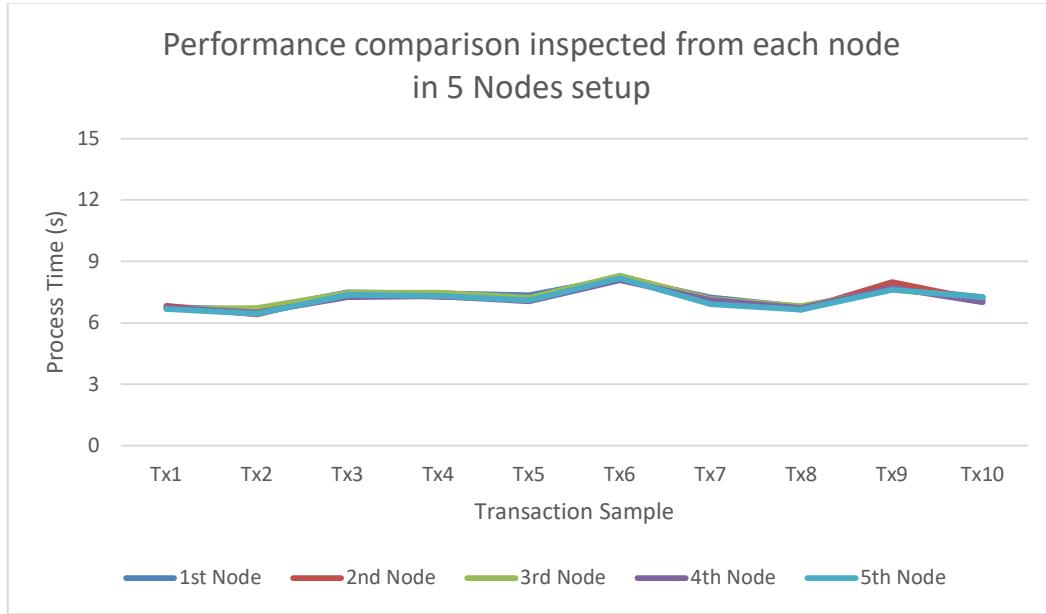


Figure 4-76 Performance comparison inspected from each node in 5 Nodes setup

4.4.2.4 Test if the number of active nodes would cause a change in the performance of the Document Register function when all active nodes perform the Document Register function at the same time.

This setup is a further analysis result of Section 4.4.2.3. The "7 Nodes" line was derived from the average values of the experiment result in Figure 4-74. The "6 Nodes" line was derived from the average values of the experiment result in Figure 4-75. The "5 Nodes" line was derived from the average values of the experiment result in Figure 4-76.

Figure 4-77 shows the performance comparison between each node number variation setup when all nodes triggering the Document Register function at the same time. The graph shows no significant difference between each setup which means that node number variation is not affecting the system performance on performing the Document Register function when all nodes trigger the function at the same time.

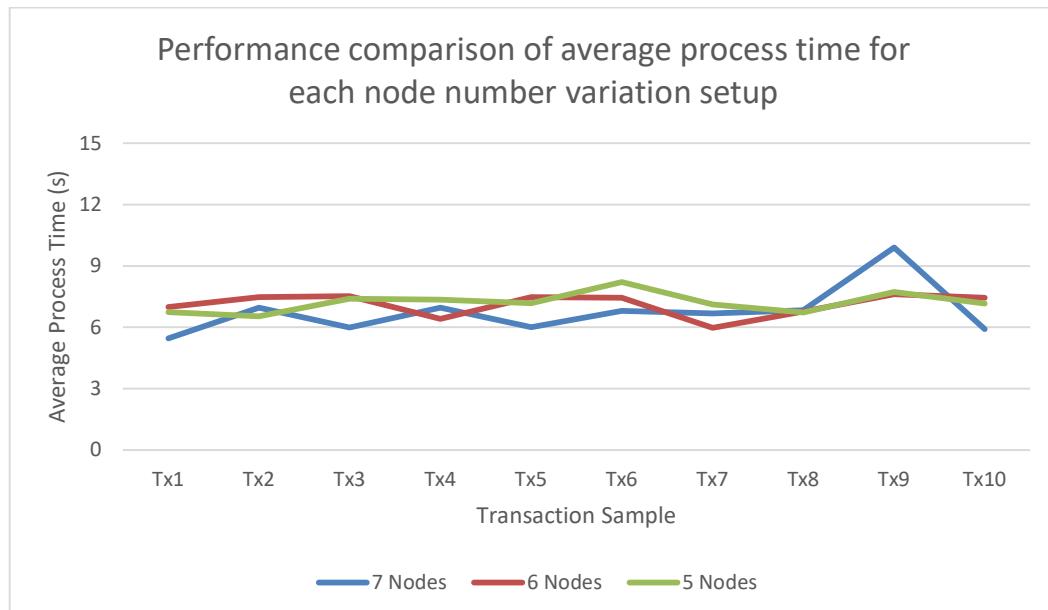


Figure 4-77 Performance comparison of average process time for each node number variation setup

4.4.2.5 Test if the number of transactions would cause a change in performance of the XDS Document Registry to perform the Document Register function.

This setup is a further analysis result of Sections 4.4.2.2 and 4.4.2.4. In Figure 4-78, the "Single Node" line was derived from the average values of the experiment result in Figure 4-73. The "All Nodes" line was derived from the average values of the experiment result in Figure 4-77.

Figure 4-78 shows that when all nodes perform the Document Register function at the same time, it took a slightly longer time to complete the function when compared to the situation when there is only a single node perform the Document Register function.

Considering the Document Register function, it is where each node gathers all transactions broadcasted into the Blockchain network at the time to put into the same Block and validate it for entering the Blockchain ledger. Whether there is a huge number of transactions entering the Blockchain or none, it should not be affecting the performance of each Blockchain node in performing the Document Register function. So, it is possible that the difference in performance shown in Figure 4-78 was a result of another factor.

Consider the nature of the 7-Nodes Example which its Blockchain nodes need to share processing units of the same host machine. The shared processing unit environment may be affecting the performance of each node resulting in a slight difference in performance.

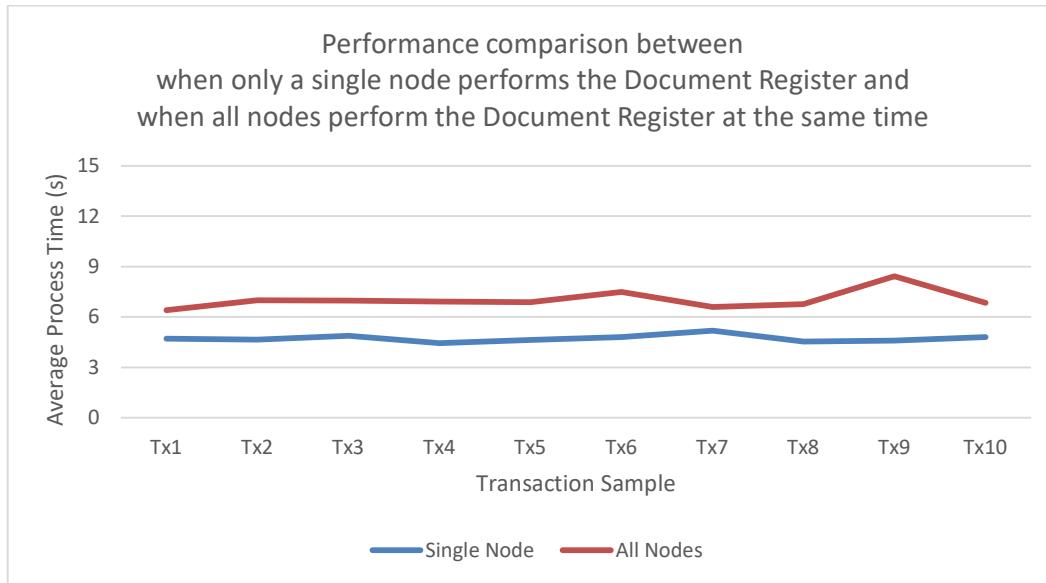


Figure 4-78 Performance comparison between
when only a single node performs the Document Register
and when all nodes perform the Document Register at the same time

4.4.2.6 Test if each active node has the same performance on performing the Document Register function when all active nodes perform the Document Register at the same time with Document Query.

This setup is performed by a method like Section 4.4.2.3 with the addition of performing the Document Query function at the same time as the Document Register function. The processing time the XDS Document Registry took to complete the process publishing the metadata attributes set into the Blockchain ledger in each active node will be measured for the experiment result.

With 7 active nodes, to complete the Document Register function, the 1st Node took an average processing time of 10.91860947 seconds. The 2nd Node took an average processing time of 11.16871924 seconds. The 3rd Node took an average processing time of 10.75588351 seconds. The 4th Node took an average processing time of 10.95396888 seconds. The 5th Node took an average processing time of 10.9228691 seconds. The 6th Node took an average processing time of 11.08287522 seconds. The 7th Node took an average processing time of 10.88583567 seconds. All active nodes show no significant difference in performance to complete the function as shown in Figure 4-79.

With 6 active nodes, to complete the Document Register function, the 1st Node took an average processing time of 9.958971148 seconds. The 2nd Node took an average processing time of 10.00410103 seconds. The 3rd Node took an average processing time of 10.07019995 seconds. The 4th Node took an average processing time of 10.12037286 seconds. The 5th Node took an average processing time of 9.624050698 seconds. The 6th Node took an average processing time of 9.993514932 seconds. All active nodes show no significant difference in performance to complete the function as shown in Figure 4-80.

With 5 active nodes, to complete the Document Register function, the 1st Node took an average processing time of 9.784849326 seconds. The 2nd Node took an average processing time of 9.632056128 seconds. The 3rd Node took an average processing time of 9.813556105 seconds. The 4th Node took an average processing time of 9.420612465 seconds. The 5th Node took an average processing time of 9.451288139 seconds. All active nodes show no significant difference in performance to complete the function as shown in Figure 4-81.

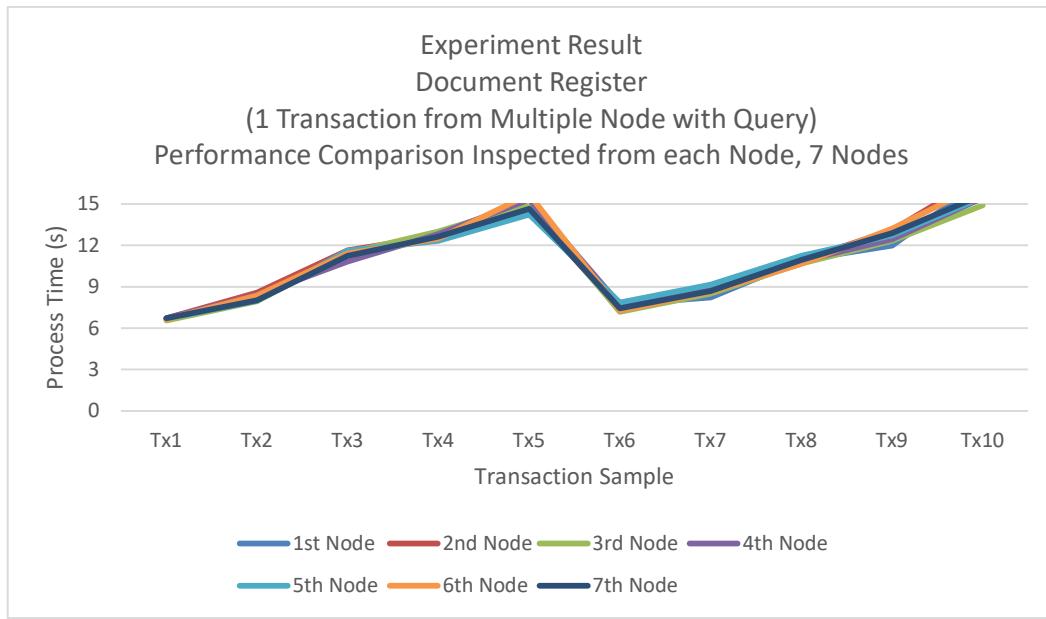


Figure 4-79 Performance comparison inspected from each node in 7 Nodes setup trigger both Document Register and Document Query

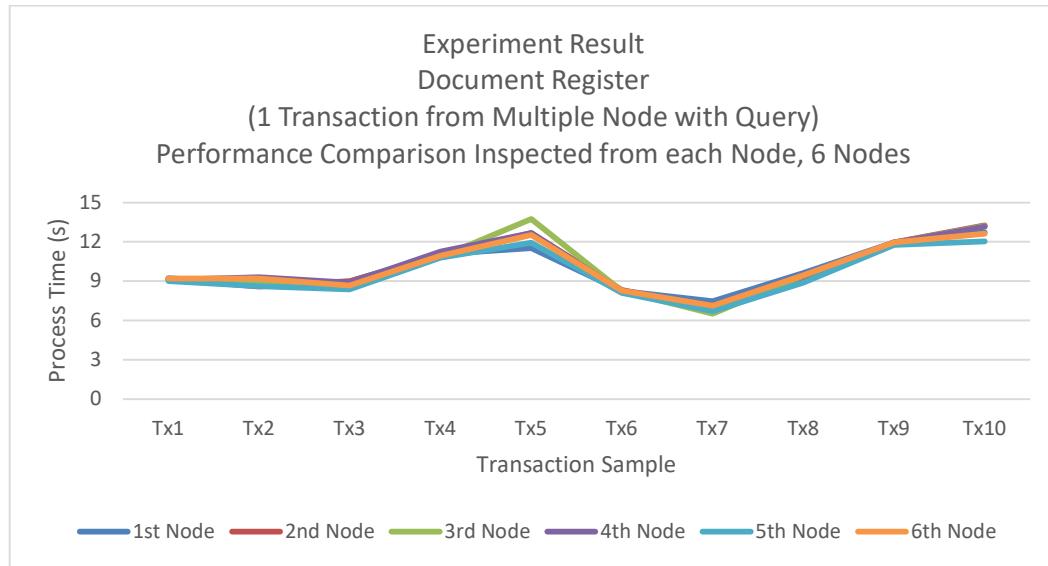


Figure 4-80 Performance comparison inspected from each node in 6 Nodes setup
trigger both Document Register and Document Query

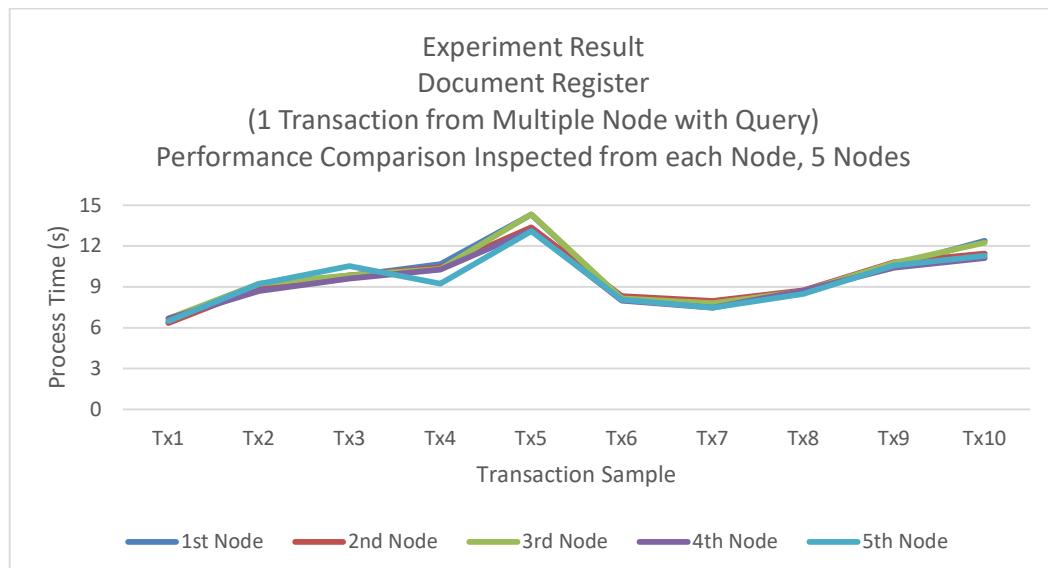


Figure 4-81 Performance comparison inspected from each node in 5 Nodes setup
trigger both Document Register and Document Query

4.4.2.7 Test if the number of active nodes would cause a change in the performance of the Document Register function when all active nodes perform both the Document Register function and Document Query function at the same time.

This setup is a further analysis result of Section 4.4.2.6. The "7 Nodes" line was derived from the average values of the experiment result in Figure 4-79. The "6 Nodes" line was derived from the average values of the experiment result in Figure 4-80. The "5 Nodes" line was derived from the average values of the experiment result in Figure 4-81.

Figure 4-82 compares the processing times the system took to complete the Document Register function which shows that there is no significant difference in performance between each node number variation setup. This means the variation in node number is not affecting the performance of the system when performing both the Document Register and Document Query at the same time.

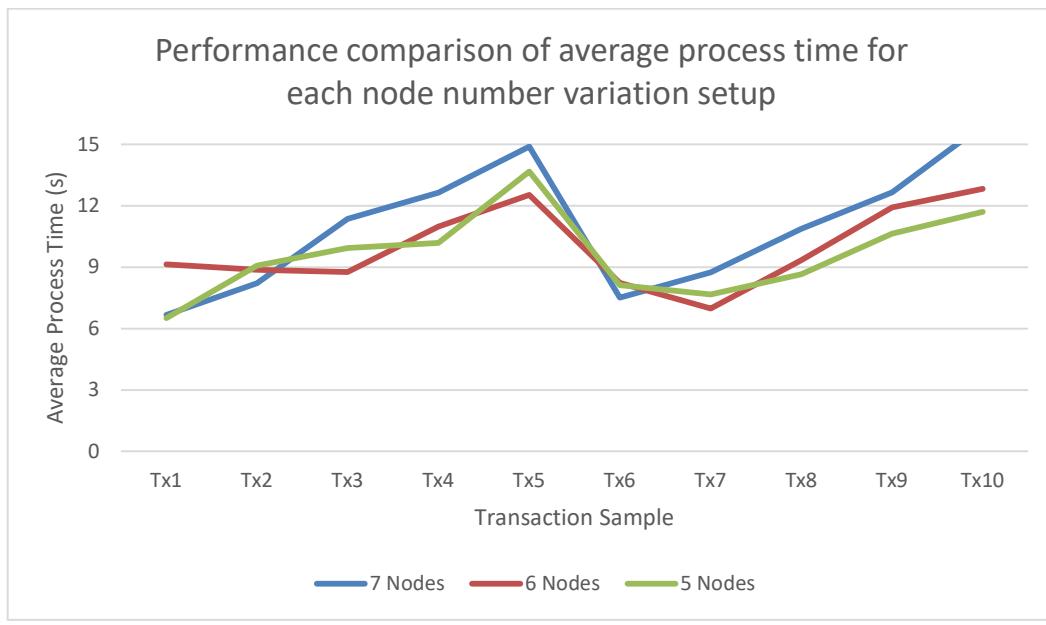


Figure 4-82 Performance comparison of average process time for each node number variation setup

4.4.2.8 Test if perform the Document Register at the same time with Document Query would cause a change in performance of the system to complete the Document Register function.

This setup is a further analysis result of Sections 4.4.2.4 and 4.4.2.7. In Figure 4-83, the "without Query" line was derived from the average values of the experiment result in Figure 4-77. The "with Query" line was derived from the average values of the experiment result in Figure 4-82.

Figure 4-83 shows significant difference between each setup which means that triggering the Document Query function at the same time as the Document Register function is affecting the performance of the system to perform the Document Register function.

Figure 4-79 to Figure 4-81 and Figure 4-83 shows that the system took a longer processing time as it proceeds to perform the Document Register function of each transaction sample when performing the Document Query function at the same time. The system also causes the test machine to freeze or show functional error after processed the Tx5 transaction set (10 times each). The Blockchain was forced to be reset to continue the experiment for Tx6 to Tx10. After investigation, we think that performing the Document Register and Document Query function at the same time causes the 7-Nodes Blockchain to accumulate redundancy over time. This should be fixed with further optimization of the XDS Document Registry Actor program.

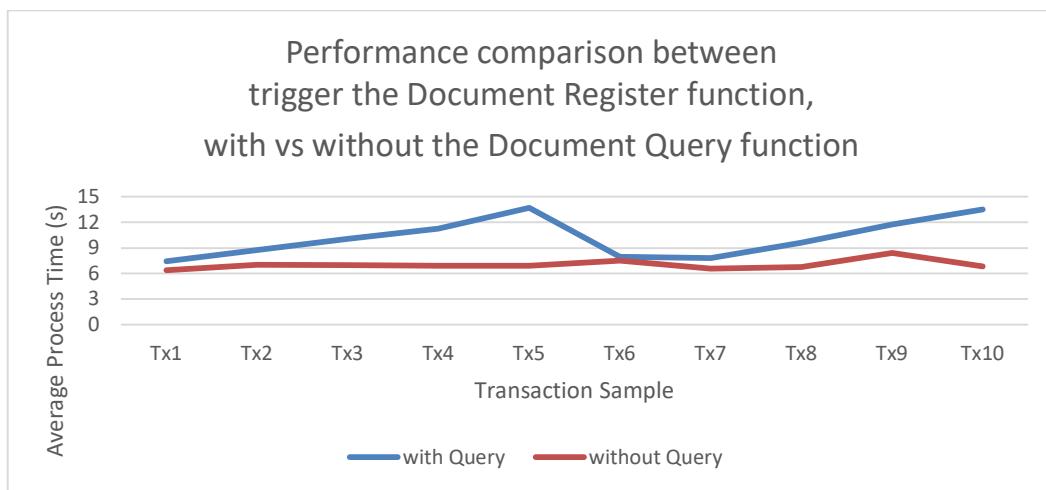


Figure 4-83 Performance comparison between trigger the Document Register function, with and without the Document Query function

4.4.2.9 Test if the number of active nodes would cause a change in the performance of the Document Query function.

This setup is performed by a method like Section 4.4.2.1 with the addition of node variation setup (with 7,6, and 5 active nodes) and perform only for the search with minimum number of search keywords. The processing time since the moment the XDS Document Consumer Actor sent the ITI-18 transaction to the XDS Document Registry Actor until the XDS Document Consumer received the search result from the XDS Document Registry will be measured for the experiment result.

Perform Document Query without the Document Register function, with 7 active nodes, the processing time the system took to complete the Document Query is an average of 302.5096151 milliseconds. With 6 active nodes, took an average of 259.7879338 milliseconds. With 5 active nodes, took an average of 244.2096615 milliseconds. Figure 4-84 show a performance comparison between each setup.

Perform Document Query at the same time as the Document Register function, with 7 active nodes, the processing time the system took to complete the Document Query is an average of 7.650895793 milliseconds. With 6 active nodes, took an average of 5.760202558 milliseconds. With 5 active nodes, took an average of 4.167169248 milliseconds. Figure 4-85 show a performance comparison between each setup.

Both Figure 4-84 and Figure 4-85 show the difference between each setup that means node number variation is affecting the system performance on performing the Document Query function. The graph suggests that the lower active nodes took a slightly shorter processing time to complete the Document Query function.

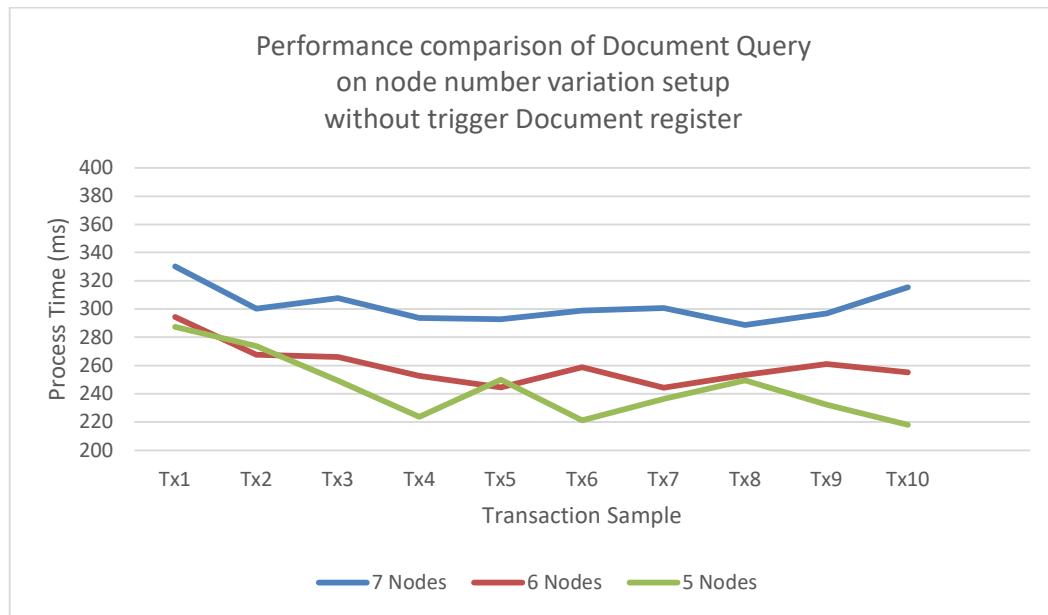


Figure 4-84 Performance comparison of Document Query on node number variation setup
without trigger Document register

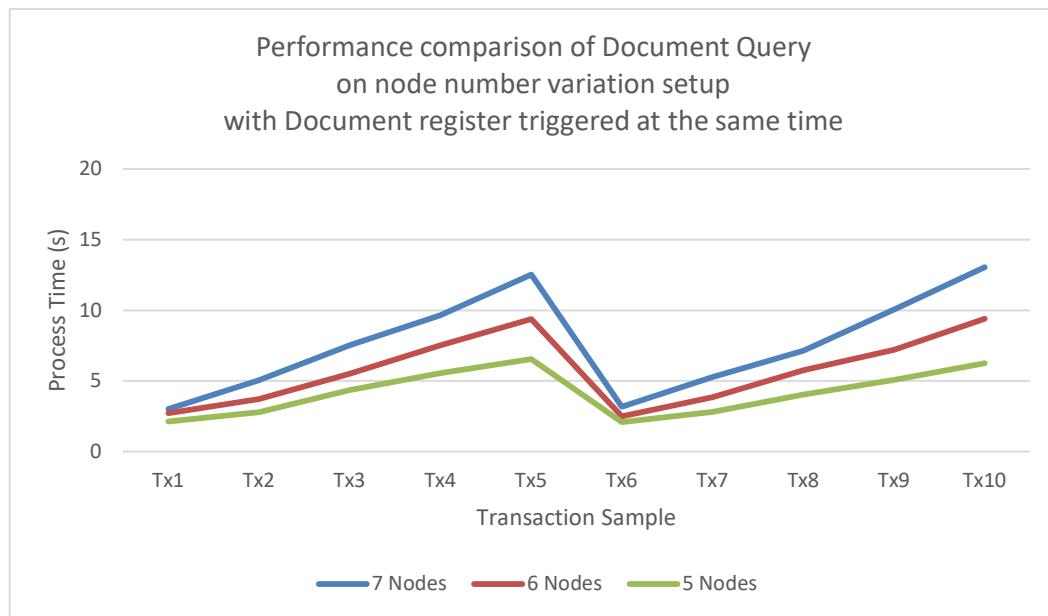


Figure 4-85 Performance comparison of Document Query on node number variation setup
with Document register triggered at the same time

4.4.2.10 Test if the number of transactions would cause a change in performance of the system to perform the Document Query function.

This setup is a further analysis result of Sections 4.4.2.9. In Figure 4-86, the "Single Node" line was derived from the average values of the experiment result in Figure 4-84. The "All Nodes" line was derived from the average values of the experiment result in Figure 4-85.

Figure 4-86 shows a significant difference in the performance of the system to perform the Document Query function.

This can be explained as the Document Query function relies heavily on the computational power of the XDS Document Registry Blockchain node to complete the search operation. The node can perform the search operation for the Document Query function at a slower rate when the node needs to spend a portion of computational power on the Document Register function at the same time. However, the performance can be further improved by improving the programming sequence of the XDS Document Registry program or assign another processing unit to trigger the Document Register function separated from the unit that triggers the Document Query function.

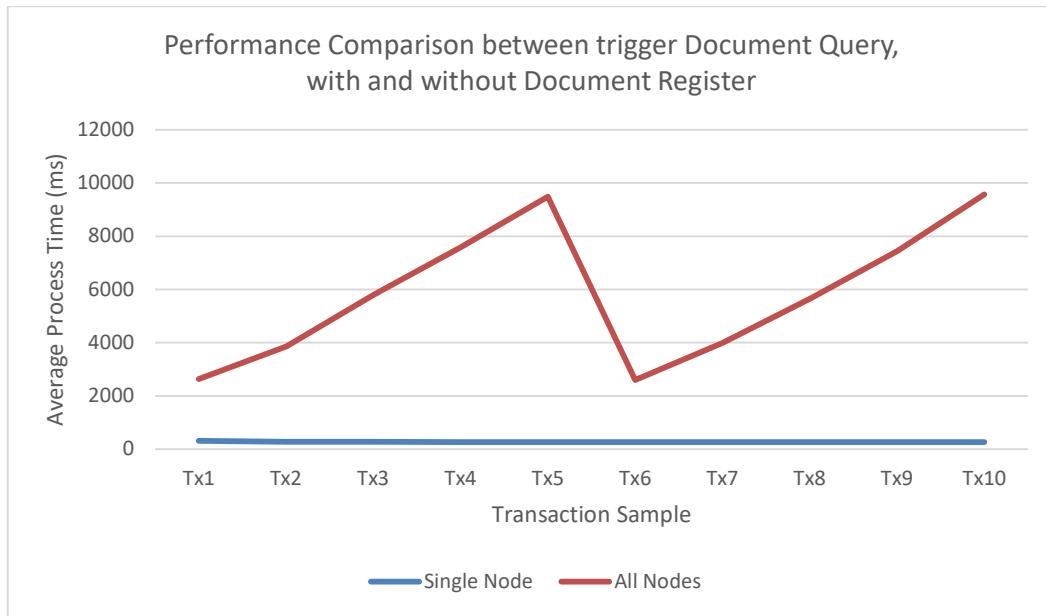


Figure 4-86 Performance Comparison between trigger Document Query, with and without Document Register

CHAPTER V

DISCUSSION AND CONCLUSION

This chapter comprises two main sections including the discussion and conclusion.

5.1 Discussion

Amongst many metadata attributes, there are attributes that value can expose patients' confidential information into the Blockchain network. For example, "DocumentEntry.sourcePatientInfo" contains demographic information of the source patient to whose medical record the document belongs. The attribute can contain multiple values such as patient name and address. So, in the actual adoption of the proposed concept, these metadata attributes values must be anonymized before entering the Blockchain ledger. This can be done by replacing the value with its hash counterpart when the attributes entering the Blockchain ledger via the Document Register function. At the same time, when the attributes were required for the search operation as search keywords input, the XDS Document Consumer will only need to hash the input value and use the hash to allow the XDS Document Registry actor to search for the matching hash value registered within the Document Registry Blockchain. This allows the concept to maintain confidentiality of patients' data while preserving the functionalities of the concept.

During the study on the IHE Profiles standard, we found that the complexity of the IHE standard gave difficulty for interpretation. There are a lot of components including transaction formats, data structures, and specific protocols that are specifically designed for each IHE Profile that published separately in different volumes of IHE Framework documents. Some part of the document was deprecated or obsoleted in the present. There are a limited number of transaction samples available from the framework which makes it difficult for a beginner to develop a system that fully complies with the standard. These make the standard implementation the most time-consuming process.

For Ethereum, the usage of Smartcontract was limited by its gas requirement. Every task performed by Smartcontract requires gas which represents the computational power of the network to perform. That means there will be more factors for the platform to be addressed before the actual adoption. We suggest that the adopted network must be able to provide enough amount of gas or disregard the component from the consideration by integrating it into the common agreement amongst the networks.

5.2 Conclusion

In this work, we achieve the system prototype for the XDS Blockchain which acts as the medium for health document sharing amongst the XDS Affinity Domain Network. The prototype was designed to be compatible with normal XDS Actors while also act as a medium for a common XDS network to interface with the IBFT Blockchain ledger. This enhances the IHE XDS.b Profile with the Blockchain characteristics while appreciating the network to further share their health document to further benefit from the network for both operational interoperability and cyber-security. However, due to the ever-changing nature of the software platform, further adoption of the implementation will need to be updated as the platform released the newer version of the software to avoid version conflict of the source code.

In the implementation of the proposed concept, we excluded an XDS On-Demand Document Repository Actor and XDS Patient Identity Feed actor to reduce the complexity of the concept demonstration. For future work, those XDS Actors should also be implemented to the XDS Blockchain concept too. The XDS On-Demand Document Repository would enhance the benefit of the XDS Blockchain as it provides On-Demand health document type which gave flexibility and a wider range of usability of shared health documents to healthcare operation. At the same time, The Patient Identity Feed Actor would aid the member of the XDS Affinity Domain Blockchain network by establishing the medium identifier for all members to seamlessly share their health documents. The Patient Identity Feed Actor may even further integrate into the Smartcontract and eliminate the need for centralized identity feed in the network. Eliminate the cost which would be spent on maintaining the Patient Identity Feed Actor for the network. Furthermore, the Smartcontract also has the potential to become the exchange medium for ITI-43 transactions where the XDS Document Consumer

negotiates with XDS Document Repository for retrieving actual health documents, allow health documents exchanging activities in the network to be recorded in the Blockchain ledger which could be further used in the incident investigation during the cyber-incident. These would maximize the potential of Blockchain technology implemented on the Cross-Enterprise Document Sharing Profile.

Other than the Cross-Enterprise Document Sharing Profile, the IHE IT Infrastructure is providing much more profiles and various tools for use in achieving healthcare interoperability. There remain a lot more possibilities of using the framework to maximize the potential of Blockchain technology and the future technology to come.

As Blockchain technology still has a long way of development and research path to go through, the concept proposed in this work also could be further developed into a more advanced version for actual adoption in the future.

REFERENCE

- [1] Weinelt B. Digital Transformation of Industries. Logistics Industry, <http://reports.weforum.org/digital-transformation/wp-content/blogs.dir/94/mp/files/pages/files/digital-enterprise-narrative-final-january-2016.pdf> (2016).
- [2] Marcelo A, Medeiros D, Ramesh K, et al. Transforming Health Systems Through Good Digital Health Governance. *adb Sustain Dev Work Pap Ser* 2018; 1–15.
- [3] Shaw T, Hines M, Kielly C. *Impact of Digital Health on the Safety and Quality of Health Care*, <https://www.safetyandquality.gov.au/wp-content/uploads/2018/02/Report-The-Impact-of-Digital-Health-on-Safety-and-Quality-of-Healthcar....pdf> (2000).
- [4] Cisco. The Digitization of the Healthcare Industry: Using Technology to Transform Care. *Cisco* 2017; 1: 12.
- [5] Bullhound G. *Digital healthcare*. 2015.
- [6] Meskó B, Drobni Z, Bényei É, et al. Digital health is a cultural transformation of traditional healthcare. *mHealth* 2017; 3: 38–38.
- [7] Carestream Health. Interoperability : Connecting the Healthcare Enterprise to Deliver Responsive Patient Care. 2015; 1–9.
- [8] PolicyMedical. Interoperability in Healthcare: To Have or Not to Have, <https://www.policymedical.com/interoperability-healthcare/> (accessed 22 September 2018).
- [9] Interoperability DH. Digital Healthcare Interoperability.
- [10] Healthcare Information and Management Systems Society. Definition of Interoperability. *Himss* 2013; 2013.
- [11] Oracle. Interoperability : A Key to Meaningful Use. *Solutions*, <http://www.oracle.com/us/industries/healthcare/interoperability-wp-188782.pdf> (2010).

- [12] HIMSS. What is Interoperability?, <https://www.himss.org/library/interoperability-standards/what-is-interoperability> (accessed 27 April 2019).
- [13] Paige Goodhew. Why Healthcare Interoperability Matters | Redox, <https://www.redoxengine.com/blog/why-healthcare-interoperability-matters/> (accessed 27 April 2019).
- [14] Dr.David Hay. Why is interoperability so important for healthcare organisations? | Orion Health, <https://orionhealth.com/global/knowledge-hub/blogs/why-is-interoperability-so-important-for-healthcare-organisations/> (accessed 27 April 2019).
- [15] Le Bris A, Asri W El. STATE OF CYBERSECURITY & CYBER THREATS IN HEALTHCARE ORGANIZATIONS Applied Cybersecurity Strategy for Managers. *ESSEC Bus Sch* 2017; 13.
- [16] Healthcare IT News. The biggest healthcare breaches of 2017, <https://www.healthcareitnews.com/slideshow/biggest-healthcare-breaches-2017-so-far?page=1> (accessed 11 September 2018).
- [17] HIPAA Journal. Largest Healthcare Data Breaches of 2018, <https://www.hipaajournal.com/largest-healthcare-data-breaches-of-2018/> (accessed 27 April 2019).
- [18] Healthcare IT News. The biggest healthcare data breaches of 2018 (so far), <https://www.healthcareitnews.com/projects/biggest-healthcare-data-breaches-2018-so-far> (accessed 27 April 2019).
- [19] IHE International Inc. About IHE, https://www.ihe.net/about_ihe/ (accessed 11 September 2018).
- [20] IHE International Inc. IHE Process, https://www.ihe.net/about_ihe/ihe_process/ (accessed 11 September 2018).
- [21] IHE International Inc. Profiles, <https://www.ihe.net/resources/profiles/> (accessed 17 September 2018).
- [22] IHE International Inc. IHE IT Infrastructure (ITI) Technical Framework Volume 1 Integration Profiles. *Int J Healthc Technol Manag* 2008; 1: 1–177.
- [23] dkorolyk. What Is The Difference Between XDS,XDS.a,XDS.b and XDS-I?,

<http://healthcareitsystems.com/2012/05/22/what-is-the-difference-between-xds-xds-a-xds-b-and-xds-i/> (2012, accessed 17 February 2019).

- [24] Luke MN, Lee SJ, Pekarek Z, et al. Blockchain in Electricity: a Critical Review of Progress to Date. 2018; 1–36.
- [25] PwC. a Catalyst for New Approaches in Insurance.
- [26] Zheng Z, Xie S, Dai H, et al. An Overview of Blockchain Technology: Architecture, Consensus, and Future Trends. *Proc - 2017 IEEE 6th Int Congr Big Data, BigData Congr 2017* 2017; 557–564.
- [27] Yaga D, Mell P, Roby N, et al. Blockchain Technology Overview (NISTIR-8202). *Draft NISTIR* 2018; 59.
- [28] Buterin V. *A NEXT GENERATION SMART CONTRACT & DECENTRALIZED APPLICATION PLATFORM.*
- [29] ethereum/devp2p: Ethereum peer-to-peer networking specifications, <https://github.com/ethereum/devp2p> (accessed 3 June 2021).
- [30] Solidity Programming Language | The Solidity language portal is a comprehensive information page for the Solidity programming language. It features documentation, binaries, blog, resources & more., <https://soliditylang.org/> (accessed 3 June 2021).
- [31] Quorum. GoQuorum, <https://github.com/ConsenSys/quorum> (2020, accessed 3 June 2021).
- [32] Morgan JP. Quorum | J.P. Morgan, <https://www.jpmorgan.com/global/Quorum> (2017, accessed 26 April 2019).
- [33] Quorum 7-nodes Example, <https://github.com/ConsenSys/quorum-examples/tree/master/examples/7nodes> (accessed 3 June 2021).
- [34] Peterson K, Deeduwanu R, Kanjamala P, et al. A Blockchain-Based Approach to Health Information Exchange Networks. *Mayo Clin* 2016; 10.
- [35] Ekblaw A, Azaria A, Halamka JD, et al. A Case Study for Blockchain in Healthcare: "MedRec" prototype for electronic health records and medical research data. *IEEE Technol Soc Mag* 2016; 1–13.

- [36] Zyskind G, Nathan O, Pentland AS. Decentralizing privacy: Using Blockchain to Protect Personal Data. *Proc - 2015 IEEE Secur Priv Work SPW 2015* 2015; 180–184.
- [37] Li H, Zhu L, Shen M, et al. Blockchain-Based Data Preservation System for Medical Data. *J Med Syst* 2018; 42: 1–13.
- [38] Tanwar S, Parekh K, Evans R. Blockchain-based electronic healthcare record system for healthcare 4.0 applications. *J Inf Secur Appl* 2020; 50: 102407.
- [39] Sultan K, Ruhi U, Lakhani R. *CONCEPTUALIZING BLOCKCHAINS: CHARACTERISTICS & APPLICATIONS*,
<https://arxiv.org/ftp/arxiv/papers/1806/1806.03693.pdf> (2018, accessed 29 October 2018).
- [40] ethereum/go-ethereum: Official Go implementation of the Ethereum protocol,
<https://github.com/ethereum/go-ethereum> (accessed 5 June 2021).
- [41] Installing Geth | Go Ethereum, <https://geth.ethereum.org/docs/install-and-build/installing-geth#install-on-ubuntu-via-ppas> (accessed 10 June 2021).
- [42] Command-line Options | Go Ethereum,
<https://geth.ethereum.org/docs/interface/command-line-options> (accessed 10 June 2021).
- [43] Install - GoQuorum,
<https://docs.goquorum.consensys.net/en/stable/HowTo/GetStarted/Install/> (accessed 10 June 2021).
- [44] ConsenSys/tessera: Tessera - Enterprise Implementation of Quorum's transaction manager, <https://github.com/ConsenSys/tessera> (accessed 5 June 2021).
- [45] ConsenSys/constellation: Peer-to-peer encrypted message exchange,
<https://github.com/ConsenSys/constellation> (accessed 5 June 2021).
- [46] quorum-examples/README.md at master · ConsenSys/quorum-examples,
<https://github.com/ConsenSys/quorum-examples/blob/master/README.md> (accessed 10 June 2021).
- [47] Remix - Ethereum IDE, <https://remix.ethereum.org/> (accessed 8 March 2021).
- [48] Node.js, <https://nodejs.org/en/> (accessed 10 June 2021).

- [49] npm, <https://www.npmjs.com/> (accessed 10 June 2021).
- [50] web3 - npm, <https://www.npmjs.com/package/web3> (accessed 10 June 2021).
- [51] xml2js - npm, <https://www.npmjs.com/package/xml2js> (accessed 10 June 2021).
- [52] fs - npm, <https://www.npmjs.com/package/fs> (accessed 10 June 2021).
- [53] net - npm, <https://www.npmjs.com/package/net> (accessed 10 June 2021).
- [54] util - npm, <https://www.npmjs.com/package/util> (accessed 10 June 2021).
- [55] moment - npm, <https://www.npmjs.com/package/moment> (accessed 10 June 2021).
- [56] cryptr - npm, <https://www.npmjs.com/package/cryptr> (accessed 10 June 2021).
- [57] web3.eth.Contract — web3.js 1.0.0 documentation,
<https://web3js.readthedocs.io/en/v1.3.4/web3-eth-contract.html> (accessed 8 March 2021).

APPENDIX

A. Metadata Attributes

Table A-1 SubmissionSet

SubmissionSet Metadata Attributes	Description
author	The humans and/or machines that authored the SubmissionSet. This attribute contains the sub-attributes: authorInstitution, authorPerson, authorRole, authorSpecialty, authorTelecommunication.
availabilityStatus	The lifecycle status of the SubmissionSet.
comments	Comments associated with the SubmissionSet.
contentTypeCode	The code specifying the type of clinical activity that resulted in placing the associated content in the SubmissionSet.
entryUUID	A globally unique identifier used to manage the entry.
homeCommunityId	A globally unique identifier for a community.
intendedRecipient	The organizations or persons for whom the SubmissionSet is intended.
limitedMetadata	A flag that the associated SubmissionSet was created using the less rigorous metadata requirements as defined for the Metadata-Limited Document Source.
patientId	The patientId represents the primary subject of care of the SubmissionSet.
sourceId	Identifier of the entity that contributed the SubmissionSet.
submissionTime	Point in time at the creating entity when the SubmissionSet was created
title	The title of the SubmissionSet.
uniqueId	Globally unique identifier for the SubmissionSet assigned by the creating entity.

Table A-2 Folder

Folder Metadata Attributes	Description
availabilityStatus	The lifecycle status of the Folder.
codeList	The set of codes specifying the type of clinical activities that resulted in placing DocumentEntry objects in the Folder.
comments	Comments associated with the Folder.
entryUUID	A globally unique identifier used to manage the entry.
homeCommunityId	A globally unique identifier for a community.
lastUpdateTime	Most recent point in time that the Folder has been modified.
limitedMetadata	A flag that the associated Folder was created using the less rigorous metadata requirements as defined for the Metadata-Limited Document Source.
patientId	The patientId represents the primary subject of care of the Folder.
title	The title of the Folder
uniqueId	Globally unique identifier for the Folder.

Table A-3 DocumentEntry

DocumentEntry Metadata Attributes	Description
author	The humans and/or machines that authored the document. This attribute contains the sub-attributes: authorInstitution, authorPerson, authorRole, authorSpecialty and authorTelecommunication.
availabilityStatus	The lifecycle status of the DocumentEntry
classCode	The code specifying the high-level use classification of the document type (e.g., Report, Summary, Images, Treatment Plan, Patient Preferences, Workflow).
comment	Comments associated with the document.
confidentialityCode	The code specifying the level of confidentiality of the documented.
creationTime	The time the author created the document.
entryUUID	A globally unique identifier used to manage the entry.
eventCodeList	This list of codes represents the main clinical acts, such as a colonoscopy or an appendectomy, being documented.
formatCode	The code specifying the detailed technical format of the document.
hash	The hash of the contents of the document.
healthcareFacility TypeCode	This code represents the type of organizational setting of the clinical encounter during which the documented act occurred.
homeCommunityId	A globally unique identifier for a community.
languageCode	Specifies the human language of character data in a document.
legalAuthenticator	Represents a participant within an authorInstitution who has legally authenticated or attested the document.
limitedMetadata	Indicates whether the DocumentEntry was created using the less rigorous requirements of metadata as defined for the Metadata-Limited Document Source.

<code>mimeType</code>	MIME type of the document.
<code>objectType</code>	The type of DocumentEntry (e.g., On-Demand DocumentEntry).
<code>patientId</code>	The patientId represents the subject of care of the document.
<code>practiceSettingCode</code>	The code specifying the clinical specialty where the act that resulted in the document was performed (e.g., Family Practice, Laboratory, Radiology).
<code>referenceIdList</code>	A list of Identifiers related to the document
<code>repositoryUniqueId</code>	The globally unique identifier of the repository where the document can be accessed.
<code>serviceStartTime</code>	The start time of the service being documented.
<code>serviceStopTime</code>	The stop time of the service being documented.
<code>size</code>	Size in bytes of the document.
<code>sourcePatientId</code>	The sourcePatientId represents the subject of care's medical record identifier (e.g., Patient Id) in the local patient identifier domain of the creating entity.
<code>sourcePatientInfo</code>	This attribute contains demographic information of the source patient to whose medical record this document belongs.
<code>title</code>	The title of the document.
<code>typeCode</code>	The code specifying the precise type of document from the user perspective (e.g., LOINC code).
<code>uniqueId</code>	Globally unique identifier assigned to the document by its creator.
<code>URI</code>	The URI for the document.

B. Full content of transaction sample.

These are full content of transaction samples created for the experiment in Sections 4.3 and 4.4.

```
<?xml version='1.0' encoding='UTF-8'?>
<soapenv:Envelope xmlns:soapenv="http://www.w3.org/2003/05/soap-envelope">
  <soapenv:Header xmlns:wsa="http://www.w3.org/2005/08/addressing">
    <wsa:To soapenv:mustUnderstand="true">http://127.0.0.1:6969/</wsa:To>
    <wsa:MessageID
      soapenv:mustUnderstand="true">urn:uuid:2311B77C122650C7B91554413514373</wsa:MessageID>
    <wsa:Action soapenv:mustUnderstand="true">urn:ihe:iti:2007:RegisterDocumentSet-b</wsa:Action>
  </soapenv:Header>
  <soapenv:Body>
    <lcm:SubmitObjectsRequest xmlns:lcm="urn:oasis:names:tc:ebxml-regrep:xsd:lcm:3.0">
      <rim:RegistryObjectList xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0">
        <rim:ExtrinsicObject id="Document01" mimeType="text/plain" objectType="urn:uuid:7edca82f-054d-47f2-a032-9b2a5b5186c1" status="urn:oasis:names:tc:ebxml-regrep:StatusType:Approved">
          <rim:Slot name="size">
            <rim:ValueList>
              <rim:Value>4</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="repositoryUniqueId">
            <rim:ValueList>
              <rim:Value>1.19.6.24.109.42.1</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="hash">
            <rim:ValueList>
              <rim:Value>e543712c0e10501972de13a5bfcbe826c49feb75</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="creationTime">
            <rim:ValueList>
              <rim:Value>20061224</rim:Value>
            </rim:ValueList>
          </rim:Slot>
        </rim:ExtrinsicObject>
      </rim:RegistryObjectList>
    </lcm:SubmitObjectsRequest>
  </soapenv:Body>
</soapenv:Envelope>
```

```
</rim:Slot>

<rim:Slot name="languageCode">
  <rim:ValueList>
    <rim:Value>en-us</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="serviceStartTime">
  <rim:ValueList>
    <rim:Value>200612230800</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="serviceStopTime">
  <rim:ValueList>
    <rim:Value>200612230900</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="sourcePatientId">
  <rim:ValueList>
    <rim:Value>89765a87b^^^&#1.3.4.5&#ISO</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="sourcePatientInfo">
  <rim:ValueList>
    <rim:Value>PID-3|pid1^^^&#1.2.3&#ISO</rim:Value>
    <rim:Value>PID-5|Doe^John^^</rim:Value>
    <rim:Value>PID-7|19560527</rim:Value>
    <rim:Value>PID-8|M</rim:Value>
    <rim:Value>PID-11|100 Main St^^Metropolis||^44130^USA</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Name>
```

```
<rim:LocalizedString value="DocA"></rim:LocalizedString>
</rim:Name>
<rim:Description></rim:Description>
<rim:Classification classificationScheme="urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d"
classifiedObject="Document01" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_1">
<rim:Slot name="authorPerson">
<rim:ValueList>
<rim:Value>^Smitty^Gerald^^^</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorInstitution">
<rim:ValueList>
<rim:Value>Cleveland Clinic</rim:Value>
<rim:Value>Parma Community</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorRole">
<rim:ValueList>
<rim:Value>Attending</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorSpecialty">
<rim:ValueList>
<rim:Value>Orthopedic</rim:Value>
</rim:ValueList>
</rim:Slot>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d"
classifiedObject="Document01" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_2">
<rim:Slot name="authorPerson">
<rim:ValueList>
```

```
<rim:Value>^Dopplemeyer^Sherry^^^</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorInstitution">
<rim:ValueList>
<rim:Value>Cleveland Clinic</rim:Value>
<rim:Value>Berea Community</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorRole">
<rim:ValueList>
<rim:Value>Primary Surgeon</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorSpecialty">
<rim:ValueList>
<rim:Value>Orthopedic</rim:Value>
</rim:ValueList>
</rim:Slot>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:41a5887f-8865-4c09-adf7-e362475b143a"
classifiedObject="Document01" nodeRepresentation="PLANS" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_3">
<rim:Slot name="codingScheme">
<rim:ValueList>
<rim:Value>1.3.6.1.4.1.19376.1.2.6.1</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Name>
<rim:LocalizedString value="Treatment Plan or Protocol"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
```

```
<rim:Classification classificationScheme="urn:uuid:f4f85eac-e6cb-4883-b524-f2705394840f"
classifiedObject="Document01" nodeRepresentation="R" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_4">
    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>2.16.840.1.113883.5.25</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="Restricted"></rim:LocalizedString>
    </rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:a09d5840-386c-46f2-b5ad-9c3699a4309d"
classifiedObject="Document01" nodeRepresentation="urn:ihe:iti:bppc:2007"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_5">
    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>1.3.6.1.4.1.19376.1.2.3</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="urn:ihe:iti:bppc:2007"></rim:LocalizedString>
    </rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:f33fb8ac-18af-42cc-ae0e-ed0b0bdb91e1"
classifiedObject="Document01" nodeRepresentation="66280005" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_6">
    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>2.16.840.1.113883.6.96</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="Private home-based care"></rim:LocalizedString>
```

```
</rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:cccf5598-8b07-4b77-a05e-ae952c785ead"
classifiedObject="Document01" nodeRepresentation="Practice-D" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_7">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="Pathology"></rim:LocalizedString>

    </rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4"
classifiedObject="Document01" nodeRepresentation="urn:connectathon:bppc:fundational:policy"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_8">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="Foundational Connectathon Read-Access Policy"></rim:LocalizedString>

    </rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4"
classifiedObject="Document01" nodeRepresentation="urn:connectathon:policy:full-access"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_9">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>

        </rim:ValueList>

    </rim:Slot>
```

```
<rim:Name>
  <rim:LocalizedString value="FULL ACCESS TO ALL POLICY"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:f0306f51-975f-434e-a61c-c59651d33983"
classifiedObject="Document01" nodeRepresentation="11502-2" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_10">
  <rim:Slot name="codingScheme">
    <rim:ValueList>
      <rim:Value>2.16.840.1.113883.6.1</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Name>
    <rim:LocalizedString value="LABORATORY REPORT.TOTAL"></rim:LocalizedString>
  </rim:Name>
</rim:Classification>
<rim:ExternalIdentifier identificationScheme="urn:uuid:58a6f841-87b3-4a3e-92fd-a8ffeff98427"
value="IHEBLUE-2736^^^&1.3.6.1.4.1.21367.13.20.3000&ISO" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_11" registryObject="Document01">
  <rim:Name>
    <rim:LocalizedString value="XDSDocumentEntry.patientId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier identificationScheme="urn:uuid:2e82c1f6-a085-4c72-9da3-8640a32e42ab"
value="1.2.42.20190405034511.30" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_12" registryObject="Document01">
  <rim:Name>
    <rim:LocalizedString value="XDSDocumentEntry.uniqueId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
</rim:ExtrinsicObject>
<rim:RegistryPackage id="SubmissionSet01" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:RegistryPackage">
  <rim:Slot name="submissionTime">
    <rim:ValueList>
```

```
<rim:Value>20041225235050</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Name>
<rim:LocalizedString value="Physical"></rim:LocalizedString>
</rim:Name>
<rim:Description>
<rim:LocalizedString value="Annual physical"></rim:LocalizedString>
</rim:Description>
<rim:Classification classificationScheme="urn:uuid:a7058bb9-b4e4-4307-ba5b-e3f0ab85e12d"
classifiedObject="SubmissionSet01" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_13">
<rim:Slot name="authorPerson">
<rim:ValueList>
<rim:Value>^Dopplemeyer^Sherry^^^</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorInstitution">
<rim:ValueList>
<rim:Value>Cleveland Clinic</rim:Value>
<rim:Value>Berea Community</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorRole">
<rim:ValueList>
<rim:Value>Primary Surgeon</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorSpecialty">
<rim:ValueList>
<rim:Value>Orthopedic</rim:Value>
</rim:ValueList>
</rim:Slot>
```

```
</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:aa543740-bdda-424e-8c96-df4873be8500"
classifiedObject="SubmissionSet01" nodeRepresentation="394747008" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_14">

    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>2.16.840.1.113883.6.96</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="Health Authority"></rim:LocalizedString>
    </rim:Name>
</rim:Classification>

<rim:ExternalIdentifier identificationScheme="urn:uuid:96fdda7c-d067-4183-912e-bf5ee74998a8"
value="1.2.42.20190405034511.31" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_15" registryObject="SubmissionSet01">

    <rim:Name>
        <rim:LocalizedString value="XDSSubmissionSet.uniqueId"></rim:LocalizedString>
    </rim:Name>
</rim:ExternalIdentifier>

<rim:ExternalIdentifier identificationScheme="urn:uuid:554ac39e-e3fe-47fe-b233-965d2a147832"
value="1.3.6.1.4.1.21367.4" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_16" registryObject="SubmissionSet01">

    <rim:Name>
        <rim:LocalizedString value="XDSSubmissionSet.sourceId"></rim:LocalizedString>
    </rim:Name>
</rim:ExternalIdentifier>

<rim:ExternalIdentifier identificationScheme="urn:uuid:6b5aea1a-874d-4603-a4bc-96a0a7b38446"
value="IHEBLUE-2736&amp;1.3.6.1.4.1.21367.13.20.3000&amp;ISO" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_17" registryObject="SubmissionSet01">

    <rim:Name>
        <rim:LocalizedString value="XDSSubmissionSet.patientId"></rim:LocalizedString>
    </rim:Name>
</rim:ExternalIdentifier>
</rim:RegistryPackage>
```

```
<rim:Classification classifiedObject="SubmissionSet01" classificationNode="urn:uuid:a54d6aa5-d40d-43f9-  
88c5-b4633d873bdd" id="ID_1507585920_1" objectType="urn:oasis:names:tc:ebxml-  
regrep:ObjectType:RegistryObject:Classification">  
  
</rim:Classification>  
  
<rim:Association associationType="urn:oasis:names:tc:ebxml-regrep:AssociationType:HasMember"  
sourceObject="SubmissionSet01" targetObject="Document01" id="ID_1507585920_2"  
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Association">  
  
<rim:Slot name="SubmissionSetStatus">  
  
<rim:ValueList>  
  
<rim:Value>Original</rim:Value>  
  
</rim:ValueList>  
  
</rim:Slot>  
  
</rim:Association>  
  
</rim:RegistryObjectList>  
  
</lcm:SubmitObjectsRequest>  
  
</soapenv:Body>  
  
</soapenv:Envelope>
```

Appendix B-1 Full content of transaction sample “Tx1”

```
<?xml version='1.0' encoding='UTF-8'?>
<soapenv:Envelope xmlns:soapenv="http://www.w3.org/2003/05/soap-envelope">
  <soapenv:Header xmlns:wsa="http://www.w3.org/2005/08/addressing">
    <wsa:To soapenv:mustUnderstand="true">http://127.0.0.1:6969/</wsa:To>
    <wsa:MessageID soapenv:mustUnderstand="true">urn:uuid:2311B77C122650C7B91554413514373</wsa:MessageID>
    <wsa:Action soapenv:mustUnderstand="true">urn:ihe:iti:2007:RegisterDocumentSet-b</wsa:Action>
  </soapenv:Header>
  <soapenv:Body>
    <lcm:SubmitObjectsRequest xmlns:lcm="urn:oasis:names:tc:ebxml-regrep:xsd:lcm:3.0">
      <rim:RegistryObjectList xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0">
        <rim:ExtrinsicObject id="Document02" mimeType="text/plain" objectType="urn:uuid:7edca82f-054d-47f2-a032-9b2a5b5186c1" status="urn:oasis:names:tc:ebxml-regrep:StatusType:Approved">
          <rim:Slot name="size">
            <rim:ValueList>
              <rim:Value>4</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="repositoryUniqueId">
            <rim:ValueList>
              <rim:Value>1.19.6.24.110.42.1</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="hash">
            <rim:ValueList>
              <rim:Value>8cd7c25aa2526918fef504fea46b79a3ebf123db</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="creationTime">
            <rim:ValueList>
              <rim:Value>20070101</rim:Value>
            </rim:ValueList>
          </rim:Slot>
        </rim:ExtrinsicObject>
      </rim:RegistryObjectList>
    </lcm:SubmitObjectsRequest>
  </soapenv:Body>
</soapenv:Envelope>
```

```
</rim:Slot>

<rim:Slot name="languageCode">
  <rim:ValueList>
    <rim:Value>en-us</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="serviceStartTime">
  <rim:ValueList>
    <rim:Value>200701011800</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="serviceStopTime">
  <rim:ValueList>
    <rim:Value>200701011900</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="sourcePatientId">
  <rim:ValueList>
    <rim:Value>6b12add33^^^&#13.4.5&#ISO</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="sourcePatientInfo">
  <rim:ValueList>
    <rim:Value>PID-3|pid1^^^&#1.2.3&#ISO</rim:Value>
    <rim:Value>PID-5|Emile^Sheehan^^^</rim:Value>
    <rim:Value>PID-7|19560527</rim:Value>
    <rim:Value>PID-8|M</rim:Value>
    <rim:Value>PID-11|3094 Glen St^^Paducah^KY^42003^USA</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Name>
```

```
<rim:LocalizedString value="DocB"></rim:LocalizedString>

</rim:Name>

<rim:Description></rim:Description>

<rim:Classification classificationScheme="urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d"
classifiedObject="Document02" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_1">

    <rim:Slot name="authorPerson">

        <rim:ValueList>

            <rim:Value>^Tymoteusz^McCabe^^^</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorInstitution">

        <rim:ValueList>

            <rim:Value>Kentucky Hospital</rim:Value>

            <rim:Value>Paducah Community</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorRole">

        <rim:ValueList>

            <rim:Value>Attending</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorSpecialty">

        <rim:ValueList>

            <rim:Value>Neurology</rim:Value>

        </rim:ValueList>

    </rim:Slot>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d"
classifiedObject="Document02" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_2">

    <rim:Slot name="authorPerson">

        <rim:ValueList>
```

```
<rim:Value>^Stevie^Lamb^^</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorInstitution">
<rim:ValueList>
<rim:Value>Kentucky Hospital</rim:Value>
<rim:Value>Paducah Community</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorRole">
<rim:ValueList>
<rim:Value>Neurologist</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorSpecialty">
<rim:ValueList>
<rim:Value>Neurology</rim:Value>
</rim:ValueList>
</rim:Slot>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:41a5887f-8865-4c09-adf7-e362475b143a"
classifiedObject="Document02" nodeRepresentation="PLANS" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_3">
<rim:Slot name="codingScheme">
<rim:ValueList>
<rim:Value>1.3.6.1.4.1.19376.1.2.6.1</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Name>
<rim:LocalizedString value="Treatment Plan or Protocol"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
```

```
<rim:Classification classificationScheme="urn:uuid:f4f85eac-e6cb-4883-b524-f2705394840f"
classifiedObject="Document02" nodeRepresentation="R" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_4">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>2.16.840.1.113883.5.25</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="Restricted"></rim:LocalizedString>

    </rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:a09d5840-386c-46f2-b5ad-9c3699a4309d"
classifiedObject="Document02" nodeRepresentation="urn:ihe:iti:bppc:2007"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_5">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>1.3.6.1.4.1.19376.1.2.3</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="urn:ihe:iti:bppc:2007"></rim:LocalizedString>

    </rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:f33fb8ac-18af-42cc-ae0e-ed0b0bdb91e1"
classifiedObject="Document02" nodeRepresentation="66280005" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_6">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>2.16.840.1.113883.6.96</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="Hospital-trauma center"></rim:LocalizedString>
```

```
</rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:cccf5598-8b07-4b77-a05e-ae952c785ead"
classifiedObject="Document02" nodeRepresentation="Practice-D" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_7">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="Neurology"></rim:LocalizedString>

    </rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4"
classifiedObject="Document02" nodeRepresentation="urn:connectathon:bppc:foundational:policy"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_8">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="Foundational Connectathon Read-Access Policy"></rim:LocalizedString>

    </rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4"
classifiedObject="Document02" nodeRepresentation="urn:connectathon:policy:full-access"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_9">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>

        </rim:ValueList>

    </rim:Slot>
```

```
<rim:Name>
  <rim:LocalizedString value="FULL ACCESS TO ALL POLICY"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:f0306f51-975f-434e-a61c-c59651d33983"
classifiedObject="Document02" nodeRepresentation="11502-2" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_10">
  <rim:Slot name="codingScheme">
    <rim:ValueList>
      <rim:Value>2.16.840.1.113883.6.1</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Name>
    <rim:LocalizedString value="LABORATORY REPORT.TOTAL"></rim:LocalizedString>
  </rim:Name>
</rim:Classification>
<rim:ExternalIdentifier identificationScheme="urn:uuid:58a6f841-87b3-4a3e-92fd-a8ffeff98427"
value="IHEBLUE-2736^^&#13.6.1.4.1.27829.13.20.3000&#13;ISO" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_11" registryObject="Document02">
  <rim:Name>
    <rim:LocalizedString value="XDSDocumentEntry.patientId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier identificationScheme="urn:uuid:2e82c1f6-a085-4c72-9da3-8640a32e42ab"
value="1.2.42.17115670011797.30" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_12" registryObject="Document02">
  <rim:Name>
    <rim:LocalizedString value="XDSDocumentEntry.uniqueId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
</rim:ExtrinsicObject>
<rim:RegistryPackage id="SubmissionSet01" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:RegistryPackage">
  <rim:Slot name="submissionTime">
    <rim:ValueList>
```

```
<rim:Value>20041225235050</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Name>
  <rim:LocalizedString value="Physical"></rim:LocalizedString>
</rim:Name>
<rim:Description>
  <rim:LocalizedString value="Annual physical"></rim:LocalizedString>
</rim:Description>
<rim:Classification classificationScheme="urn:uuid:a7058bb9-b4e4-4307-ba5b-e3f0ab85e12d"
classifiedObject="SubmissionSet01" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_13">
  <rim:Slot name="authorPerson">
    <rim:ValueList>
      <rim:Value>^Stevie^Lamb^^</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Slot name="authorInstitution">
    <rim:ValueList>
      <rim:Value>Kentucky Hospital</rim:Value>
      <rim:Value>Paducah Community</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Slot name="authorRole">
    <rim:ValueList>
      <rim:Value>Neurologist</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Slot name="authorSpecialty">
    <rim:ValueList>
      <rim:Value>Neurology</rim:Value>
    </rim:ValueList>
  </rim:Slot>
```

```
</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:aa543740-bdda-424e-8c96-df4873be8500"
classifiedObject="SubmissionSet01" nodeRepresentation="394747008" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_14">

    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>2.16.840.1.113883.6.96</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="Health Authority"></rim:LocalizedString>
    </rim:Name>
</rim:Classification>

<rim:ExternalIdentifier identificationScheme="urn:uuid:96fdda7c-d067-4183-912e-bf5ee74998a8"
value="1.2.42.20190405034511.31" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_15" registryObject="SubmissionSet01">

    <rim:Name>
        <rim:LocalizedString value="XDSSubmissionSet.uniqueId"></rim:LocalizedString>
    </rim:Name>
</rim:ExternalIdentifier>

<rim:ExternalIdentifier identificationScheme="urn:uuid:554ac39e-e3fe-47fe-b233-965d2a147832"
value="1.3.6.1.4.1.21367.4" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_16" registryObject="SubmissionSet01">

    <rim:Name>
        <rim:LocalizedString value="XDSSubmissionSet.sourceId"></rim:LocalizedString>
    </rim:Name>
</rim:ExternalIdentifier>

<rim:ExternalIdentifier identificationScheme="urn:uuid:6b5aea1a-874d-4603-a4bc-96a0a7b38446"
value="IHEBLUE-2736&amp;1.3.6.1.4.1.21367.13.20.3000&amp;ISO" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_17" registryObject="SubmissionSet01">

    <rim:Name>
        <rim:LocalizedString value="XDSSubmissionSet.patientId"></rim:LocalizedString>
    </rim:Name>
</rim:ExternalIdentifier>
</rim:RegistryPackage>
```

```
<rim:Classification classifiedObject="SubmissionSet01" classificationNode="urn:uuid:a54d6aa5-d40d-43f9-  
88c5-b4633d873bdd" id="ID_1507585920_1" objectType="urn:oasis:names:tc:ebxml-  
regrep:ObjectType:RegistryObject:Classification">  
  
</rim:Classification>  
  
<rim:Association associationType="urn:oasis:names:tc:ebxml-regrep:AssociationType:HasMember"  
sourceObject="SubmissionSet01" targetObject="Document02" id="ID_1507585920_2"  
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Association">  
  
<rim:Slot name="SubmissionSetStatus">  
  
<rim:ValueList>  
  
<rim:Value>Original</rim:Value>  
  
</rim:ValueList>  
  
</rim:Slot>  
  
</rim:Association>  
  
</rim:RegistryObjectList>  
  
</lcm:SubmitObjectsRequest>  
  
</soapenv:Body>  
  
</soapenv:Envelope>
```

Appendix B-2 Full content of transaction sample “Tx2”

```
<?xml version='1.0' encoding='UTF-8'?>

<soapenv:Envelope xmlns:soapenv="http://www.w3.org/2003/05/soap-envelope">
  <soapenv:Header xmlns:wsa="http://www.w3.org/2005/08/addressing">
    <wsa:To soapenv:mustUnderstand="true">http://127.0.0.1:6969/</wsa:To>
    <wsa:MessageID soapenv:mustUnderstand="true">urn:uuid:2311B77C122650C7B91554413514373</wsa:MessageID>
    <wsa:Action soapenv:mustUnderstand="true">urn:ihe:iti:2007:RegisterDocumentSet-b</wsa:Action>
  </soapenv:Header>
  <soapenv:Body>
    <lcm:SubmitObjectsRequest xmlns:lcm="urn:oasis:names:tc:ebxml-regrep:xsd:lcm:3.0">
      <rim:RegistryObjectList xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0">
        <rim:ExtrinsicObject id="Document03" mimeType="text/plain" objectType="urn:uuid:7edca82f-054d-47f2-a032-9b2a5b5186c1" status="urn:oasis:names:tc:ebxml-regrep:StatusType:Approved">
          <rim:Slot name="size">
            <rim:ValueList>
              <rim:Value>4</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="repositoryUniqueId">
            <rim:ValueList>
              <rim:Value>1.19.6.24.111.42.1</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="hash">
            <rim:ValueList>
              <rim:Value>824d0d3f18b2008b911415101ff75abe954de8dc</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="creationTime">
            <rim:ValueList>
              <rim:Value>20070215</rim:Value>
            </rim:ValueList>
          </rim:Slot>
        </rim:ExtrinsicObject>
      </rim:RegistryObjectList>
    </lcm:SubmitObjectsRequest>
  </soapenv:Body>
</soapenv:Envelope>
```

```
</rim:Slot>

<rim:Slot name="languageCode">
  <rim:ValueList>
    <rim:Value>en-us</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="serviceStartTime">
  <rim:ValueList>
    <rim:Value>200702151000</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="serviceStopTime">
  <rim:ValueList>
    <rim:Value>200702151100</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="sourcePatientId">
  <rim:ValueList>
    <rim:Value>818f14933^^^&#13.4.5&#ISO</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="sourcePatientInfo">
  <rim:ValueList>
    <rim:Value>PID-3|pid1^^^&#1.2.3&#ISO</rim:Value>
    <rim:Value>PID-5|Alissa^Lugo^^^</rim:Value>
    <rim:Value>PID-7|19560527</rim:Value>
    <rim:Value>PID-8|F</rim:Value>
    <rim:Value>PID-11|147 Cambridge Court^^Springdale^AR^72764^USA</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Name>
```

```
<rim:LocalizedString value="DocC"></rim:LocalizedString>

</rim:Name>

<rim:Description></rim:Description>

<rim:Classification classificationScheme="urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d"
classifiedObject="Document03" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_1">

    <rim:Slot name="authorPerson">

        <rim:ValueList>

            <rim:Value>^Sharna^Hood^^^</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorInstitution">

        <rim:ValueList>

            <rim:Value>Springdale Clinic</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorRole">

        <rim:ValueList>

            <rim:Value>Attending</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorSpecialty">

        <rim:ValueList>

            <rim:Value>Physiotherapy</rim:Value>

        </rim:ValueList>

    </rim:Slot>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d"
classifiedObject="Document03" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_2">

    <rim:Slot name="authorPerson">

        <rim:ValueList>

            <rim:Value>^Romana^Woodward^^^</rim:Value>
```

```
</rim:ValueList>

</rim:Slot>

<rim:Slot name="authorInstitution">

    <rim:ValueList>

        <rim:Value>Springdale Clinic</rim:Value>

    </rim:ValueList>

</rim:Slot>

<rim:Slot name="authorRole">

    <rim:ValueList>

        <rim:Value>Physical therapist</rim:Value>

    </rim:ValueList>

</rim:Slot>

<rim:Slot name="authorSpecialty">

    <rim:ValueList>

        <rim:Value>Physiotherapy</rim:Value>

    </rim:ValueList>

</rim:Slot>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:41a5887f-8865-4c09-adf7-e362475b143a"
classifiedObject="Document03" nodeRepresentation="PLANS" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_3">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>1.3.6.1.4.1.19376.1.2.6.1</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="Treatment Plan or Protocol"></rim:LocalizedString>

    </rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:f4f85eac-e6cb-4883-b524-f2705394840f"
classifiedObject="Document03" nodeRepresentation="R" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_4">
```

```
<rim:Slot name="codingScheme">
  <rim:ValueList>
    <rim:Value>2.16.840.1.113883.5.25</rim:Value>
  </rim:ValueList>
</rim:Slot>
<rim:Name>
  <rim:LocalizedString value="Restricted"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:a09d5840-386c-46f2-b5ad-9c3699a4309d"
classifiedObject="Document03" nodeRepresentation="urn:ihe:iti:bppc:2007"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_5">
  <rim:Slot name="codingScheme">
    <rim:ValueList>
      <rim:Value>1.3.6.1.4.1.19376.1.2.3</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Name>
    <rim:LocalizedString value="urn:ihe:iti:bppc:2007"></rim:LocalizedString>
  </rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:f33fb8ac-18af-42cc-ae0e-ed0b0bdb91e1"
classifiedObject="Document03" nodeRepresentation="66280005" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_6">
  <rim:Slot name="codingScheme">
    <rim:ValueList>
      <rim:Value>2.16.840.1.113883.6.96</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Name>
    <rim:LocalizedString value="Hospital-rehabilitation"></rim:LocalizedString>
  </rim:Name>
</rim:Classification>
```

```
<rim:Classification classificationScheme="urn:uuid:cccf5598-8b07-4b77-a05e-ae952c785ead"
classifiedObject="Document03" nodeRepresentation="Practice-D" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_7">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="Rehabilitation"></rim:LocalizedString>

    </rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4"
classifiedObject="Document03" nodeRepresentation="urn:connectathon:bppc:fundational:policy"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_8">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="Foundational Connectathon Read-Access Policy"></rim:LocalizedString>

    </rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4"
classifiedObject="Document03" nodeRepresentation="urn:connectathon:policy:full-access"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_9">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="FULL ACCESS TO ALL POLICY"></rim:LocalizedString>

    </rim:Name>
```

```
</rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:f0306f51-975f-434e-a61c-c59651d33983"
classifiedObject="Document03" nodeRepresentation="11502-2" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_10">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>2.16.840.1.113883.6.1</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="LABORATORY REPORT.TOTAL"></rim:LocalizedString>

    </rim:Name>

</rim:Classification>

<rim:ExternalIdentifier identificationScheme="urn:uuid:58a6f841-87b3-4a3e-92fd-a8ffeff98427"
value="IHEBLUE-2736^^^&#1.3.6.1.4.1.56658.13.20.3000&ISO" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_11" registryObject="Document03">

    <rim:Name>

        <rim:LocalizedString value="XDSDocumentEntry.patientId"></rim:LocalizedString>

    </rim:Name>

</rim:ExternalIdentifier>

<rim:ExternalIdentifier identificationScheme="urn:uuid:2e82c1f6-a085-4c72-9da3-8640a32e42ab"
value="1.2.42.21345401333474.30" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_12" registryObject="Document03">

    <rim:Name>

        <rim:LocalizedString value="XDSDocumentEntry.uniqueld"></rim:LocalizedString>

    </rim:Name>

</rim:ExternalIdentifier>

</rim:ExtrinsicObject>

<rim:RegistryPackage id="SubmissionSet01" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:RegistryPackage">

    <rim:Slot name="submissionTime">

        <rim:ValueList>

            <rim:Value>20041225235050</rim:Value>

        </rim:ValueList>
```

```
</rim:Slot>

<rim:Name>
  <rim:LocalizedString value="Physical"></rim:LocalizedString>
</rim:Name>

<rim:Description>
  <rim:LocalizedString value="Annual physical"></rim:LocalizedString>
</rim:Description>

<rim:Classification classificationScheme="urn:uuid:a7058bb9-b4e4-4307-ba5b-e3f0ab85e12d"
classifiedObject="SubmissionSet01" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_13">

  <rim:Slot name="authorPerson">
    <rim:ValueList>
      <rim:Value>^Romana^Woodward^^^</rim:Value>
    </rim:ValueList>
  </rim:Slot>

  <rim:Slot name="authorInstitution">
    <rim:ValueList>
      <rim:Value>Springdale Clinic</rim:Value>
    </rim:ValueList>
  </rim:Slot>

  <rim:Slot name="authorRole">
    <rim:ValueList>
      <rim:Value>Physical therapist</rim:Value>
    </rim:ValueList>
  </rim:Slot>

  <rim:Slot name="authorSpecialty">
    <rim:ValueList>
      <rim:Value>Physiotherapy</rim:Value>
    </rim:ValueList>
  </rim:Slot>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:aa543740-bdda-424e-8c96-df4873be8500"
classifiedObject="SubmissionSet01" nodeRepresentation="394747008" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_14">
```

```
<rim:Slot name="codingScheme">
  <rim:ValueList>
    <rim:Value>2.16.840.1.113883.6.96</rim:Value>
  </rim:ValueList>
</rim:Slot>
<rim:Name>
  <rim:LocalizedString value="Health Authority"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
<rim:ExternalIdentifier identificationScheme="urn:uuid:96fdda7c-d067-4183-912e-bf5ee74998a8"
value="1.2.42.20190405034511.31" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_15" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.uniqueId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier identificationScheme="urn:uuid:554ac39e-e3fe-47fe-b233-965d2a147832"
value="1.3.6.1.4.1.21367.4" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_16" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.sourceId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier identificationScheme="urn:uuid:6b5aea1a-874d-4603-a4bc-96a0a7b38446"
value="IHEBLUE-2736^^^&#13.6.1.4.1.21367.13.20.3000&ISO" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_17" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.patientId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
</rim:RegistryPackage>
<rim:Classification classifiedObject="SubmissionSet01" classificationNode="urn:uuid:a54d6aa5-d40d-43f9-
88c5-b4633d873bdd" id="ID_1507585920_1" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification">
</rim:Classification>
```

```
<rim:Association associationType="urn:oasis:names:tc:ebxml-regrep:AssociationType:HasMember"
sourceObject="SubmissionSet01" targetObject="Document03" id="ID_1507585920_2"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Association">

    <rim:Slot name="SubmissionSetStatus">
        <rim:ValueList>
            <rim:Value>Original</rim:Value>
        </rim:ValueList>
    </rim:Slot>
</rim:Association>
</rim:RegistryObjectList>
</lcm:SubmitObjectsRequest>
</soapenv:Body>
</soapenv:Envelope>
```

Appendix B-3 Full content of transaction sample “Tx3”

```
<?xml version='1.0' encoding='UTF-8'?>

<soapenv:Envelope xmlns:soapenv="http://www.w3.org/2003/05/soap-envelope">
  <soapenv:Header xmlns:wsa="http://www.w3.org/2005/08/addressing">
    <wsa:To soapenv:mustUnderstand="true">http://127.0.0.1:6969/</wsa:To>
    <wsa:MessageID soapenv:mustUnderstand="true">urn:uuid:2311B77C122650C7B91554413514373</wsa:MessageID>
    <wsa:Action soapenv:mustUnderstand="true">urn:ihe:iti:2007:RegisterDocumentSet-b</wsa:Action>
  </soapenv:Header>
  <soapenv:Body>
    <lcm:SubmitObjectsRequest xmlns:lcm="urn:oasis:names:tc:ebxml-regrep:xsd:lcm:3.0">
      <rim:RegistryObjectList xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0">
        <rim:ExtrinsicObject id="Document04" mimeType="text/plain" objectType="urn:uuid:7edca82f-054d-47f2-a032-9b2a5b5186c1" status="urn:oasis:names:tc:ebxml-regrep:StatusType:Approved">
          <rim:Slot name="size">
            <rim:ValueList>
              <rim:Value>4</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="repositoryUniqueId">
            <rim:ValueList>
              <rim:Value>1.19.6.24.112.42.1</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="hash">
            <rim:ValueList>
              <rim:Value>3f1c9ea8a6743efa9f289ecc1719196098bfcbba6</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="creationTime">
            <rim:ValueList>
              <rim:Value>20070225</rim:Value>
            </rim:ValueList>
          </rim:Slot>
        </rim:ExtrinsicObject>
      </rim:RegistryObjectList>
    </lcm:SubmitObjectsRequest>
  </soapenv:Body>
</soapenv:Envelope>
```

```
</rim:Slot>

<rim:Slot name="languageCode">
  <rim:ValueList>
    <rim:Value>en-us</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="serviceStartTime">
  <rim:ValueList>
    <rim:Value>200702250800</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="serviceStopTime">
  <rim:ValueList>
    <rim:Value>200702250900</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="sourcePatientId">
  <rim:ValueList>
    <rim:Value>057a0fed7^^^&#13.4.5&#ISO</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="sourcePatientInfo">
  <rim:ValueList>
    <rim:Value>PID-3|pid1^^^&#1.2.3&#ISO</rim:Value>
    <rim:Value>PID-5|Vivek^Trevino^^</rim:Value>
    <rim:Value>PID-7|19560527</rim:Value>
    <rim:Value>PID-8|M</rim:Value>
    <rim:Value>PID-11|2061 Abia Martin Drive^^Westbury^NY^11590^USA</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Name>
```

```
<rim:LocalizedString value="DocD"></rim:LocalizedString>

</rim:Name>

<rim:Description></rim:Description>

<rim:Classification classificationScheme="urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d"
classifiedObject="Document04" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_1">

    <rim:Slot name="authorPerson">

        <rim:ValueList>

            <rim:Value>^Bear^Ryan^^^</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorInstitution">

        <rim:ValueList>

            <rim:Value>Westbury Hospital</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorRole">

        <rim:ValueList>

            <rim:Value>Attending</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorSpecialty">

        <rim:ValueList>

            <rim:Value>Urology</rim:Value>

        </rim:ValueList>

    </rim:Slot>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d"
classifiedObject="Document04" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_2">

    <rim:Slot name="authorPerson">

        <rim:ValueList>

            <rim:Value>^Sameeha^Mustafa^^^</rim:Value>
```

```
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorInstitution">
    <rim:ValueList>
        <rim:Value>Westbury Hospital</rim:Value>
    </rim:ValueList>
</rim:Slot>
<rim:Slot name="authorRole">
    <rim:ValueList>
        <rim:Value>Primary Surgeon</rim:Value>
    </rim:ValueList>
</rim:Slot>
<rim:Slot name="authorSpecialty">
    <rim:ValueList>
        <rim:Value>Urology</rim:Value>
    </rim:ValueList>
</rim:Slot>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:41a5887f-8865-4c09-adf7-e362475b143a"
classifiedObject="Document04" nodeRepresentation="PLANS" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_3">
    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>1.3.6.1.4.1.19376.1.2.6.1</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="Treatment Plan or Protocol"></rim:LocalizedString>
    </rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:f4f85eac-e6cb-4883-b524-f2705394840f"
classifiedObject="Document04" nodeRepresentation="R" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_4">
```

```
<rim:Slot name="codingScheme">
  <rim:ValueList>
    <rim:Value>2.16.840.1.113883.5.25</rim:Value>
  </rim:ValueList>
</rim:Slot>
<rim:Name>
  <rim:LocalizedString value="Restricted"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:a09d5840-386c-46f2-b5ad-9c3699a4309d"
classifiedObject="Document04" nodeRepresentation="urn:ihe:iti:bppc:2007"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_5">
  <rim:Slot name="codingScheme">
    <rim:ValueList>
      <rim:Value>1.3.6.1.4.1.19376.1.2.3</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Name>
    <rim:LocalizedString value="urn:ihe:iti:bppc:2007"></rim:LocalizedString>
  </rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:f33fb8ac-18af-42cc-ae0e-ed0b0bdb91e1"
classifiedObject="Document04" nodeRepresentation="66280005" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_6">
  <rim:Slot name="codingScheme">
    <rim:ValueList>
      <rim:Value>2.16.840.1.113883.6.96</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Name>
    <rim:LocalizedString value="Hospital-long term care"></rim:LocalizedString>
  </rim:Name>
</rim:Classification>
```

```
<rim:Classification classificationScheme="urn:uuid:cccf5598-8b07-4b77-a05e-ae952c785ead"
classifiedObject="Document04" nodeRepresentation="Practice-D" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_7">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="Urological oncology"></rim:LocalizedString>

    </rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4"
classifiedObject="Document04" nodeRepresentation="urn:connectathon:bppc:fundational:policy"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_8">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="Foundational Connectathon Read-Access Policy"></rim:LocalizedString>

    </rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4"
classifiedObject="Document04" nodeRepresentation="urn:connectathon:policy:full-access"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_9">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="FULL ACCESS TO ALL POLICY"></rim:LocalizedString>

    </rim:Name>
```

```
</rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:f0306f51-975f-434e-a61c-c59651d33983"
classifiedObject="Document04" nodeRepresentation="11502-2" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_10">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>2.16.840.1.113883.6.1</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="LABORATORY REPORT.TOTAL"></rim:LocalizedString>

    </rim:Name>

</rim:Classification>

<rim:ExternalIdentifier identificationScheme="urn:uuid:58a6f841-87b3-4a3e-92fd-a8ffeff98427"
value="IHEBLUE-2736^^^&#13.6.1.4.1.50877.13.20.3000&ISO" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_11" registryObject="Document04">

    <rim:Name>

        <rim:LocalizedString value="XDSDocumentEntry.patientId"></rim:LocalizedString>

    </rim:Name>

</rim:ExternalIdentifier>

<rim:ExternalIdentifier identificationScheme="urn:uuid:2e82c1f6-a085-4c72-9da3-8640a32e42ab"
value="1.2.42.05195861265360.30" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_12" registryObject="Document04">

    <rim:Name>

        <rim:LocalizedString value="XDSDocumentEntry.uniqueld"></rim:LocalizedString>

    </rim:Name>

</rim:ExternalIdentifier>

</rim:ExtrinsicObject>

<rim:RegistryPackage id="SubmissionSet01" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:RegistryPackage">

    <rim:Slot name="submissionTime">

        <rim:ValueList>

            <rim:Value>20041225235050</rim:Value>

        </rim:ValueList>
```

```
</rim:Slot>

<rim:Name>
  <rim:LocalizedString value="Physical"></rim:LocalizedString>
</rim:Name>

<rim:Description>
  <rim:LocalizedString value="Annual physical"></rim:LocalizedString>
</rim:Description>

<rim:Classification classificationScheme="urn:uuid:a7058bb9-b4e4-4307-ba5b-e3f0ab85e12d"
classifiedObject="SubmissionSet01" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_13">

  <rim:Slot name="authorPerson">
    <rim:ValueList>
      <rim:Value>^Sameeha^Mustafa^^^</rim:Value>
    </rim:ValueList>
  </rim:Slot>

  <rim:Slot name="authorInstitution">
    <rim:ValueList>
      <rim:Value>Westbury Hospital</rim:Value>
    </rim:ValueList>
  </rim:Slot>

  <rim:Slot name="authorRole">
    <rim:ValueList>
      <rim:Value>Primary Surgeon</rim:Value>
    </rim:ValueList>
  </rim:Slot>

  <rim:Slot name="authorSpecialty">
    <rim:ValueList>
      <rim:Value>Urology</rim:Value>
    </rim:ValueList>
  </rim:Slot>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:aa543740-bdda-424e-8c96-df4873be8500"
classifiedObject="SubmissionSet01" nodeRepresentation="394747008" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_14">
```

```
<rim:Slot name="codingScheme">
  <rim:ValueList>
    <rim:Value>2.16.840.1.113883.6.96</rim:Value>
  </rim:ValueList>
</rim:Slot>
<rim:Name>
  <rim:LocalizedString value="Health Authority"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
<rim:ExternalIdentifier identificationScheme="urn:uuid:96fdda7c-d067-4183-912e-bf5ee74998a8"
value="1.2.42.20190405034511.31" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_15" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.uniqueId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier identificationScheme="urn:uuid:554ac39e-e3fe-47fe-b233-965d2a147832"
value="1.3.6.1.4.1.21367.4" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_16" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.sourceId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier identificationScheme="urn:uuid:6b5aea1a-874d-4603-a4bc-96a0a7b38446"
value="IHEBLUE-2736^^^&#13.6.1.4.1.21367.13.20.3000&ISO" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_17" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.patientId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
</rim:RegistryPackage>
<rim:Classification classifiedObject="SubmissionSet01" classificationNode="urn:uuid:a54d6aa5-d40d-43f9-
88c5-b4633d873bdd" id="ID_1507585920_1" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification">
</rim:Classification>
```

```
<rim:Association associationType="urn:oasis:names:tc:ebxml-regrep:AssociationType:HasMember"
sourceObject="SubmissionSet01" targetObject="Document04" id="ID_1507585920_2"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Association">

    <rim:Slot name="SubmissionSetStatus">
        <rim:ValueList>
            <rim:Value>Original</rim:Value>
        </rim:ValueList>
    </rim:Slot>
</rim:Association>
</rim:RegistryObjectList>
</lcm:SubmitObjectsRequest>
</soapenv:Body>
</soapenv:Envelope>
```

Appendix B-4 Full content of transaction sample “Tx4”

```
<?xml version='1.0' encoding='UTF-8'?>

<soapenv:Envelope xmlns:soapenv="http://www.w3.org/2003/05/soap-envelope">
  <soapenv:Header xmlns:wsa="http://www.w3.org/2005/08/addressing">
    <wsa:To soapenv:mustUnderstand="true">http://127.0.0.1:6969/</wsa:To>
    <wsa:MessageID
      soapenv:mustUnderstand="true">urn:uuid:2311B77C122650C7B91554413514373</wsa:MessageID>
    <wsa:Action soapenv:mustUnderstand="true">urn:ihe:iti:2007:RegisterDocumentSet-b</wsa:Action>
  </soapenv:Header>
  <soapenv:Body>
    <lcm:SubmitObjectsRequest xmlns:lcm="urn:oasis:names:tc:ebxml-regrep:xsd:lcm:3.0">
      <rim:RegistryObjectList xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0">
        <rim:ExtrinsicObject id="Document05" mimeType="text/plain" objectType="urn:uuid:7edca82f-054d-47f2-a032-9b2a5b5186c1" status="urn:oasis:names:tc:ebxml-regrep>StatusType:Approved">
          <rim:Slot name="size">
            <rim:ValueList>
              <rim:Value>4</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="repositoryUniqueId">
            <rim:ValueList>
              <rim:Value>1.19.6.24.113.42.1</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="hash">
            <rim:ValueList>
              <rim:Value>b7ba19a806546ab34d1b0df2569889d2aee9092d</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="creationTime">
            <rim:ValueList>
              <rim:Value>20070302</rim:Value>
            </rim:ValueList>
          </rim:Slot>
        </rim:ExtrinsicObject>
      </rim:RegistryObjectList>
    </lcm:SubmitObjectsRequest>
  </soapenv:Body>
</soapenv:Envelope>
```

```
</rim:Slot>

<rim:Slot name="languageCode">
  <rim:ValueList>
    <rim:Value>en-us</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="serviceStartTime">
  <rim:ValueList>
    <rim:Value>200703021300</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="serviceStopTime">
  <rim:ValueList>
    <rim:Value>200703021530</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="sourcePatientId">
  <rim:ValueList>
    <rim:Value>2cf8cd9ce^^^&1.3.4.5&ISO</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="sourcePatientInfo">
  <rim:ValueList>
    <rim:Value>PID-3|pid1^^^&1.2.3&ISO</rim:Value>
    <rim:Value>PID-5|Rui^Corbett^^</rim:Value>
    <rim:Value>PID-7|19560527</rim:Value>
    <rim:Value>PID-8|M</rim:Value>
    <rim:Value>PID-11|3870 Ocala Street^^Winter Park^FL^32789^USA</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Name>
```

```
<rim:LocalizedString value="DocE"></rim:LocalizedString>

</rim:Name>

<rim:Description></rim:Description>

<rim:Classification classificationScheme="urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d"
classifiedObject="Document05" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_1">

    <rim:Slot name="authorPerson">

        <rim:ValueList>

            <rim:Value>^Katy^Cairns^^^</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorInstitution">

        <rim:ValueList>

            <rim:Value>Winter Park Hospital</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorRole">

        <rim:ValueList>

            <rim:Value>Attending</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorSpecialty">

        <rim:ValueList>

            <rim:Value>Nephrology</rim:Value>

        </rim:ValueList>

    </rim:Slot>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d"
classifiedObject="Document05" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_2">

    <rim:Slot name="authorPerson">

        <rim:ValueList>

            <rim:Value>^Anabel^Delarosa^^^</rim:Value>
```

```
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorInstitution">
  <rim:ValueList>
    <rim:Value>Winter Park Hospital</rim:Value>
  </rim:ValueList>
</rim:Slot>
<rim:Slot name="authorRole">
  <rim:ValueList>
    <rim:Value>Nephrologist</rim:Value>
  </rim:ValueList>
</rim:Slot>
<rim:Slot name="authorSpecialty">
  <rim:ValueList>
    <rim:Value>Nephrology</rim:Value>
  </rim:ValueList>
</rim:Slot>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:41a5887f-8865-4c09-adf7-e362475b143a"
classifiedObject="Document05" nodeRepresentation="PLANS" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_3">
  <rim:Slot name="codingScheme">
    <rim:ValueList>
      <rim:Value>1.3.6.1.4.1.19376.1.2.6.1</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Name>
    <rim:LocalizedString value="Treatment Plan or Protocol"></rim:LocalizedString>
  </rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:f4f85eac-e6cb-4883-b524-f2705394840f"
classifiedObject="Document05" nodeRepresentation="R" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_4">
```

```
<rim:Slot name="codingScheme">
  <rim:ValueList>
    <rim:Value>2.16.840.1.113883.5.25</rim:Value>
  </rim:ValueList>
</rim:Slot>
<rim:Name>
  <rim:LocalizedString value="Restricted"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:a09d5840-386c-46f2-b5ad-9c3699a4309d"
classifiedObject="Document05" nodeRepresentation="urn:ihe:iti:bppc:2007"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_5">
  <rim:Slot name="codingScheme">
    <rim:ValueList>
      <rim:Value>1.3.6.1.4.1.19376.1.2.3</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Name>
    <rim:LocalizedString value="urn:ihe:iti:bppc:2007"></rim:LocalizedString>
  </rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:f33fb8ac-18af-42cc-ae0e-ed0b0bdb91e1"
classifiedObject="Document05" nodeRepresentation="66280005" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_6">
  <rim:Slot name="codingScheme">
    <rim:ValueList>
      <rim:Value>2.16.840.1.113883.6.96</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Name>
    <rim:LocalizedString value="Dialysis unit--hospital"></rim:LocalizedString>
  </rim:Name>
</rim:Classification>
```

```
<rim:Classification classificationScheme="urn:uuid:cccf5598-8b07-4b77-a05e-ae952c785ead"
classifiedObject="Document05" nodeRepresentation="Practice-D" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_7">
    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="Nephrology"></rim:LocalizedString>
    </rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4"
classifiedObject="Document05" nodeRepresentation="urn:connectathon:bppc:fundational:policy"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_8">
    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="Foundational Connectathon Read-Access Policy"></rim:LocalizedString>
    </rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4"
classifiedObject="Document05" nodeRepresentation="urn:connectathon:policy:full-access"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_9">
    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="FULL ACCESS TO ALL POLICY"></rim:LocalizedString>
```

```
</rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:f0306f51-975f-434e-a61c-c59651d33983"
classifiedObject="Document05" nodeRepresentation="11502-2" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_10">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>2.16.840.1.113883.6.1</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="LABORATORY REPORT.TOTAL"></rim:LocalizedString>

    </rim:Name>

    </rim:Classification>

    <rim:ExternalIdentifier identificationScheme="urn:uuid:58a6f841-87b3-4a3e-92fd-a8ffeff98427"
value="IHEBLUE-2736^^&#13.6.1.4.1.20232.13.20.3000&ISO" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_11" registryObject="Document05">

        <rim:Name>

            <rim:LocalizedString value="XDSDocumentEntry.patientId"></rim:LocalizedString>

        </rim:Name>

    </rim:ExternalIdentifier>

    <rim:ExternalIdentifier identificationScheme="urn:uuid:2e82c1f6-a085-4c72-9da3-8640a32e42ab"
value="1.2.42.62551796790265.30" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_12" registryObject="Document05">

        <rim:Name>

            <rim:LocalizedString value="XDSDocumentEntry.uniqueId"></rim:LocalizedString>

        </rim:Name>

    </rim:ExternalIdentifier>

</rim:ExtrinsicObject>

<rim:RegistryPackage id="SubmissionSet01" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:RegistryPackage">

    <rim:Slot name="submissionTime">

        <rim:ValueList>

            <rim:Value>20041225235050</rim:Value>

        </rim:ValueList>

    </rim:Slot>

</rim:RegistryPackage>
```

```
</rim:Slot>

<rim:Name>
  <rim:LocalizedString value="Physical"></rim:LocalizedString>
</rim:Name>
<rim:Description>
  <rim:LocalizedString value="Annual physical"></rim:LocalizedString>
</rim:Description>

<rim:Classification classificationScheme="urn:uuid:a7058bb9-b4e4-4307-ba5b-e3f0ab85e12d"
classifiedObject="SubmissionSet01" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_13">
  <rim:Slot name="authorPerson">
    <rim:ValueList>
      <rim:Value>^Anabel^Delarosa^^^</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Slot name="authorInstitution">
    <rim:ValueList>
      <rim:Value>Winter Park Hospital</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Slot name="authorRole">
    <rim:ValueList>
      <rim:Value>Nephrologist</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Slot name="authorSpecialty">
    <rim:ValueList>
      <rim:Value>Nephrology</rim:Value>
    </rim:ValueList>
  </rim:Slot>
</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:aa543740-bdda-424e-8c96-df4873be8500"
classifiedObject="SubmissionSet01" nodeRepresentation="394747008" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_14">
```

```
<rim:Slot name="codingScheme">
  <rim:ValueList>
    <rim:Value>2.16.840.1.113883.6.96</rim:Value>
  </rim:ValueList>
</rim:Slot>
<rim:Name>
  <rim:LocalizedString value="Health Authority"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
<rim:ExternalIdentifier identificationScheme="urn:uuid:96fdda7c-d067-4183-912e-bf5ee74998a8"
value="1.2.42.20190405034511.31" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_15" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.uniqueId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier identificationScheme="urn:uuid:554ac39e-e3fe-47fe-b233-965d2a147832"
value="1.3.6.1.4.1.21367.4" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_16" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.sourceId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier identificationScheme="urn:uuid:6b5aea1a-874d-4603-a4bc-96a0a7b38446"
value="IHEBLUE-2736^^&#136.1.4.1.21367.13.20.3000&ISO" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_17" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.patientId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
</rim:RegistryPackage>
<rim:Classification classifiedObject="SubmissionSet01" classificationNode="urn:uuid:a54d6aa5-d40d-43f9-
88c5-b4633d873bdd" id="ID_1507585920_1" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification">
</rim:Classification>
```

```
<rim:Association associationType="urn:oasis:names:tc:ebxml-regrep:AssociationType:HasMember"
sourceObject="SubmissionSet01" targetObject="Document05" id="ID_1507585920_2"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Association">

<rim:Slot name="SubmissionSetStatus">
  <rim:ValueList>
    <rim:Value>Original</rim:Value>
  </rim:ValueList>
</rim:Slot>
</rim:Association>
</rim:RegistryObjectList>
</lcm:SubmitObjectsRequest>
</soapenv:Body>
</soapenv:Envelope>
```

Appendix B-5 Full content of transaction sample “Tx5”

```
<?xml version='1.0' encoding='UTF-8'?>

<soapenv:Envelope xmlns:soapenv="http://www.w3.org/2003/05/soap-envelope">
  <soapenv:Header xmlns:wsa="http://www.w3.org/2005/08/addressing">
    <wsa:To soapenv:mustUnderstand="true">http://127.0.0.1:6969/</wsa:To>
    <wsa:MessageID
      soapenv:mustUnderstand="true">urn:uuid:2311B77C122650C7B91554413514373</wsa:MessageID>
    <wsa:Action soapenv:mustUnderstand="true">urn:ihe:iti:2007:RegisterDocumentSet-b</wsa:Action>
  </soapenv:Header>
  <soapenv:Body>
    <lcm:SubmitObjectsRequest xmlns:lcm="urn:oasis:names:tc:ebxml-regrep:xsd:lcm:3.0">
      <rim:RegistryObjectList xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0">
        <rim:ExtrinsicObject id="Document06" mimeType="text/plain" objectType="urn:uuid:7edca82f-054d-47f2-a032-9b2a5b5186c1" status="urn:oasis:names:tc:ebxml-regrep:StatusType:Approved">
          <rim:Slot name="size">
            <rim:ValueList>
              <rim:Value>4</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="repositoryUniqueId">
            <rim:ValueList>
              <rim:Value>1.19.6.24.114.42.1</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="hash">
            <rim:ValueList>
              <rim:Value>ceb184540ee6704b82af22ea23c8c76a8bba4dc3</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="creationTime">
            <rim:ValueList>
              <rim:Value>20070317</rim:Value>
            </rim:ValueList>
          </rim:Slot>
        </rim:ExtrinsicObject>
      </rim:RegistryObjectList>
    </lcm:SubmitObjectsRequest>
  </soapenv:Body>
</soapenv:Envelope>
```

```
</rim:Slot>

<rim:Slot name="languageCode">
  <rim:ValueList>
    <rim:Value>en-us</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="serviceStartTime">
  <rim:ValueList>
    <rim:Value>200703170800</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="serviceStopTime">
  <rim:ValueList>
    <rim:Value>200703170900</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="sourcePatientId">
  <rim:ValueList>
    <rim:Value>1ea6205bb^^^&1.3.4.5&ISO</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="sourcePatientInfo">
  <rim:ValueList>
    <rim:Value>PID-3|pid1^^^&1.2.3&ISO</rim:Value>
    <rim:Value>PID-5|Maira^Chambers^^^</rim:Value>
    <rim:Value>PID-7|19560527</rim:Value>
    <rim:Value>PID-8|F</rim:Value>
    <rim:Value>PID-11|2352 Modoc Alley^^Preston^ID^83263^USA</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Name>
```

```
<rim:LocalizedString value="DocF"></rim:LocalizedString>
</rim:Name>
<rim:Description></rim:Description>
<rim:Classification classificationScheme="urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d"
classifiedObject="Document06" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_1">
<rim:Slot name="authorPerson">
<rim:ValueList>
<rim:Value>^TJay^ODoherty^^^</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorInstitution">
<rim:ValueList>
<rim:Value>Preston Hospital</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorRole">
<rim:ValueList>
<rim:Value>Attending</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorSpecialty">
<rim:ValueList>
<rim:Value>Gynaecology</rim:Value>
</rim:ValueList>
</rim:Slot>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d"
classifiedObject="Document06" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_2">
<rim:Slot name="authorPerson">
<rim:ValueList>
<rim:Value>^Lilia^Hood^^^</rim:Value>
```

```
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorInstitution">
    <rim:ValueList>
        <rim:Value>Preston Hospital</rim:Value>
    </rim:ValueList>
</rim:Slot>
<rim:Slot name="authorRole">
    <rim:ValueList>
        <rim:Value>Gynaecologist</rim:Value>
    </rim:ValueList>
</rim:Slot>
<rim:Slot name="authorSpecialty">
    <rim:ValueList>
        <rim:Value>Gynaecology</rim:Value>
    </rim:ValueList>
</rim:Slot>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:41a5887f-8865-4c09-adf7-e362475b143a"
classifiedObject="Document06" nodeRepresentation="PLANS" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_3">
    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>1.3.6.1.4.1.19376.1.2.6.1</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="Treatment Plan or Protocol"></rim:LocalizedString>
    </rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:f4f85eac-e6cb-4883-b524-f2705394840f"
classifiedObject="Document06" nodeRepresentation="R" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_4">
```

```
<rim:Slot name="codingScheme">
  <rim:ValueList>
    <rim:Value>2.16.840.1.113883.5.25</rim:Value>
  </rim:ValueList>
</rim:Slot>
<rim:Name>
  <rim:LocalizedString value="Restricted"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:a09d5840-386c-46f2-b5ad-9c3699a4309d"
classifiedObject="Document06" nodeRepresentation="urn:ihe:iti:bppc:2007"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_5">
  <rim:Slot name="codingScheme">
    <rim:ValueList>
      <rim:Value>1.3.6.1.4.1.19376.1.2.3</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Name>
    <rim:LocalizedString value="urn:ihe:iti:bppc:2007"></rim:LocalizedString>
  </rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:f33fb8ac-18af-42cc-ae0e-ed0b0bdb91e1"
classifiedObject="Document06" nodeRepresentation="66280005" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_6">
  <rim:Slot name="codingScheme">
    <rim:ValueList>
      <rim:Value>2.16.840.1.113883.6.96</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Name>
    <rim:LocalizedString value="Hospital-government"></rim:LocalizedString>
  </rim:Name>
</rim:Classification>
```

```
<rim:Classification classificationScheme="urn:uuid:cccf5598-8b07-4b77-a05e-ae952c785ead"
classifiedObject="Document06" nodeRepresentation="Practice-D" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_7">

    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="Gynecological oncology"></rim:LocalizedString>
    </rim:Name>
</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4"
classifiedObject="Document06" nodeRepresentation="urn:connectathon:bppc:fundational:policy"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_8">

    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="Foundational Connectathon Read-Access Policy"></rim:LocalizedString>
    </rim:Name>
</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4"
classifiedObject="Document06" nodeRepresentation="urn:connectathon:policy:full-access"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_9">

    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="FULL ACCESS TO ALL POLICY"></rim:LocalizedString>
    </rim:Name>
</rim:Classification>
```

```
</rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:f0306f51-975f-434e-a61c-c59651d33983"
classifiedObject="Document06" nodeRepresentation="11502-2" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_10">
<rim:Slot name="codingScheme">
<rim:ValueList>
<rim:Value>2.16.840.1.113883.6.1</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Name>
<rim:LocalizedString value="LABORATORY REPORT.TOTAL"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
<rim:ExternalIdentifier identificationScheme="urn:uuid:58a6f841-87b3-4a3e-92fd-a8feff98427"
value="IHEBLUE-2736^^&#13.6.1.4.1.28694.13.20.3000&ISO" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_11" registryObject="Document06">
<rim:Name>
<rim:LocalizedString value="XDSDocumentEntry.patientId"></rim:LocalizedString>
</rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier identificationScheme="urn:uuid:2e82c1f6-a085-4c72-9da3-8640a32e42ab"
value="1.2.42.20558236010995.30" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_12" registryObject="Document06">
<rim:Name>
<rim:LocalizedString value="XDSDocumentEntry.uniqueId"></rim:LocalizedString>
</rim:Name>
</rim:ExternalIdentifier>
</rim:ExtrinsicObject>
<rim:RegistryPackage id="SubmissionSet01" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:RegistryPackage">
<rim:Slot name="submissionTime">
<rim:ValueList>
<rim:Value>20041225235050</rim:Value>
</rim:ValueList>
```

```
</rim:Slot>

<rim:Name>
  <rim:LocalizedString value="Physical"></rim:LocalizedString>
</rim:Name>
<rim:Description>
  <rim:LocalizedString value="Annual physical"></rim:LocalizedString>
</rim:Description>

<rim:Classification classificationScheme="urn:uuid:a7058bb9-b4e4-4307-ba5b-e3f0ab85e12d"
classifiedObject="SubmissionSet01" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_13">
  <rim:Slot name="authorPerson">
    <rim:ValueList>
      <rim:Value>^Lillia^Hood^^^</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Slot name="authorInstitution">
    <rim:ValueList>
      <rim:Value>Preston Hospital</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Slot name="authorRole">
    <rim:ValueList>
      <rim:Value>Gynaecologist</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Slot name="authorSpecialty">
    <rim:ValueList>
      <rim:Value>Gynaecology</rim:Value>
    </rim:ValueList>
  </rim:Slot>
</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:aa543740-bdda-424e-8c96-df4873be8500"
classifiedObject="SubmissionSet01" nodeRepresentation="394747008" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_14">
```

```
<rim:Slot name="codingScheme">
  <rim:ValueList>
    <rim:Value>2.16.840.1.113883.6.96</rim:Value>
  </rim:ValueList>
</rim:Slot>
<rim:Name>
  <rim:LocalizedString value="Health Authority"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
<rim:ExternalIdentifier identificationScheme="urn:uuid:96fdda7c-d067-4183-912e-bf5ee74998a8"
value="1.2.42.20190405034511.31" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_15" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.uniqueId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier identificationScheme="urn:uuid:554ac39e-e3fe-47fe-b233-965d2a147832"
value="1.3.6.1.4.1.21367.4" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_16" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.sourceId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier identificationScheme="urn:uuid:6b5aea1a-874d-4603-a4bc-96a0a7b38446"
value="IHEBLUE-2736^^&1.3.6.1.4.1.21367.13.20.3000&ISO" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_17" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.patientId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
</rim:RegistryPackage>
<rim:Classification classifiedObject="SubmissionSet01" classificationNode="urn:uuid:a54d6aa5-d40d-43f9-
88c5-b4633d873bdd" id="ID_1507585920_1" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification">
</rim:Classification>
```

```
<rim:Association associationType="urn:oasis:names:tc:ebxml-regrep:AssociationType:HasMember"
sourceObject="SubmissionSet01" targetObject="Document06" id="ID_1507585920_2"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Association">

<rim:Slot name="SubmissionSetStatus">
  <rim:ValueList>
    <rim:Value>Original</rim:Value>
  </rim:ValueList>
</rim:Slot>
</rim:Association>
</rim:RegistryObjectList>
</lcm:SubmitObjectsRequest>
</soapenv:Body>
</soapenv:Envelope>
```

Appendix B-6 Full content of transaction sample “Tx6”

```
<?xml version='1.0' encoding='UTF-8'?>

<soapenv:Envelope xmlns:soapenv="http://www.w3.org/2003/05/soap-envelope">

  <soapenv:Header xmlns:wsa="http://www.w3.org/2005/08/addressing">
    <wsa:To soapenv:mustUnderstand="true">http://127.0.0.1:6969/</wsa:To>
    <wsa:MessageID
      soapenv:mustUnderstand="true">urn:uuid:2311B77C122650C7B91554413514373</wsa:MessageID>
    <wsa:Action soapenv:mustUnderstand="true">urn:ihe:iti:2007:RegisterDocumentSet-b</wsa:Action>
  </soapenv:Header>

  <soapenv:Body>
    <lcm:SubmitObjectsRequest xmlns:lcm="urn:oasis:names:tc:ebxml-regrep:xsd:lcm:3.0">
      <rim:RegistryObjectList xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0">
        <rim:ExtrinsicObject id="Document07" mimeType="text/plain" objectType="urn:uuid:7edca82f-054d-47f2-a032-9b2a5b5186c1" status="urn:oasis:names:tc:ebxml-regrep>StatusType:Approved">
          <rim:Slot name="size">
            <rim:ValueList>
              <rim:Value>4</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="repositoryUniqueId">
            <rim:ValueList>
              <rim:Value>1.19.6.24.115.42.1</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="hash">
            <rim:ValueList>
              <rim:Value>2ea5f1f52a743115d722db1f4a3cc8c4c738b476</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="creationTime">
            <rim:ValueList>
              <rim:Value>20070403</rim:Value>
            </rim:ValueList>
          </rim:Slot>
        </rim:ExtrinsicObject>
      </rim:RegistryObjectList>
    </lcm:SubmitObjectsRequest>
  </soapenv:Body>
</soapenv:Envelope>
```

```
</rim:Slot>

<rim:Slot name="languageCode">
  <rim:ValueList>
    <rim:Value>en-us</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="serviceStartTime">
  <rim:ValueList>
    <rim:Value>200704030900</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="serviceStopTime">
  <rim:ValueList>
    <rim:Value>200704031000</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="sourcePatientId">
  <rim:ValueList>
    <rim:Value>9926a4bf6^^^&#13.4.5&#13;ISO</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="sourcePatientInfo">
  <rim:ValueList>
    <rim:Value>PID-3|pid1^^^&#12.3&#13;ISO</rim:Value>
    <rim:Value>PID-5|Kaiya^Zamora^^^</rim:Value>
    <rim:Value>PID-7|19560527</rim:Value>
    <rim:Value>PID-8|F</rim:Value>
    <rim:Value>PID-11|1269 Hall Street^^North Las Vegas^NV^89030^USA</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Name>
```

```
<rim:LocalizedString value="DocG"></rim:LocalizedString>

</rim:Name>

<rim:Description></rim:Description>

<rim:Classification classificationScheme="urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d"
classifiedObject="Document07" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_1">

    <rim:Slot name="authorPerson">

        <rim:ValueList>

            <rim:Value>^Mujtaba^Palacios^^^</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorInstitution">

        <rim:ValueList>

            <rim:Value>Nevada Hospital</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorRole">

        <rim:ValueList>

            <rim:Value>Attending</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorSpecialty">

        <rim:ValueList>

            <rim:Value>Physiology</rim:Value>

        </rim:ValueList>

    </rim:Slot>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d"
classifiedObject="Document07" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_2">

    <rim:Slot name="authorPerson">

        <rim:ValueList>

            <rim:Value>^Jolie^Parker^^^</rim:Value>
```

```
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorInstitution">
  <rim:ValueList>
    <rim:Value>Nevada Hospital</rim:Value>
  </rim:ValueList>
</rim:Slot>
<rim:Slot name="authorRole">
  <rim:ValueList>
    <rim:Value>Primary Physiologist</rim:Value>
  </rim:ValueList>
</rim:Slot>
<rim:Slot name="authorSpecialty">
  <rim:ValueList>
    <rim:Value>Physiology</rim:Value>
  </rim:ValueList>
</rim:Slot>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:41a5887f-8865-4c09-adf7-e362475b143a"
classifiedObject="Document07" nodeRepresentation="PLANS" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_3">
  <rim:Slot name="codingScheme">
    <rim:ValueList>
      <rim:Value>1.3.6.1.4.1.19376.1.2.6.1</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Name>
    <rim:LocalizedString value="Treatment Plan or Protocol"></rim:LocalizedString>
  </rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:f4f85eac-e6cb-4883-b524-f2705394840f"
classifiedObject="Document07" nodeRepresentation="R" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_4">
```

```
<rim:Slot name="codingScheme">
  <rim:ValueList>
    <rim:Value>2.16.840.1.113883.5.25</rim:Value>
  </rim:ValueList>
</rim:Slot>
<rim:Name>
  <rim:LocalizedString value="Restricted"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:a09d5840-386c-46f2-b5ad-9c3699a4309d"
classifiedObject="Document07" nodeRepresentation="urn:ihe:iti:bppc:2007"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_5">
  <rim:Slot name="codingScheme">
    <rim:ValueList>
      <rim:Value>1.3.6.1.4.1.19376.1.2.3</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Name>
    <rim:LocalizedString value="urn:ihe:iti:bppc:2007"></rim:LocalizedString>
  </rim:Name>
  </rim:Classification>
<rim:Classification classificationScheme="urn:uuid:f33fb8ac-18af-42cc-ae0e-ed0b0bdb91e1"
classifiedObject="Document07" nodeRepresentation="66280005" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_6">
  <rim:Slot name="codingScheme">
    <rim:ValueList>
      <rim:Value>2.16.840.1.113883.6.96</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Name>
    <rim:LocalizedString value="Hospital-community"></rim:LocalizedString>
  </rim:Name>
  </rim:Classification>
```

```
<rim:Classification classificationScheme="urn:uuid:cccf5598-8b07-4b77-a05e-ae952c785ead"
classifiedObject="Document07" nodeRepresentation="Practice-D" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_7">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="General practice"></rim:LocalizedString>

    </rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4"
classifiedObject="Document07" nodeRepresentation="urn:connectathon:bppc:foundation:policy"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_8">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="Foundational Connectathon Read-Access Policy"></rim:LocalizedString>

    </rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4"
classifiedObject="Document07" nodeRepresentation="urn:connectathon:policy:full-access"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_9">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="FULL ACCESS TO ALL POLICY"></rim:LocalizedString>
```

```
</rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:f0306f51-975f-434e-a61c-c59651d33983"
classifiedObject="Document07" nodeRepresentation="11502-2" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_10">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>2.16.840.1.113883.6.1</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="LABORATORY REPORT.TOTAL"></rim:LocalizedString>

    </rim:Name>

</rim:Classification>

<rim:ExternalIdentifier identificationScheme="urn:uuid:58a6f841-87b3-4a3e-92fd-a8ffeff98427"
value="IHEBLUE-2736^^&#13.6.1.4.1.41480.13.20.3000&#13;ISO" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_11" registryObject="Document07">

    <rim:Name>

        <rim:LocalizedString value="XDSDocumentEntry.patientId"></rim:LocalizedString>

    </rim:Name>

</rim:ExternalIdentifier>

<rim:ExternalIdentifier identificationScheme="urn:uuid:2e82c1f6-a085-4c72-9da3-8640a32e42ab"
value="1.2.42.55694976369743.30" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_12" registryObject="Document07">

    <rim:Name>

        <rim:LocalizedString value="XDSDocumentEntry.uniqueId"></rim:LocalizedString>

    </rim:Name>

</rim:ExternalIdentifier>

</rim:ExtrinsicObject>

<rim:RegistryPackage id="SubmissionSet01" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:RegistryPackage">

    <rim:Slot name="submissionTime">

        <rim:ValueList>

            <rim:Value>20041225235050</rim:Value>

        </rim:ValueList>

    </rim:Slot>

</rim:RegistryPackage>
```

```
</rim:Slot>

<rim:Name>
  <rim:LocalizedString value="Physical"></rim:LocalizedString>
</rim:Name>
<rim:Description>
  <rim:LocalizedString value="Annual physical"></rim:LocalizedString>
</rim:Description>

<rim:Classification classificationScheme="urn:uuid:a7058bb9-b4e4-4307-ba5b-e3f0ab85e12d"
classifiedObject="SubmissionSet01" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_13">
  <rim:Slot name="authorPerson">
    <rim:ValueList>
      <rim:Value>^Jolie^Parker^^^</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Slot name="authorInstitution">
    <rim:ValueList>
      <rim:Value>Nevada Hospital</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Slot name="authorRole">
    <rim:ValueList>
      <rim:Value>Primary Physiologist</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Slot name="authorSpecialty">
    <rim:ValueList>
      <rim:Value>Physiology</rim:Value>
    </rim:ValueList>
  </rim:Slot>
</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:aa543740-bdda-424e-8c96-df4873be8500"
classifiedObject="SubmissionSet01" nodeRepresentation="394747008" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_14">
```

```
<rim:Slot name="codingScheme">
  <rim:ValueList>
    <rim:Value>2.16.840.1.113883.6.96</rim:Value>
  </rim:ValueList>
</rim:Slot>
<rim:Name>
  <rim:LocalizedString value="Health Authority"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
<rim:ExternalIdentifier identificationScheme="urn:uuid:96fdda7c-d067-4183-912e-bf5ee74998a8"
value="1.2.42.20190405034511.31" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_15" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.uniqueId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier identificationScheme="urn:uuid:554ac39e-e3fe-47fe-b233-965d2a147832"
value="1.3.6.1.4.1.21367.4" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_16" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.sourceId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier identificationScheme="urn:uuid:6b5aea1a-874d-4603-a4bc-96a0a7b38446"
value="IHEBLUE-2736^^&#13.6.1.4.1.21367.13.20.3000&ISO" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_17" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.patientId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
</rim:RegistryPackage>
<rim:Classification classifiedObject="SubmissionSet01" classificationNode="urn:uuid:a54d6aa5-d40d-43f9-
88c5-b4633d873bdd" id="ID_1507585920_1" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification">
</rim:Classification>
```

```
<rim:Association associationType="urn:oasis:names:tc:ebxml-regrep:AssociationType:HasMember"
sourceObject="SubmissionSet01" targetObject="Document07" id="ID_1507585920_2"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Association">

    <rim:Slot name="SubmissionSetStatus">
        <rim:ValueList>
            <rim:Value>Original</rim:Value>
        </rim:ValueList>
    </rim:Slot>
</rim:Association>
</rim:RegistryObjectList>
</lcm:SubmitObjectsRequest>
</soapenv:Body>
</soapenv:Envelope>
```

Appendix B-7 Full content of transaction sample “Tx7”

```
<?xml version='1.0' encoding='UTF-8'?>

<soapenv:Envelope xmlns:soapenv="http://www.w3.org/2003/05/soap-envelope">
  <soapenv:Header xmlns:wsa="http://www.w3.org/2005/08/addressing">
    <wsa:To soapenv:mustUnderstand="true">http://127.0.0.1:6969/</wsa:To>
    <wsa:MessageID
      soapenv:mustUnderstand="true">urn:uuid:2311B77C122650C7B91554413514373</wsa:MessageID>
    <wsa:Action soapenv:mustUnderstand="true">urn:ihe:iti:2007:RegisterDocumentSet-b</wsa:Action>
  </soapenv:Header>
  <soapenv:Body>
    <lcm:SubmitObjectsRequest xmlns:lcm="urn:oasis:names:tc:ebxml-regrep:xsd:lcm:3.0">
      <rim:RegistryObjectList xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0">
        <rim:ExtrinsicObject id="Document08" mimeType="text/plain" objectType="urn:uuid:7edca82f-054d-47f2-a032-9b2a5b5186c1" status="urn:oasis:names:tc:ebxml-regrep>StatusType:Approved">
          <rim:Slot name="size">
            <rim:ValueList>
              <rim:Value>4</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="repositoryUniqueId">
            <rim:ValueList>
              <rim:Value>1.19.6.24.116.42.1</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="hash">
            <rim:ValueList>
              <rim:Value>489e1c4afa021fc3a3fe3d267cb04c8debbdee4c</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="creationTime">
            <rim:ValueList>
              <rim:Value>20070311</rim:Value>
            </rim:ValueList>
          </rim:Slot>
        </rim:ExtrinsicObject>
      </rim:RegistryObjectList>
    </lcm:SubmitObjectsRequest>
  </soapenv:Body>
</soapenv:Envelope>
```

```
</rim:Slot>

<rim:Slot name="languageCode">
  <rim:ValueList>
    <rim:Value>en-us</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="serviceStartTime">
  <rim:ValueList>
    <rim:Value>200703111000</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="serviceStopTime">
  <rim:ValueList>
    <rim:Value>200703111030</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="sourcePatientId">
  <rim:ValueList>
    <rim:Value>9ed9d95ba^^^&#1.3.4.5&#ISO</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="sourcePatientInfo">
  <rim:ValueList>
    <rim:Value>PID-3|pid1^^^&#1.2.3&#ISO</rim:Value>
    <rim:Value>PID-5|Mccauley^Stanley^^</rim:Value>
    <rim:Value>PID-7|19560527</rim:Value>
    <rim:Value>PID-8|M</rim:Value>
    <rim:Value>PID-11|4495 Bungalow Road^^Omaha^NE^68114^USA</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Name>
```

```
<rim:LocalizedString value="DocH"></rim:LocalizedString>

</rim:Name>

<rim:Description></rim:Description>

<rim:Classification classificationScheme="urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d"
classifiedObject="Document08" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_1">

    <rim:Slot name="authorPerson">

        <rim:ValueList>

            <rim:Value>^Mahima^Ho^^</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorInstitution">

        <rim:ValueList>

            <rim:Value>Bungalow Clinic</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorRole">

        <rim:ValueList>

            <rim:Value>Attending</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorSpecialty">

        <rim:ValueList>

            <rim:Value>Physiology</rim:Value>

        </rim:ValueList>

    </rim:Slot>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d"
classifiedObject="Document08" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_2">

    <rim:Slot name="authorPerson">

        <rim:ValueList>

            <rim:Value>^Sullivan^Mahoney^^^</rim:Value>
```

```
</rim:ValueList>

</rim:Slot>

<rim:Slot name="authorInstitution">

    <rim:ValueList>

        <rim:Value>Bungalow Clinic</rim:Value>

    </rim:ValueList>

</rim:Slot>

<rim:Slot name="authorRole">

    <rim:ValueList>

        <rim:Value>Physiologist</rim:Value>

    </rim:ValueList>

</rim:Slot>

<rim:Slot name="authorSpecialty">

    <rim:ValueList>

        <rim:Value>Physiology</rim:Value>

    </rim:ValueList>

</rim:Slot>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:41a5887f-8865-4c09-adf7-e362475b143a"
classifiedObject="Document08" nodeRepresentation="PLANS" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_3">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>1.3.6.1.4.1.19376.1.2.6.1</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="Treatment Plan or Protocol"></rim:LocalizedString>

    </rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:f4f85eac-e6cb-4883-b524-f2705394840f"
classifiedObject="Document08" nodeRepresentation="R" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_4">
```

```
<rim:Slot name="codingScheme">
  <rim:ValueList>
    <rim:Value>2.16.840.1.113883.5.25</rim:Value>
  </rim:ValueList>
</rim:Slot>
<rim:Name>
  <rim:LocalizedString value="Restricted"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:a09d5840-386c-46f2-b5ad-9c3699a4309d"
classifiedObject="Document08" nodeRepresentation="urn:ihe:iti:bppc:2007"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_5">
  <rim:Slot name="codingScheme">
    <rim:ValueList>
      <rim:Value>1.3.6.1.4.1.19376.1.2.3</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Name>
    <rim:LocalizedString value="urn:ihe:iti:bppc:2007"></rim:LocalizedString>
  </rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:f33fb8ac-18af-42cc-ae0e-ed0b0bdb91e1"
classifiedObject="Document08" nodeRepresentation="66280005" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_6">
  <rim:Slot name="codingScheme">
    <rim:ValueList>
      <rim:Value>2.16.840.1.113883.6.96</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Name>
    <rim:LocalizedString value="Local community health center"></rim:LocalizedString>
  </rim:Name>
</rim:Classification>
```

```
<rim:Classification classificationScheme="urn:uuid:cccf5598-8b07-4b77-a05e-ae952c785ead"
classifiedObject="Document08" nodeRepresentation="Practice-D" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_7">
    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="Clinical physiology"></rim:LocalizedString>
    </rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4"
classifiedObject="Document08" nodeRepresentation="urn:connectathon:bppc:fundational:policy"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_8">
    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="Foundational Connectathon Read-Access Policy"></rim:LocalizedString>
    </rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4"
classifiedObject="Document08" nodeRepresentation="urn:connectathon:policy:full-access"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_9">
    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="FULL ACCESS TO ALL POLICY"></rim:LocalizedString>
```

```
</rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:f0306f51-975f-434e-a61c-c59651d33983"
classifiedObject="Document08" nodeRepresentation="11502-2" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_10">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>2.16.840.1.113883.6.1</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="LABORATORY REPORT.TOTAL"></rim:LocalizedString>

    </rim:Name>

    </rim:Classification>

    <rim:ExternalIdentifier identificationScheme="urn:uuid:58a6f841-87b3-4a3e-92fd-a8ffeff98427"
value="IHEBLUE-2736^^^&#13.6.1.4.1.88518.13.20.3000&ISO" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_11" registryObject="Document08">

        <rim:Name>

            <rim:LocalizedString value="XDSDocumentEntry.patientId"></rim:LocalizedString>

        </rim:Name>

    </rim:ExternalIdentifier>

    <rim:ExternalIdentifier identificationScheme="urn:uuid:2e82c1f6-a085-4c72-9da3-8640a32e42ab"
value="1.2.42.79196258923277.30" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_12" registryObject="Document08">

        <rim:Name>

            <rim:LocalizedString value="XDSDocumentEntry.uniqueId"></rim:LocalizedString>

        </rim:Name>

    </rim:ExternalIdentifier>

</rim:ExtrinsicObject>

<rim:RegistryPackage id="SubmissionSet01" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:RegistryPackage">

    <rim:Slot name="submissionTime">

        <rim:ValueList>

            <rim:Value>20041225235050</rim:Value>

        </rim:ValueList>

    </rim:Slot>

</rim:RegistryPackage>
```

```
</rim:Slot>

<rim:Name>
  <rim:LocalizedString value="Physical"></rim:LocalizedString>
</rim:Name>

<rim:Description>
  <rim:LocalizedString value="Annual physical"></rim:LocalizedString>
</rim:Description>

<rim:Classification classificationScheme="urn:uuid:a7058bb9-b4e4-4307-ba5b-e3f0ab85e12d"
classifiedObject="SubmissionSet01" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_13">

  <rim:Slot name="authorPerson">
    <rim:ValueList>
      <rim:Value>^Sullivan^Mahoney^^^</rim:Value>
    </rim:ValueList>
  </rim:Slot>

  <rim:Slot name="authorInstitution">
    <rim:ValueList>
      <rim:Value>Bungalow Clinic</rim:Value>
    </rim:ValueList>
  </rim:Slot>

  <rim:Slot name="authorRole">
    <rim:ValueList>
      <rim:Value>Physiologist</rim:Value>
    </rim:ValueList>
  </rim:Slot>

  <rim:Slot name="authorSpecialty">
    <rim:ValueList>
      <rim:Value>Physiology</rim:Value>
    </rim:ValueList>
  </rim:Slot>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:aa543740-bdda-424e-8c96-df4873be8500"
classifiedObject="SubmissionSet01" nodeRepresentation="394747008" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_14">
```

```
<rim:Slot name="codingScheme">
  <rim:ValueList>
    <rim:Value>2.16.840.1.113883.6.96</rim:Value>
  </rim:ValueList>
</rim:Slot>
<rim:Name>
  <rim:LocalizedString value="Health Authority"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
<rim:ExternalIdentifier identificationScheme="urn:uuid:96fdda7c-d067-4183-912e-bf5ee74998a8"
value="1.2.42.20190405034511.31" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_15" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.uniqueId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier identificationScheme="urn:uuid:554ac39e-e3fe-47fe-b233-965d2a147832"
value="1.3.6.1.4.1.21367.4" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_16" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.sourceId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier identificationScheme="urn:uuid:6b5aea1a-874d-4603-a4bc-96a0a7b38446"
value="IHEBLUE-2736^^&#136.1.4.1.21367.13.20.3000&ISO" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_17" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.patientId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
</rim:RegistryPackage>
<rim:Classification classifiedObject="SubmissionSet01" classificationNode="urn:uuid:a54d6aa5-d40d-43f9-
88c5-b4633d873bdd" id="ID_1507585920_1" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification">
</rim:Classification>
```

```
<rim:Association associationType="urn:oasis:names:tc:ebxml-regrep:AssociationType:HasMember"
sourceObject="SubmissionSet01" targetObject="Document08" id="ID_1507585920_2"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Association">

<rim:Slot name="SubmissionSetStatus">
  <rim:ValueList>
    <rim:Value>Original</rim:Value>
  </rim:ValueList>
</rim:Slot>
</rim:Association>
</rim:RegistryObjectList>
</lcm:SubmitObjectsRequest>
</soapenv:Body>
</soapenv:Envelope>
```

Appendix B-8 Full content of transaction sample “Tx8”

```
<?xml version='1.0' encoding='UTF-8'?>

<soapenv:Envelope xmlns:soapenv="http://www.w3.org/2003/05/soap-envelope">
  <soapenv:Header xmlns:wsa="http://www.w3.org/2005/08/addressing">
    <wsa:To soapenv:mustUnderstand="true">http://127.0.0.1:6969/</wsa:To>
    <wsa:MessageID
      soapenv:mustUnderstand="true">urn:uuid:2311B77C122650C7B91554413514373</wsa:MessageID>
    <wsa:Action soapenv:mustUnderstand="true">urn:ihe:iti:2007:RegisterDocumentSet-b</wsa:Action>
  </soapenv:Header>
  <soapenv:Body>
    <lcm:SubmitObjectsRequest xmlns:lcm="urn:oasis:names:tc:ebxml-regrep:xsd:lcm:3.0">
      <rim:RegistryObjectList xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0">
        <rim:ExtrinsicObject id="Document09" mimeType="text/plain" objectType="urn:uuid:7edca82f-054d-47f2-a032-9b2a5b5186c1" status="urn:oasis:names:tc:ebxml-regrep>StatusType:Approved">
          <rim:Slot name="size">
            <rim:ValueList>
              <rim:Value>4</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="repositoryUniqueId">
            <rim:ValueList>
              <rim:Value>1.19.6.24.117.42.1</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="hash">
            <rim:ValueList>
              <rim:Value>ed5ee56d4975cb3052526d66f3fbddc7210c2140</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="creationTime">
            <rim:ValueList>
              <rim:Value>20070419</rim:Value>
            </rim:ValueList>
          </rim:Slot>
        </rim:ExtrinsicObject>
      </rim:RegistryObjectList>
    </lcm:SubmitObjectsRequest>
  </soapenv:Body>
</soapenv:Envelope>
```

```
</rim:Slot>

<rim:Slot name="languageCode">
  <rim:ValueList>
    <rim:Value>en-us</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="serviceStartTime">
  <rim:ValueList>
    <rim:Value>200704190800</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="serviceStopTime">
  <rim:ValueList>
    <rim:Value>200704190900</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="sourcePatientId">
  <rim:ValueList>
    <rim:Value>9a399c351^^^&#13.4.5&#ISO</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="sourcePatientInfo">
  <rim:ValueList>
    <rim:Value>PID-3|pid1^^^&#1.2.3&#ISO</rim:Value>
    <rim:Value>PID-5Loretta^Parker^^^</rim:Value>
    <rim:Value>PID-7|19560527</rim:Value>
    <rim:Value>PID-8|F</rim:Value>
    <rim:Value>PID-11|1974 Lynn Street^^Dorchester^MA^02122^USA</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Name>
```

```
<rim:LocalizedString value="Doc1"></rim:LocalizedString>
</rim:Name>
<rim:Description></rim:Description>
<rim:Classification classificationScheme="urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d"
classifiedObject="Document09" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_1">
<rim:Slot name="authorPerson">
<rim:ValueList>
<rim:Value>^Nuala^Ballard^^^</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorInstitution">
<rim:ValueList>
<rim:Value>Massachusetts Health Institute</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorRole">
<rim:ValueList>
<rim:Value>Attending</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorSpecialty">
<rim:ValueList>
<rim:Value>Gastroenterology</rim:Value>
</rim:ValueList>
</rim:Slot>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d"
classifiedObject="Document09" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_2">
<rim:Slot name="authorPerson">
<rim:ValueList>
<rim:Value>^Safiyah^Madden^^^</rim:Value>
```

```
</rim:ValueList>

</rim:Slot>

<rim:Slot name="authorInstitution">

    <rim:ValueList>

        <rim:Value>Massachusetts Health Institute</rim:Value>

    </rim:ValueList>

</rim:Slot>

<rim:Slot name="authorRole">

    <rim:ValueList>

        <rim:Value>Gastroenterologist</rim:Value>

    </rim:ValueList>

</rim:Slot>

<rim:Slot name="authorSpecialty">

    <rim:ValueList>

        <rim:Value>Gastroenterology</rim:Value>

    </rim:ValueList>

</rim:Slot>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:41a5887f-8865-4c09-adf7-e362475b143a"
classifiedObject="Document09" nodeRepresentation="PLANS" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_3">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>1.3.6.1.4.1.19376.1.2.6.1</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="Treatment Plan or Protocol"></rim:LocalizedString>

    </rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:f4f85eac-e6cb-4883-b524-f2705394840f"
classifiedObject="Document09" nodeRepresentation="R" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_4">
```

```
<rim:Slot name="codingScheme">
  <rim:ValueList>
    <rim:Value>2.16.840.1.113883.5.25</rim:Value>
  </rim:ValueList>
</rim:Slot>
<rim:Name>
  <rim:LocalizedString value="Restricted"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:a09d5840-386c-46f2-b5ad-9c3699a4309d"
classifiedObject="Document09" nodeRepresentation="urn:ihe:iti:bppc:2007"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_5">
  <rim:Slot name="codingScheme">
    <rim:ValueList>
      <rim:Value>1.3.6.1.4.1.19376.1.2.3</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Name>
    <rim:LocalizedString value="urn:ihe:iti:bppc:2007"></rim:LocalizedString>
  </rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:f33fb8ac-18af-42cc-ae0e-ed0b0bdb91e1"
classifiedObject="Document09" nodeRepresentation="66280005" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_6">
  <rim:Slot name="codingScheme">
    <rim:ValueList>
      <rim:Value>2.16.840.1.113883.6.96</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Name>
    <rim:LocalizedString value="Hospital outpatient gastroenterology clinic"></rim:LocalizedString>
  </rim:Name>
</rim:Classification>
```

```
<rim:Classification classificationScheme="urn:uuid:cccf5598-8b07-4b77-a05e-ae952c785ead"
classifiedObject="Document09" nodeRepresentation="Practice-D" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_7">

<rim:Slot name="codingScheme">
<rim:ValueList>
<rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Name>
<rim:LocalizedString value="Gastroenterology"></rim:LocalizedString>
</rim:Name>
</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4"
classifiedObject="Document09" nodeRepresentation="urn:connectathon:bppc:fundational:policy"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_8">

<rim:Slot name="codingScheme">
<rim:ValueList>
<rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Name>
<rim:LocalizedString value="Foundational Connectathon Read-Access Policy"></rim:LocalizedString>
</rim:Name>
</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4"
classifiedObject="Document09" nodeRepresentation="urn:connectathon:policy:full-access"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_9">

<rim:Slot name="codingScheme">
<rim:ValueList>
<rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Name>
<rim:LocalizedString value="FULL ACCESS TO ALL POLICY"></rim:LocalizedString>
```

```
</rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:f0306f51-975f-434e-a61c-c59651d33983"
classifiedObject="Document09" nodeRepresentation="11502-2" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_10">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>2.16.840.1.113883.6.1</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="LABORATORY REPORT.TOTAL"></rim:LocalizedString>

    </rim:Name>

</rim:Classification>

<rim:ExternalIdentifier identificationScheme="urn:uuid:58a6f841-87b3-4a3e-92fd-a8ffeff98427"
value="IHEBLUE-2736^^^&#13.6.1.4.1.91167.13.20.3000&ISO" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_11" registryObject="Document09">

    <rim:Name>

        <rim:LocalizedString value="XDSDocumentEntry.patientId"></rim:LocalizedString>

    </rim:Name>

</rim:ExternalIdentifier>

<rim:ExternalIdentifier identificationScheme="urn:uuid:2e82c1f6-a085-4c72-9da3-8640a32e42ab"
value="1.2.42.71294592707618.30" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_12" registryObject="Document09">

    <rim:Name>

        <rim:LocalizedString value="XDSDocumentEntry.uniqueId"></rim:LocalizedString>

    </rim:Name>

</rim:ExternalIdentifier>

</rim:ExtrinsicObject>

<rim:RegistryPackage id="SubmissionSet01" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:RegistryPackage">

    <rim:Slot name="submissionTime">

        <rim:ValueList>

            <rim:Value>20041225235050</rim:Value>

        </rim:ValueList>
```

```
</rim:Slot>

<rim:Name>
  <rim:LocalizedString value="Physical"></rim:LocalizedString>
</rim:Name>
<rim:Description>
  <rim:LocalizedString value="Annual physical"></rim:LocalizedString>
</rim:Description>

<rim:Classification classificationScheme="urn:uuid:a7058bb9-b4e4-4307-ba5b-e3f0ab85e12d"
classifiedObject="SubmissionSet01" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_13">
  <rim:Slot name="authorPerson">
    <rim:ValueList>
      <rim:Value>^Safiyah^Madden^^^</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Slot name="authorInstitution">
    <rim:ValueList>
      <rim:Value>Massachusetts Health Institute</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Slot name="authorRole">
    <rim:ValueList>
      <rim:Value>Gastroenterologist</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Slot name="authorSpecialty">
    <rim:ValueList>
      <rim:Value>Gastroenterology</rim:Value>
    </rim:ValueList>
  </rim:Slot>
</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:aa543740-bdda-424e-8c96-df4873be8500"
classifiedObject="SubmissionSet01" nodeRepresentation="394747008" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_14">
```

```
<rim:Slot name="codingScheme">
  <rim:ValueList>
    <rim:Value>2.16.840.1.113883.6.96</rim:Value>
  </rim:ValueList>
</rim:Slot>
<rim:Name>
  <rim:LocalizedString value="Health Authority"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
<rim:ExternalIdentifier identificationScheme="urn:uuid:96fdda7c-d067-4183-912e-bf5ee74998a8"
value="1.2.42.20190405034511.31" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_15" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.uniqueId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier identificationScheme="urn:uuid:554ac39e-e3fe-47fe-b233-965d2a147832"
value="1.3.6.1.4.1.21367.4" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_16" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.sourceId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier identificationScheme="urn:uuid:6b5aea1a-874d-4603-a4bc-96a0a7b38446"
value="IHEBLUE-2736^^&#13;1.3.6.1.4.1.21367.13.20.3000&ISO" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_17" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.patientId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
</rim:RegistryPackage>
<rim:Classification classifiedObject="SubmissionSet01" classificationNode="urn:uuid:a54d6aa5-d40d-43f9-
88c5-b4633d873bdd" id="ID_1507585920_1" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification">
</rim:Classification>
```

```
<rim:Association associationType="urn:oasis:names:tc:ebxml-regrep:AssociationType:HasMember"
sourceObject="SubmissionSet01" targetObject="Document09" id="ID_1507585920_2"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Association">

<rim:Slot name="SubmissionSetStatus">
  <rim:ValueList>
    <rim:Value>Original</rim:Value>
  </rim:ValueList>
</rim:Slot>
</rim:Association>
</rim:RegistryObjectList>
</lcm:SubmitObjectsRequest>
</soapenv:Body>
</soapenv:Envelope>
```

Appendix B-9 Full content of transaction sample “Tx9”

```
<?xml version='1.0' encoding='UTF-8'?>

<soapenv:Envelope xmlns:soapenv="http://www.w3.org/2003/05/soap-envelope">
  <soapenv:Header xmlns:wsa="http://www.w3.org/2005/08/addressing">
    <wsa:To soapenv:mustUnderstand="true">http://127.0.0.1:6969/</wsa:To>
    <wsa:MessageID
      soapenv:mustUnderstand="true">urn:uuid:2311B77C122650C7B91554413514373</wsa:MessageID>
    <wsa:Action soapenv:mustUnderstand="true">urn:ihe:iti:2007:RegisterDocumentSet-b</wsa:Action>
  </soapenv:Header>
  <soapenv:Body>
    <lcm:SubmitObjectsRequest xmlns:lcm="urn:oasis:names:tc:ebxml-regrep:xsd:lcm:3.0">
      <rim:RegistryObjectList xmlns:rim="urn:oasis:names:tc:ebxml-regrep:xsd:rim:3.0">
        <rim:ExtrinsicObject id="Document10" mimeType="text/plain" objectType="urn:uuid:7edca82f-054d-47f2-a032-9b2a5b5186c1" status="urn:oasis:names:tc:ebxml-regrep>StatusType:Approved">
          <rim:Slot name="size">
            <rim:ValueList>
              <rim:Value>4</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="repositoryUniqueId">
            <rim:ValueList>
              <rim:Value>1.19.6.24.118.42.1</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="hash">
            <rim:ValueList>
              <rim:Value>ff6c5cb547ffc4aad72161e8e63b3f1108ac8b4c</rim:Value>
            </rim:ValueList>
          </rim:Slot>
          <rim:Slot name="creationTime">
            <rim:ValueList>
              <rim:Value>20070510</rim:Value>
            </rim:ValueList>
          </rim:Slot>
        </rim:ExtrinsicObject>
      </rim:RegistryObjectList>
    </lcm:SubmitObjectsRequest>
  </soapenv:Body>
</soapenv:Envelope>
```

```
</rim:Slot>

<rim:Slot name="languageCode">
  <rim:ValueList>
    <rim:Value>en-us</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="serviceStartTime">
  <rim:ValueList>
    <rim:Value>200705100800</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="serviceStopTime">
  <rim:ValueList>
    <rim:Value>200705100900</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="sourcePatientId">
  <rim:ValueList>
    <rim:Value>6e4efa3ec^^^&#13.4.5&#ISO</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Slot name="sourcePatientInfo">
  <rim:ValueList>
    <rim:Value>PID-3|pid1^^^&#1.2.3&#ISO</rim:Value>
    <rim:Value>PID-5|Evan^Griffith^^</rim:Value>
    <rim:Value>PID-7|19560527</rim:Value>
    <rim:Value>PID-8|M</rim:Value>
    <rim:Value>PID-11|259 Froe Street^^Wheeling^WV^26003^USA</rim:Value>
  </rim:ValueList>
</rim:Slot>

<rim:Name>
```

```
<rim:LocalizedString value="DocJ"></rim:LocalizedString>

</rim:Name>

<rim:Description></rim:Description>

<rim:Classification classificationScheme="urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d"
classifiedObject="Document10" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_1">

    <rim:Slot name="authorPerson">

        <rim:ValueList>

            <rim:Value>^Harriette^Whitworth^^^</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorInstitution">

        <rim:ValueList>

            <rim:Value>Wheeling Hospital</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorRole">

        <rim:ValueList>

            <rim:Value>Attending</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Slot name="authorSpecialty">

        <rim:ValueList>

            <rim:Value>Cardiology</rim:Value>

        </rim:ValueList>

    </rim:Slot>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:93606bcf-9494-43ec-9b4e-a7748d1a838d"
classifiedObject="Document10" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_2">

    <rim:Slot name="authorPerson">

        <rim:ValueList>

            <rim:Value>^Zaine^Lord^^^</rim:Value>

        </rim:ValueList>

    </rim:Slot>
```

```
</rim:ValueList>
</rim:Slot>
<rim:Slot name="authorInstitution">
    <rim:ValueList>
        <rim:Value>Wheeling Hospital</rim:Value>
    </rim:ValueList>
</rim:Slot>
<rim:Slot name="authorRole">
    <rim:ValueList>
        <rim:Value>Primary Surgeon</rim:Value>
    </rim:ValueList>
</rim:Slot>
<rim:Slot name="authorSpecialty">
    <rim:ValueList>
        <rim:Value>Cardiology</rim:Value>
    </rim:ValueList>
</rim:Slot>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:41a5887f-8865-4c09-adf7-e362475b143a"
classifiedObject="Document10" nodeRepresentation="PLANS" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_3">
    <rim:Slot name="codingScheme">
        <rim:ValueList>
            <rim:Value>1.3.6.1.4.1.19376.1.2.6.1</rim:Value>
        </rim:ValueList>
    </rim:Slot>
    <rim:Name>
        <rim:LocalizedString value="Treatment Plan or Protocol"></rim:LocalizedString>
    </rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:f4f85eac-e6cb-4883-b524-f2705394840f"
classifiedObject="Document10" nodeRepresentation="R" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_4">
```

```
<rim:Slot name="codingScheme">
  <rim:ValueList>
    <rim:Value>2.16.840.1.113883.5.25</rim:Value>
  </rim:ValueList>
</rim:Slot>
<rim:Name>
  <rim:LocalizedString value="Restricted"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:a09d5840-386c-46f2-b5ad-9c3699a4309d"
classifiedObject="Document10" nodeRepresentation="urn:ihe:iti:bppc:2007"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_5">
  <rim:Slot name="codingScheme">
    <rim:ValueList>
      <rim:Value>1.3.6.1.4.1.19376.1.2.3</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Name>
    <rim:LocalizedString value="urn:ihe:iti:bppc:2007"></rim:LocalizedString>
  </rim:Name>
</rim:Classification>
<rim:Classification classificationScheme="urn:uuid:f33fb8ac-18af-42cc-ae0e-ed0b0bdb91e1"
classifiedObject="Document10" nodeRepresentation="66280005" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_6">
  <rim:Slot name="codingScheme">
    <rim:ValueList>
      <rim:Value>2.16.840.1.113883.6.96</rim:Value>
    </rim:ValueList>
  </rim:Slot>
  <rim:Name>
    <rim:LocalizedString value="Hospital-Veterans' Administration"></rim:LocalizedString>
  </rim:Name>
</rim:Classification>
```

```
<rim:Classification classificationScheme="urn:uuid:cccf5598-8b07-4b77-a05e-ae952c785ead"
classifiedObject="Document10" nodeRepresentation="Practice-D" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_7">

<rim:Slot name="codingScheme">
<rim:ValueList>
<rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Name>
<rim:LocalizedString value="Surgery-Cardiac surgery"></rim:LocalizedString>
</rim:Name>
</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4"
classifiedObject="Document10" nodeRepresentation="urn:connectathon:bppc:fundational:policy"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_8">

<rim:Slot name="codingScheme">
<rim:ValueList>
<rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Name>
<rim:LocalizedString value="Foundational Connectathon Read-Access Policy"></rim:LocalizedString>
</rim:Name>
</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:2c6b8cb7-8b2a-4051-b291-b1ae6a575ef4"
classifiedObject="Document10" nodeRepresentation="urn:connectathon:policy:full-access"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Classification" id="id_9">

<rim:Slot name="codingScheme">
<rim:ValueList>
<rim:Value>1.3.6.1.4.1.21367.2017.3</rim:Value>
</rim:ValueList>
</rim:Slot>
<rim:Name>
<rim:LocalizedString value="FULL ACCESS TO ALL POLICY"></rim:LocalizedString>
```

```
</rim:Name>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:f0306f51-975f-434e-a61c-c59651d33983"
classifiedObject="Document10" nodeRepresentation="11502-2" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_10">

    <rim:Slot name="codingScheme">

        <rim:ValueList>

            <rim:Value>2.16.840.1.113883.6.1</rim:Value>

        </rim:ValueList>

    </rim:Slot>

    <rim:Name>

        <rim:LocalizedString value="LABORATORY REPORT.TOTAL"></rim:LocalizedString>

    </rim:Name>

    </rim:Classification>

    <rim:ExternalIdentifier identificationScheme="urn:uuid:58a6f841-87b3-4a3e-92fd-a8ffeff98427"
value="IHEBLUE-2736^^&#13.6.1.4.1.00234.13.20.3000&ISO" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_11" registryObject="Document10">

        <rim:Name>

            <rim:LocalizedString value="XDSDocumentEntry.patientId"></rim:LocalizedString>

        </rim:Name>

    </rim:ExternalIdentifier>

    <rim:ExternalIdentifier identificationScheme="urn:uuid:2e82c1f6-a085-4c72-9da3-8640a32e42ab"
value="1.2.42.44004336459043.30" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_12" registryObject="Document10">

        <rim:Name>

            <rim:LocalizedString value="XDSDocumentEntry.uniqueId"></rim:LocalizedString>

        </rim:Name>

    </rim:ExternalIdentifier>

</rim:ExtrinsicObject>

<rim:RegistryPackage id="SubmissionSet01" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:RegistryPackage">

    <rim:Slot name="submissionTime">

        <rim:ValueList>

            <rim:Value>20041225235050</rim:Value>

        </rim:ValueList>
```

```
</rim:Slot>

<rim:Name>
  <rim:LocalizedString value="Physical"></rim:LocalizedString>
</rim:Name>

<rim:Description>
  <rim:LocalizedString value="Annual physical"></rim:LocalizedString>
</rim:Description>

<rim:Classification classificationScheme="urn:uuid:a7058bb9-b4e4-4307-ba5b-e3f0ab85e12d"
classifiedObject="SubmissionSet01" nodeRepresentation="" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_13">

  <rim:Slot name="authorPerson">
    <rim:ValueList>
      <rim:Value>^Zaine^Lord^^^</rim:Value>
    </rim:ValueList>
  </rim:Slot>

  <rim:Slot name="authorInstitution">
    <rim:ValueList>
      <rim:Value>Wheeling Hospital</rim:Value>
    </rim:ValueList>
  </rim:Slot>

  <rim:Slot name="authorRole">
    <rim:ValueList>
      <rim:Value>Primary Surgeon</rim:Value>
    </rim:ValueList>
  </rim:Slot>

  <rim:Slot name="authorSpecialty">
    <rim:ValueList>
      <rim:Value>Cardiology</rim:Value>
    </rim:ValueList>
  </rim:Slot>

</rim:Classification>

<rim:Classification classificationScheme="urn:uuid:aa543740-bdda-424e-8c96-df4873be8500"
classifiedObject="SubmissionSet01" nodeRepresentation="394747008" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification" id="id_14">
```

```
<rim:Slot name="codingScheme">
  <rim:ValueList>
    <rim:Value>2.16.840.1.113883.6.96</rim:Value>
  </rim:ValueList>
</rim:Slot>
<rim:Name>
  <rim:LocalizedString value="Health Authority"></rim:LocalizedString>
</rim:Name>
</rim:Classification>
<rim:ExternalIdentifier identificationScheme="urn:uuid:96fdda7c-d067-4183-912e-bf5ee74998a8"
value="1.2.42.20190405034511.31" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_15" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.uniqueId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier identificationScheme="urn:uuid:554ac39e-e3fe-47fe-b233-965d2a147832"
value="1.3.6.1.4.1.21367.4" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_16" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.sourceId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
<rim:ExternalIdentifier identificationScheme="urn:uuid:6b5aea1a-874d-4603-a4bc-96a0a7b38446"
value="IHEBLUE-2736^^&#13.6.1.4.1.21367.13.20.3000&ISO" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:ExternalIdentifier" id="id_17" registryObject="SubmissionSet01">
  <rim:Name>
    <rim:LocalizedString value="XDSSubmissionSet.patientId"></rim:LocalizedString>
  </rim:Name>
</rim:ExternalIdentifier>
</rim:RegistryPackage>
<rim:Classification classifiedObject="SubmissionSet01" classificationNode="urn:uuid:a54d6aa5-d40d-43f9-
88c5-b4633d873bdd" id="ID_1507585920_1" objectType="urn:oasis:names:tc:ebxml-
regrep:ObjectType:RegistryObject:Classification">
</rim:Classification>
```

```
<rim:Association associationType="urn:oasis:names:tc:ebxml-regrep:AssociationType:HasMember"
sourceObject="SubmissionSet01" targetObject="Document10" id="ID_1507585920_2"
objectType="urn:oasis:names:tc:ebxml-regrep:ObjectType:RegistryObject:Association">

<rim:Slot name="SubmissionSetStatus">
  <rim:ValueList>
    <rim:Value>Original</rim:Value>
  </rim:ValueList>
</rim:Slot>
</rim:Association>
</rim:RegistryObjectList>
</lcm:SubmitObjectsRequest>
</soapenv:Body>
</soapenv:Envelope>
```

Appendix B-10 Full content of transaction sample “Tx10”

B. Experiment Result for Section 4.4.2

Raw data for Section 4.4.2.1 with minimum search keywords

	Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
Process Time	361.5501	321.9779	296.8513	288.9975	321.6248	300.7045	291.6251	284.6361	293.0078	314.4867
	328.3096	288.428	304.6246	278.6577	291.1331	297.1532	333.1004	285.9932	287.7625	317.6712
	290.7664	306.7773	308.1006	294.7269	284.9566	307.1629	256.034	281.7649	280.7085	398.6213
	364.0201	296.2914	268.5683	300.2671	276.3719	266.0841	300.1949	287.3013	305.3752	271.5091
	329.1722	284.9879	339.6045	308.2748	271.4789	317.9875	294.9599	263.2637	296.5325	295.7916
	294.024	303.3484	311.2926	283.0728	311.5203	307.2749	309.714	280.873	275.8628	285.6257
	303.3317	316.5503	286.3469	305.986	297.3743	307.8647	303.7185	282.9706	300.5428	282.0309
	308.9477	286.298	309.3546	294.2719	275.1136	273.2222	333.0603	334.033	299.8779	274.1863
	404.0886	296.3726	276.1675	305.1688	294.6468	293.2474	304.8766	296.5421	289.3705	391.6395
	316.9525	302.006	376.3464	276.8336	302.9856	319.8724	278.599	289.6617	340.2034	321.7385
Average	330.1163	300.3038	307.7257	293.6257	292.7206	299.0574	300.5883	288.704	296.9244	315.3301

Raw data for Section 4.4.2.1 with maximum search keywords

	Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
Process Time	295.2806	320.5024	304.5893	257.8478	290.7988	303.6325	315.7229	291.3759	287.6642	300.1845
	268.3097	269.4562	298.2768	307.078	389.2062	321.2631	279.6589	267.7094	317.3643	304.6549
	364.2183	284.0702	404.4955	332.3231	309.1843	327.8908	296.513	277.1485	278.443	311.6176
	323.7353	298.8492	274.6096	288.3095	313.1121	292.5901	309.5612	278.401	253.4089	272.3898
	277.506	318.1052	314.1802	312.3103	253.1484	326.4243	331.3146	274.0725	270.3752	294.7594
	286.9077	339.3985	303.7118	293.9657	292.4213	396.6533	299.6992	298.6558	315.7477	271.0378
	295.4567	317.4593	306.1546	284.8343	306.1946	296.0514	319.3008	303.2261	287.7795	293.3666
	303.3449	257.162	273.2708	312.9825	272.4797	305.1728	278.2808	262.2752	260.1112	336.1655
	247.2612	272.1019	245.5428	290.3839	289.1424	290.8117	311.063	386.3543	307.3423	271.7562
	292.8699	271.8207	305.2499	273.2218	328.7851	285.0503	304.2626	287.3717	311.3424	298.6512
Average	295.489	294.8926	303.0081	295.3257	304.4473	314.554	304.5377	292.659	288.9579	295.4584

Raw data for Section 4.4.2.2 with 7 active nodes

	Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
Process Time	2.68073	3.151614	2.661582	5.237348	4.541333	3.311541	6.615839	5.640675	7.618481	4.11658
	4.372585	6.394495	2.216457	2.758618	3.496835	4.551798	2.835121	2.684245	3.399676	2.324835
	2.215025	6.994962	2.293773	2.643011	2.40669	5.827773	2.840869	2.590497	2.883383	7.156621
	4.824055	2.954028	6.703593	2.954469	6.882535	2.816632	2.436429	3.630659	2.657426	2.540885
	2.484757	2.169813	6.365845	2.702546	3.435865	4.844194	6.753344	2.811427	2.902904	2.322986
	6.590677	2.213652	7.392581	2.504734	6.337972	2.79669	3.162911	2.670018	3.341148	2.818651
	6.872279	2.637137	2.673112	2.600543	6.200746	2.358182	3.151459	2.701559	3.140091	3.113012
	2.891139	2.444129	2.262201	2.530835	3.155368	2.715653	3.147318	2.627268	3.917894	3.364169
	2.864586	6.963518	6.496215	2.450075	2.156459	2.728363	3.226092	2.384504	3.169569	3.325037
	2.666282	2.713009	2.660164	2.419571	2.79651	2.931885	6.44408	2.521418	3.148796	3.358816
Average	3.846212	3.863636	4.172552	2.880175	4.141031	3.488271	4.061346	3.026227	3.617937	3.444159

Raw data for Section 4.4.2.2 with 6 active nodes

	Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
Process Time	6.880628	3.938475	5.230393	6.810856	5.900798	3.26112	4.248382	2.973701	3.893158	5.335234
	8.21377	2.923259	3.264188	3.172868	2.820754	12.50073	12.18951	2.781588	3.239	3.263277
	2.816022	8.306507	8.495377	2.927673	7.764292	2.649918	2.869132	2.770278	8.614435	8.594275
	2.584044	2.977262	2.813614	6.985399	3.462449	3.256951	2.682154	3.462817	3.154	3.114753
	2.890357	3.134744	3.429335	4.159583	3.104246	3.465109	10.35582	8.14886	2.823066	3.958465
	3.419065	6.783448	2.76202	2.725988	2.617308	3.430552	3.30789	3.640485	3.190139	3.385063
	8.286262	8.567907	2.955045	11.79742	3.288132	8.643554	3.118872	3.225435	3.155186	3.43903
	2.360498	3.100079	8.216567	2.590899	7.796244	3.124284	3.413362	4.480756	8.581782	8.516605
	2.381852	2.738307	2.909863	2.743144	2.76369	2.726006	3.274998	8.707057	3.284112	3.234782
	3.150281	5.850814	3.79289	2.785076	2.935758	3.354323	8.455066	3.318851	3.155815	3.267826
Average	4.298278	4.83208	4.386929	4.669891	4.245367	4.641255	5.391518	4.350983	4.309069	4.610931

Raw data for Section 4.4.2.2 with 5 active nodes

	Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
Process Time	11.28528	5.716336	4.106565	3.854076	9.750213	3.249585	4.726692	10.75421	1.798116	9.31799
	2.723173	3.49951	2.725831	7.753251	2.887039	7.879125	6.463516	8.353327	11.78947	7.799165
	3.214391	8.330988	8.170676	2.998909	2.905998	3.19525	3.960724	3.412023	8.522973	2.384024
	8.30914	8.546567	8.324266	3.241913	8.165692	3.233768	11.49424	3.729393	3.233613	3.554789
	8.387923	3.16485	3.426457	8.146069	8.576572	8.485378	8.465468	8.273408	3.595532	8.456423
	3.239683	3.308106	11.55166	8.491374	2.89582	8.572759	3.200905	8.188239	6.537505	8.592069
	3.287175	5.412601	8.12281	2.933324	3.109568	6.785974	3.181069	2.375766	8.586562	3.397658
	8.45797	8.41878	3.191035	3.133708	5.965457	8.600581	8.332304	2.755142	2.87528	3.175573
	8.375442	3.725271	3.12257	8.752813	8.445579	8.662234	8.284439	6.488892	3.114275	8.462259
	2.94391	2.614038	8.140122	8.412796	2.765969	3.985776	3.062941	8.261957	8.243523	8.57635
Average	6.022409	5.273705	6.088199	5.771823	5.546791	6.265043	6.11723	6.259236	5.829685	6.37163

Raw data for Section 4.4.2.3 with 7 active nodes

1st Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
6.156735	8.636554	6.208585	7.658495	10.17554	6.782309	8.446497	8.685504	37.18996	5.137619
5.56816	8.423783	7.550394	3.375108	5.938423	7.388122	6.855765	6.431094	5.278317	6.930143
4.822655	7.269939	6.567002	7.210126	5.991954	7.459164	7.195279	6.771607	6.389932	8.309827
4.266415	7.741778	2.152551	7.500981	2.576576	6.96675	5.745021	7.256076	8.115372	2.8799
5.634261	7.852192	7.432676	6.408233	7.473243	6.572273	6.119251	2.339185	4.183155	5.986353
6.362324	5.403609	4.715459	5.223318	7.238745	7.254771	5.356058	8.605071	6.558008	6.827084
4.759757	7.331461	4.62882	7.55669	7.101153	7.26637	6.752975	5.924426	7.557353	6.737186
5.29052	7.55689	6.683296	7.644746	3.47895	8.367521	5.922679	4.760416	7.765911	6.991613
7.327436	6.778447	7.524533	7.774795	2.247269	6.337485	6.754916	5.89436	7.180417	3.375356
5.617162	4.394353	6.969221	7.997927	4.702248	4.726713	6.719917	6.207209	7.813705	7.500567
5.580542	7.138901	6.043254	6.835042	5.69241	6.912148	6.586836	6.287495	9.803213	6.067565

2nd Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
6.683668	8.582416	6.173577	8.304825	10.58071	7.260624	9.783247	7.971569	24.45546	5.578423
5.563531	7.877425	6.971251	3.273537	5.860319	7.291958	6.132884	6.43743	5.155888	6.951285
4.489251	6.972192	6.508708	7.546228	6.652256	7.468606	7.432737	6.855071	6.326591	8.266131
3.739953	7.727328	2.406526	7.18475	2.543018	7.792587	6.994329	7.28506	8.171559	2.992477
5.618089	6.978388	8.251861	7.819232	9.106248	5.796757	8.726992	1.932043	4.722442	6.289573
6.397426	5.985544	2.734183	4.499038	7.244137	6.817798	5.360008	7.985187	6.359737	6.830905
4.75534	6.422682	5.260378	9.278745	7.830003	7.276213	6.691008	8.243455	7.563669	6.742426
5.316346	7.525126	6.127974	6.906472	3.489438	6.982435	5.133131	3.992565	7.747239	7.521511
7.322104	6.728719	8.298717	7.75542	2.706946	6.285372	6.683382	5.88694	7.151131	3.406218
5.611484	4.330142	7.638482	8.846142	3.423786	4.667864	6.860224	6.31478	7.749186	8.307681
5.549719	6.912996	6.037166	7.141439	5.943686	6.764021	6.979794	6.29041	8.54029	6.288663

3rd Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
5.524663	8.491591	5.931654	8.269655	9.620887	5.865324	7.660748	8.315766	26.1499	4.51412
5.49087	8.220674	7.636295	2.591438	5.808405	7.378855	6.650718	6.209331	4.689591	6.883403
4.431998	6.440907	5.881471	7.164125	6.608407	7.337733	8.782406	6.818349	6.322113	7.869806
4.263667	7.662517	2.40473	7.210505	2.17496	10.10262	7.228851	6.531207	7.986246	2.494081
5.59619	7.763459	7.447655	7.100105	7.651282	6.57691	5.902624	7.738004	4.615854	5.357589
6.344224	5.917073	4.169753	5.123137	7.172896	6.841588	5.348025	7.936876	6.518084	6.741083
4.214945	7.191953	6.290075	8.735479	7.748678	7.275534	8.106321	9.283047	7.52449	6.798439
5.250506	7.454568	6.625137	6.903288	2.65372	6.246209	5.79938	4.815904	7.682766	7.521964
7.328059	6.722762	8.119924	7.397246	7.76316	6.217737	6.738865	5.758865	6.696798	2.704068
5.587934	4.317662	7.550931	8.463739	3.948021	4.565891	6.627835	8.625179	7.574794	7.436004
5.403305	7.018317	6.205763	6.895872	6.115042	6.84084	6.884578	7.203253	8.576064	5.832056

4th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
5.822906	8.017848	5.248173	8.292215	8.599189	6.616286	9.727232	7.904948	54.78347	4.863864
5.457295	8.287573	6.890059	3.286249	5.838061	7.876121	6.945701	5.506504	5.235159	6.883044
4.406671	7.213728	6.774234	8.370515	6.560616	7.390243	7.42347	6.755829	6.296909	8.256539
4.173291	7.607869	2.301876	7.186669	3.440693	7.670536	5.957095	7.241796	8.112987	1.602612
5.114192	7.733366	6.767712	7.190757	7.371987	7.169365	8.827859	9.632614	4.560715	5.958545
6.318377	5.938529	2.746037	5.112204	7.212116	6.82524	5.294338	7.901724	6.518297	6.811145
4.686221	6.95632	6.579968	6.850695	7.650942	7.262953	6.669867	6.849528	6.935958	6.648083
5.200907	6.782916	6.660399	6.924828	3.736215	6.668799	5.783247	4.823271	7.665121	7.52098
7.28372	7.218489	5.689081	7.714603	7.669557	5.36778	5.846173	4.996511	7.145455	3.260042
5.526823	3.684338	7.827761	8.466977	2.583879	4.536387	7.128253	6.204433	7.548836	6.818396
5.39904	6.944098	5.74853	6.939571	6.066325	6.738371	6.960324	6.781716	11.48029	5.862325

5th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
6.11713	8.674216	6.201628	8.384152	10.68864	7.375094	8.365662	8.684627	64.70663	5.126121
5.485135	7.758413	6.312485	3.271247	5.804365	7.293392	6.656896	6.237331	5.237016	6.833296
4.368129	6.946183	6.45457	7.290438	6.623766	7.382133	7.23499	5.954525	6.252629	8.323128
4.752598	7.581756	2.346434	7.252496	1.98709	7.526504	6.211426	7.23265	8.216799	1.546644
5.741866	7.844224	7.348982	7.200565	7.337278	6.537884	7.842104	8.423819	4.593344	5.772574
5.759641	5.87287	3.826743	5.571826	7.151174	6.85057	5.185283	8.964937	6.451701	6.789762
4.673805	6.894731	6.241744	9.234814	7.729553	6.57501	6.584397	6.681922	7.496783	6.621658
5.147224	7.490463	6.691456	6.200116	3.458812	7.126482	5.701507	5.209789	7.141183	7.538483
7.184862	5.972681	6.406229	7.657228	7.70766	6.973808	6.62125	5.765241	7.621398	3.19396
5.467648	4.273249	7.582052	8.171918	3.201819	3.766301	5.942315	5.452054	7.639103	7.85368
5.469804	6.930878	5.941232	7.02348	6.169016	6.740718	6.634583	6.86069	12.53566	5.959931

6th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
6.595732	8.675289	6.174526	8.332376	7.878559	6.591337	8.412086	8.515557	31.67096	5.123828
5.47848	8.265275	7.346266	3.302075	5.803454	6.589016	5.289716	6.283148	5.226903	6.325886
4.426059	6.975892	6.332195	6.353887	6.499499	7.266784	8.306363	6.630488	5.724189	7.687875
4.107875	6.986092	1.653151	7.670367	1.850417	8.65851	7.115389	7.925571	7.873942	1.481383
5.597847	7.599152	7.312882	6.945914	6.557253	7.852946	5.174505	7.110789	4.532097	5.680673
6.203142	5.793055	4.470087	5.134521	7.932804	6.740757	5.260439	8.745116	6.390104	6.102413
4.534146	6.821919	5.727626	9.354981	7.601881	7.284519	6.801277	9.210964	7.462993	6.635469
4.574617	7.471666	6.55278	6.87441	3.4373	7.372331	5.670133	4.762791	7.475878	7.561303
7.327112	6.671377	6.736234	7.697215	7.678688	6.999695	6.709612	5.757348	7.185125	3.217183
5.522863	4.295027	7.440364	7.113888	4.771625	4.563828	6.928679	8.999668	6.939501	7.283642
5.436787	6.955474	5.974611	6.877963	6.001148	6.991972	6.56682	7.394144	9.048169	5.709965

7th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
6.919127	8.436136	6.116499	8.305493	10.69919	6.552293	8.288923	9.201347	34.29017	5.129032
5.393302	7.822077	6.952342	3.228449	5.305882	7.25164	6.785388	6.192072	5.202679	6.706507
4.413561	6.850168	6.287944	7.641947	6.501736	6.961127	5.643661	6.6899	6.162728	7.183257
4.254102	7.50193	2.192614	6.296422	1.986907	8.306016	5.841351	7.133776	7.203577	1.422424
5.423395	6.201656	7.745488	6.866527	8.907946	6.405416	5.947203	7.673194	4.56772	5.58339
6.183088	5.779001	1.963837	5.282339	6.315591	6.675581	4.452011	7.100434	6.398845	6.554959
4.458547	6.792244	6.147996	9.246097	7.609804	7.226447	6.351224	9.193194	7.391859	6.683189
5.157078	7.575314	6.388698	6.729582	3.324644	7.11929	5.649479	4.694798	7.488304	7.465765
6.141253	6.520122	8.336054	7.651975	7.79383	6.347848	6.559234	5.549855	6.975705	3.127365
5.358043	4.278864	7.454342	8.368694	3.197911	4.529405	6.51127	7.571956	7.578346	7.308622
5.37015	6.775751	5.958581	6.961752	6.164344	6.737506	6.202974	7.100053	9.325993	5.716451

Raw data for Section 4.4.2.3 with 6 active nodes

1st Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
11.46209	11.88321	6.889543	5.915352	7.353555	6.149953	5.816049	13.76806	13.14112	10.36855
6.885258	6.367067	10.77867	6.712438	5.379693	7.705222	6.730972	4.113955	6.110586	7.218615
12.91019	7.576502	6.746116	9.182513	12.51816	1.891975	2.755309	6.93392	4.862846	7.385056
2.819701	8.517017	6.560728	3.458776	5.669583	13.22261	6.216988	13.20765	7.841636	8.14978
4.482488	2.482077	8.169377	6.88016	7.159928	3.997069	8.424831	8.674906	3.332602	7.646569
4.483084	7.272829	3.233336	12.72215	8.557667	5.474808	2.258602	7.719318	7.604972	7.359415
3.824447	12.18488	6.231299	2.786805	7.669589	12.46779	8.69956	2.492918	11.33169	7.181561
4.587321	2.370263	13.18579	6.998355	7.135597	7.954111	3.320436	9.316883	7.370094	7.718978
7.664676	7.2657	8.238511	2.472202	7.603119	13.17233	7.32298	9.322717	7.388488	4.82549
12.27495	2.489389	7.483035	8.501697	6.812369	3.851158	7.566883	3.593695	8.295113	8.103579
7.13942	6.840894	7.75164	6.563045	7.585927	7.588703	5.911261	7.914401	7.727915	7.595759

2nd Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
11.31436	11.85622	5.991775	4.603647	7.245831	5.981853	5.746772	13.83118	13.11477	10.39049
6.80812	5.978383	10.71758	6.340939	5.161157	6.485522	7.270146	4.14781	5.718251	6.713608
12.87351	7.54197	5.634254	9.14828	12.51608	3.117954	2.149453	6.869645	4.898418	7.197842
2.845728	8.577689	6.36672	4.431753	5.263866	12.99343	6.904748	2.933581	7.659468	8.221559
4.486647	2.447933	8.976574	6.932525	7.163043	3.196703	8.396662	8.58517	3.436611	7.13161
4.503661	7.247682	2.969459	12.77147	8.519328	5.45505	2.323613	7.296618	7.747564	7.341936
3.826524	12.77959	6.256021	2.78235	7.162256	12.82172	8.134205	3.3771	11.38409	7.122968
4.615255	2.401484	12.92154	6.805413	7.533437	7.416274	4.665012	3.428534	6.793164	7.84333
7.678827	7.256057	7.917866	2.504192	7.531959	13.18073	6.849037	9.298749	7.451655	4.790552
12.32069	2.473064	7.821649	8.484601	6.29036	3.660866	7.626289	3.23996	8.339038	7.864225
7.127333	6.856008	7.557343	6.480517	7.438731	7.431009	6.006594	6.300835	7.654303	7.461812

3rd Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
11.33187	11.73437	5.927689	5.182651	6.77984	6.623063	5.813765	13.691	13.27964	10.28363
6.818277	6.324543	10.68379	6.26587	4.89033	6.933696	6.147301	3.492173	6.519086	7.396749
12.82064	7.529329	6.119197	9.465351	12.41894	1.873331	3.886914	6.836403	4.867568	6.922009
2.472754	8.491238	6.273514	3.086421	5.614086	12.94679	6.164404	2.829371	7.675992	8.554669
4.14433	2.171333	8.260409	6.826353	7.945022	2.746992	8.44528	8.601326	2.828163	7.526796
4.149021	7.197301	2.473717	12.72541	8.506517	5.477473	3.753066	7.615243	7.076025	7.331108
3.832644	12.86796	6.247425	2.281388	7.709386	12.37143	7.989612	3.563381	11.33486	7.474431
4.193033	1.914934	12.87693	5.988047	7.127922	7.913094	3.254609	9.353578	7.158778	7.661169
7.61642	7.235547	8.767704	2.441079	7.443091	13.14685	6.325618	9.354739	7.303032	4.688765
12.3482	13.439	7.478316	8.396982	6.711042	3.188977	7.566303	2.585821	8.311056	7.858678
6.972719	7.890556	7.510869	6.265955	7.514617	7.32217	5.934687	6.792303	7.63542	7.569801

4th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
11.34841	11.84874	6.151702	4.924421	7.157797	5.964676	6.247987	13.67698	13.32116	10.23625
6.818774	6.299777	10.6768	5.843449	4.926785	6.887187	6.694748	5.929629	6.413834	7.216832
12.75765	7.337864	6.209666	9.405379	13.14846	1.696918	2.693365	6.806841	4.435224	6.453376
2.817147	8.600157	5.887176	4.332485	5.612651	12.97434	5.556349	2.402643	7.555906	8.464543
4.446165	1.897667	8.933343	6.853453	6.599129	3.214121	8.332444	8.602169	3.219057	7.497416
4.451349	7.171605	2.91548	12.76382	8.443595	5.447526	2.793211	7.637551	6.969669	6.729469
3.768265	12.73221	6.192788	2.768983	7.554196	12.3629	8.671657	2.772528	11.25936	7.395185
4.596157	2.238648	12.84067	6.705163	6.505283	8.36472	2.887051	9.364274	7.158838	7.615843
7.619743	7.168697	8.894031	1.966874	7.484075	13.34679	6.821875	9.36542	6.878791	4.222599
12.24119	13.16346	6.981226	8.392609	6.677561	3.657031	7.486296	2.946629	8.221007	7.797789
7.086485	7.845881	7.568288	6.395664	7.410953	7.391621	5.818498	6.950466	7.543285	7.36293

5th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
11.15518	11.89337	6.571993	5.415179	7.337013	5.640327	6.724391	3.541715	12.74949	9.933508
6.809706	6.289176	10.22733	7.113444	5.41132	8.255769	2.630307	5.920783	6.152518	7.157789
12.47712	7.321245	6.322506	8.609711	11.96898	2.849655	6.5589	6.844639	4.876354	6.902648
2.92747	8.743573	6.293877	3.307942	5.60262	12.43361	7.828576	2.872294	7.138185	8.196044
3.256048	2.396759	7.693489	6.904692	6.989087	3.252756	2.732116	8.303976	3.250386	7.482086
3.257519	7.184155	2.917988	12.19283	7.953125	5.416524	7.966014	7.637088	6.994981	7.140615
3.27766	11.67633	6.227276	3.163658	7.631374	11.85316	4.653306	3.353619	10.88461	6.558179
4.508366	2.272037	12.34817	6.520822	7.662911	7.797127	6.769272	8.5458	7.856473	7.636883
7.62055	7.192035	8.130516	2.420324	7.556884	5.297452	7.485652	8.551637	7.295369	4.627279
11.8809	12.70737	7.407907	7.958778	6.712185	12.55643	12.42345	2.932646	8.388209	7.288761
6.717051	7.767605	7.414105	6.360738	7.482549	7.535281	6.577199	5.85042	7.558657	7.292379

6th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
11.3664	11.85953	5.617506	5.556867	7.241522	6.725616	5.757189	13.80222	13.35786	10.43491
6.428402	6.164627	10.59002	6.841215	4.349432	7.560931	7.141863	4.647115	6.299461	7.322369
12.80488	7.42129	5.992734	9.339009	12.46191	1.989081	2.553935	6.26032	4.792111	6.846769
2.8438	8.439431	6.149473	4.391153	5.468011	12.88918	5.890721	2.938109	7.462027	7.999434
4.404734	1.803037	8.351668	6.282554	7.465523	3.216211	8.291146	8.661372	3.190502	7.381856
4.406204	6.647828	2.771886	12.68534	8.386293	4.886381	2.831387	7.590761	6.429026	7.142281
3.688115	12.75468	5.709378	2.766673	7.407452	12.28578	7.36059	3.20443	11.26505	6.959581
4.502079	2.372884	12.78081	5.379024	6.908584	7.751013	3.300308	9.324637	7.707644	7.475134
7.188464	6.653349	8.269145	2.714906	7.5275	13.17212	6.67626	9.325379	7.28831	4.611185
12.30177	13.18483	7.385165	8.464887	6.713302	3.651225	6.856728	2.921839	8.270322	7.812735
6.993485	7.730149	7.361778	6.442163	7.392953	7.412754	5.666013	6.867618	7.606231	7.398626

Raw data for Section 4.4.2.3 with 5 active nodes

1st Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
3.986688	6.632686	10.48263	7.446025	5.916561	13.29078	10.35086	3.349684	13.42117	2.724086
11.90735	7.383919	8.211287	6.790804	6.376931	7.227767	3.447641	5.358191	5.728222	4.262106
7.349292	8.271763	7.660125	7.141525	7.232295	6.343785	4.908368	6.451343	4.610986	3.858552
5.355022	6.636519	8.119421	7.465883	7.756409	8.108793	3.717245	7.762134	10.27966	11.5124
8.656236	5.66878	8.559476	7.489747	7.19916	8.119435	4.930182	6.401261	8.757926	9.119999
8.298255	7.110044	4.788246	7.217113	8.398348	7.944344	12.58665	6.43074	2.685092	3.365822
2.848842	6.714535	4.979436	7.635227	2.916885	8.968004	9.208777	7.199736	8.372393	12.4629
7.686563	7.488843	6.402843	6.843481	11.94107	8.37979	7.237741	8.169939	7.530727	8.947207
8.156631	2.969335	3.359371	8.954284	8.844841	7.415364	8.692452	8.651698	3.304293	3.948762
3.46077	7.503521	12.42625	7.564354	6.876175	6.138341	7.369541	8.143337	12.3921	12.32633
6.770565	6.637995	7.498908	7.454844	7.345867	8.19364	7.244945	6.791806	7.708257	7.252816

2nd Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
3.959136	6.59611	10.46228	6.967747	5.558667	13.57204	10.21416	2.962196	13.44244	2.721348
11.90886	7.167331	8.177128	6.582189	6.371108	7.197462	3.125824	5.394726	5.679819	3.817444
7.367707	8.138834	7.359141	7.133794	7.302862	6.760427	4.375628	6.256479	6.492425	3.874794
5.692839	6.652458	8.150662	7.107996	7.44164	8.113272	3.715688	7.409827	10.29791	11.55023
8.758763	4.761524	8.601385	7.522348	7.382893	8.103928	4.935216	6.377328	8.767124	8.556623
8.310455	7.102238	4.418051	7.285576	9.122022	7.58757	12.61697	6.464004	3.204946	3.368258
2.831033	6.72838	4.914769	7.239663	1.115505	8.914134	8.684188	6.834232	8.361374	12.47717
7.658665	7.19099	6.357043	6.790308	11.94112	8.479601	6.912217	8.190156	7.54705	8.993918
8.317832	2.979941	3.824889	8.9282	8.822945	7.984649	8.656559	8.69778	3.30976	3.271072
3.458694	6.759596	12.44492	7.217619	6.569718	6.182641	8.334729	7.75018	12.8852	12.35476
6.826398	6.40774	7.471027	7.277544	7.162848	8.289573	7.157118	6.633691	7.998805	7.098562

3rd Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
3.776415	6.581263	10.45049	7.315597	5.874998	13.22618	10.26433	3.3256	13.39637	2.686266
11.85639	7.3647	8.146281	6.484483	6.320663	7.167187	3.464609	5.365371	5.668589	3.721053
7.371479	8.674475	7.603366	7.404767	7.239019	6.345778	4.338227	6.20997	4.246499	3.48018
5.349543	6.855874	8.649856	7.422055	7.743221	8.123602	3.661275	7.744713	10.2001	11.52444
8.71322	5.249415	8.515927	7.460731	7.976684	8.822906	4.626538	6.333813	8.710245	8.57423
8.226366	7.959646	4.707951	7.435213	8.306948	8.597205	12.58044	6.369615	2.844009	3.234511
2.576045	6.714923	4.110002	7.562615	1.208349	8.930551	8.662832	7.194204	8.372783	12.40624
7.62689	7.468891	6.375867	7.235679	11.90465	8.292722	7.990905	8.128546	7.546951	8.900563
8.143036	2.879283	3.668418	8.96673	8.837162	7.415097	8.6596	8.64954	2.929503	2.859643
3.190723	7.580934	12.39151	7.548576	6.86269	6.112367	7.3573	8.771213	12.40397	14.81387
6.683011	6.73294	7.461967	7.483645	7.227438	8.303359	7.160606	6.809258	7.631901	7.220099

4th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
3.977609	6.580979	10.15227	7.278134	5.777487	12.80964	10.19433	3.319096	13.19418	2.338303
11.64802	7.372787	8.161859	6.194194	5.941812	7.16055	3.452689	4.978478	5.589793	3.671693
7.344305	7.820257	7.563017	7.309581	7.209228	6.326743	3.945996	6.210284	5.989181	3.823436
5.308925	6.749395	8.205956	7.380865	7.708106	7.747603	3.634165	7.758667	9.890347	11.10753
8.374919	4.991546	8.494132	7.147431	6.800638	8.646793	4.918747	5.995571	8.711453	9.404007
8.252009	6.780687	4.680262	7.17579	8.850444	8.259087	12.21901	6.367842	2.627376	3.32672
2.784106	6.685362	3.758944	7.605582	1.14197	8.562343	8.606757	7.132525	8.042631	12.31368
7.366497	7.449764	6.356741	6.457597	11.53589	8.21753	7.223147	7.82796	7.545286	8.918757
8.729406	3.637095	3.328197	8.926978	8.763516	7.42161	8.299753	8.731073	3.217482	3.239328
3.575057	7.045734	11.87541	7.499659	6.850935	5.734439	8.559898	8.920597	12.29899	11.9915
6.736085	6.511361	7.257679	7.297581	7.058003	8.088634	7.105449	6.724209	7.710672	7.013495

5th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
4.133716	6.36949	10.50015	7.436478	6.114637	13.29313	9.956421	3.318059	13.34496	3.061889
11.80437	7.327603	7.802286	6.523071	6.238013	6.800424	3.41107	5.51678	5.155935	3.537589
7.12583	8.851277	7.471287	6.746043	6.797209	6.29819	4.258077	5.818925	4.506848	3.798731
5.284841	6.281399	8.496799	7.342205	7.695585	8.288721	3.224047	7.681043	10.2198	11.43297
8.693872	5.207055	8.165197	7.377328	7.589147	7.716005	4.840333	6.32816	9.219844	8.556724
7.99516	6.980871	4.662798	6.911014	7.93563	7.877424	12.5149	5.999896	2.596846	3.298813
2.779498	6.39006	3.952347	7.567019	1.215112	8.848928	8.280428	6.992094	8.36846	12.35583
7.553701	7.411974	6.36832	6.712312	12.17958	7.847606	7.160346	8.571596	7.118682	8.501103
7.794419	2.624962	3.722359	8.575097	8.477446	7.805358	8.596277	8.275898	3.253307	3.16661
3.480102	6.955257	12.39572	7.901804	6.782149	6.991466	6.864312	7.956795	12.33392	14.79422
6.664551	6.439995	7.353727	7.309237	7.10245	8.176725	6.910621	6.645925	7.61186	7.250448

Raw data for Section 4.4.2.6 with 7 active nodes

1st Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
9.354991	6.181495	10.99878	12.44329	12.91413	9.222523	5.512126	9.410267	11.22815	14.63084
6.220997	9.359747	10.7683	11.8901	13.9177	5.634824	9.377141	9.373849	8.497758	17.54392
8.758062	7.694936	15.64953	11.44431	16.94866	8.990652	4.247952	10.19404	10.8137	18.27393
10.36775	8.480315	8.411745	13.26821	14.70972	7.917703	8.992862	13.60359	8.631554	13.7417
4.938108	5.585059	12.86497	12.87941	9.51582	8.914895	8.279584	7.404539	8.716153	15.64791
4.658653	8.763382	10.59123	12.29373	15.57782	7.764818	9.902902	8.809201	12.41077	11.39779
6.701448	4.989417	11.83509	12.77098	19.58617	9.583422	9.257553	11.89923	13.26488	15.50423
4.944515	10.6923	11.54142	12.29351	11.48276	7.778218	11.28529	8.735538	11.8737	19.41342
6.277191	8.189495	12.13792	12.18501	12.2397	6.165804	5.850107	13.30286	19.64593	19.82339
4.382608	13.10561	9.484642	14.26659	20.11534	5.116272	9.592226	16.45718	14.62344	20.92799
6.660432	8.304175	11.42836	12.57351	14.70078	7.708913	8.229774	10.91903	11.9706	16.69051

2nd Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
8.943964	5.488248	11.61758	12.42357	13.32048	8.41597	8.880283	9.520489	9.622287	14.22346
6.581323	8.983191	10.49507	12.34718	13.22538	5.458893	9.66549	9.64393	13.51681	16.64221
8.87379	6.549736	16.24462	12.13515	16.41962	9.413332	4.574573	10.56636	12.12488	18.36046
10.30642	8.694411	7.967138	13.606	13.18915	7.4372	8.861047	12.32726	13.35236	13.55321
5.713864	4.978451	12.62905	11.68653	11.53535	8.156909	9.628209	7.368272	9.236209	15.7616
4.619601	8.678529	10.51804	13.23319	15.58572	6.222783	9.554707	9.817156	12.54386	15.69538
6.656064	9.840215	11.84923	12.32206	14.84476	8.59739	9.592282	11.53519	13.47008	15.34755
3.908503	11.41012	11.40671	12.39326	16.63716	8.507961	10.96453	8.366936	11.98523	18.8786
5.277475	7.625902	13.8435	12.63341	16.59517	6.930908	8.845268	13.31929	19.53096	20.94678
6.429691	13.58083	9.781141	14.13137	15.17625	4.74964	9.377164	16.55125	15.50108	20.79509
6.73107	8.582964	11.63521	12.69117	14.6529	7.389099	8.994355	10.90161	13.08837	17.02044

3rd Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
8.97819	6.372209	11.71159	12.80333	12.29932	8.889025	6.868234	8.5427	9.959938	13.9049
6.441635	7.647952	11.28563	11.48046	13.90591	4.720332	8.813427	9.522707	13.88719	11.94355
8.715983	6.819124	15.2794	11.95043	16.90098	9.645268	9.469051	10.21311	11.48294	13.45789
10.37998	8.110215	9.356967	12.49843	11.83117	7.424586	5.675627	12.68621	12.35586	13.40304
6.220791	7.198565	12.25312	16.43177	14.39608	8.488433	9.565981	6.834491	9.261188	14.66849
4.629941	7.650871	10.16468	13.37823	15.93037	6.695633	9.777679	9.802317	12.71047	16.32104
6.70636	5.705607	12.32941	12.56784	15.42933	5.250646	5.905214	11.52861	12.92926	14.29643
4.224351	10.97961	10.77923	11.80523	15.6962	8.886186	10.51175	8.401304	12.27438	14.81751
4.997812	6.927156	11.57576	12.74593	13.41448	6.584599	9.13595	12.8052	19.50982	14.76565
4.292868	12.11181	9.839162	14.25868	20.30234	5.192512	9.453581	16.51163	8.816544	21.3078
6.558791	7.952312	11.45749	12.99203	15.01062	7.177722	8.517649	10.68483	12.31876	14.88863

4th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
8.907368	6.422723	11.60175	12.27238	13.24864	8.838589	5.588562	9.163868	10.82262	14.33972
6.530505	9.774074	10.92006	10.50979	13.86706	5.612807	8.314695	9.828856	13.15721	7.491364
8.61111	6.264296	16.63836	12.12931	16.94856	9.775186	9.36498	9.983768	11.18616	18.85978
9.882387	7.700734	9.158342	13.20295	14.46905	7.366258	6.918055	13.28155	7.807842	13.48188
6.266796	7.668627	7.288505	16.27231	14.15572	8.730058	9.582608	7.993317	9.148379	13.67961
5.592576	8.19381	9.196853	12.51773	15.93721	6.954441	10.54467	9.450103	12.24544	11.66453
5.49126	6.295402	10.8798	12.41611	19.53076	9.663325	9.506291	10.99425	13.55643	14.71238
3.997012	10.7224	11.47444	12.20341	15.81119	7.493622	11.2492	7.457854	12.10914	19.19064
6.327298	7.975255	11.2783	12.38754	13.671	7.919655	8.875958	13.9259	19.2002	20.13902
5.480066	12.80138	9.732381	14.38844	15.44859	4.691607	10.47122	16.5981	15.21713	20.78645
6.708638	8.38187	10.81688	12.83	15.30878	7.704555	9.041624	10.86776	12.44506	15.43454

5th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
8.536773	6.123528	11.72082	12.50582	13.84826	9.194292	5.544657	9.464762	10.83736	14.16935
6.392909	8.776998	10.63696	11.36923	13.83679	4.581555	8.4549	9.383549	13.76022	7.416211
8.696734	6.778096	15.81718	12.56536	16.93647	9.54365	9.171722	9.397834	11.33562	18.36717
9.446949	6.403661	7.732163	13.22585	14.77889	6.237793	8.8797	13.35492	9.280906	13.51028
7.140921	7.315646	12.60729	12.23945	9.282494	8.105478	9.233577	11.38388	9.227133	14.59046
4.358656	8.669591	8.523449	11.7048	15.14963	6.976211	10.37931	9.653025	12.75785	10.86975
6.838359	4.855103	11.56359	11.63007	15.2488	8.181818	9.316523	11.58965	13.24492	16.33187
3.463822	10.51909	11.95999	12.34017	14.83957	7.869991	11.13261	8.616479	12.81866	18.81646
5.806062	7.737579	11.23429	12.20941	12.67938	6.607406	9.604431	13.19285	19.13669	20.67505
6.225488	12.65	14.27846	13.37302	15.50338	11.19911	9.739008	16.32189	14.79132	19.96003
6.690667	7.982929	11.60742	12.31632	14.21037	7.849731	9.145643	11.23588	12.71907	15.47066

6th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
8.978062	6.604549	12.10357	11.65096	13.19132	9.138902	4.931511	9.211206	10.59672	14.16843
5.24665	10.19638	10.68379	11.45262	13.83881	4.434735	7.29118	8.772939	13.62673	12.97278
8.161263	5.409197	15.89437	12.65568	16.89109	9.519113	9.242412	9.906979	11.17032	18.33366
10.50962	8.736187	8.322978	13.28921	15.1277	6.175188	6.93353	12.84716	12.29617	13.45872
6.756143	6.723965	12.64883	11.75979	14.37086	7.117854	9.522575	7.48093	13.54806	14.50606
5.543714	8.384914	10.32074	12.45512	15.99224	7.723533	10.5766	10.41586	12.74987	15.65342
4.833983	5.852737	11.95384	12.49222	19.19788	9.498469	8.988181	10.44856	13.65165	14.98161
3.938927	11.46039	11.58434	12.29055	14.74444	8.426713	10.9269	8.6644	11.30718	19.4659
6.476171	7.262647	11.43826	12.2999	12.91098	6.610274	8.972058	13.1237	18.44607	20.19098
5.998614	12.88604	9.234617	14.66757	20.59821	3.989144	8.947435	15.74939	14.6751	20.87802
6.644314	8.3517	11.41853	12.50136	15.68635	7.263392	8.633238	10.66211	13.20679	16.46096

7th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
6.880249	5.76619	11.20935	12.77446	13.20768	7.828996	7.669181	9.33248	10.66787	8.963309
8.127948	7.52986	10.79615	11.48539	13.14092	4.363063	8.215848	9.260837	13.43542	12.22678
5.365057	4.746602	16.32745	12.56368	16.91938	9.43014	2.185908	9.993687	11.35797	18.21922
8.622852	8.336561	8.333011	13.7934	14.92185	6.980016	9.179874	12.87602	12.37001	17.62438
8.693417	7.255572	7.390639	11.92485	9.016432	7.544678	9.237559	7.484911	9.267779	14.61168
6.26068	8.86982	10.14097	12.48089	15.61539	7.653372	10.53109	9.66717	12.55967	11.3395
5.56366	5.837365	11.51817	12.48605	19.56513	8.555495	9.669139	10.92165	13.1342	14.88376
6.874939	11.19659	12.1483	12.31547	15.37898	6.851693	10.94685	9.664388	11.93513	18.21213
3.963424	7.869333	10.21705	12.54086	13.40125	6.738208	9.697336	13.70354	19.27095	19.84644
6.88881	12.68038	14.23867	13.87033	15.36904	8.58649	9.546679	16.37161	14.84639	20.70255
6.724104	8.008827	11.23198	12.62354	14.65361	7.453215	8.687946	10.92763	12.88454	15.66298

Raw data for Section 4.4.2.6 with 6 active nodes

1st Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
7.442725	7.657259	8.147203	8.430155	8.312464	8.918848	12.40078	14.61588	7.755913	9.110275
8.659984	12.12299	8.270152	11.62902	10.53802	11.90562	6.719217	8.503208	8.129849	12.89799
12.65077	6.603417	6.431062	14.90044	7.639501	6.805112	5.681315	8.964408	11.12203	13.64485
4.954675	6.920036	8.264474	11.36385	8.636012	4.938079	5.768172	7.346715	9.973658	11.86135
9.568029	9.501208	12.46372	10.25868	11.52331	13.16833	6.301532	8.973932	17.23747	14.10825
12.9102	6.750391	8.659801	7.310659	11.50757	7.478964	6.214849	9.627392	12.78293	7.614251
4.245529	7.427034	9.124394	11.73813	14.62356	6.690698	11.46854	8.42105	8.706324	12.27525
12.92888	12.42698	12.31214	11.71608	13.18444	5.831956	6.798324	7.959008	17.26799	18.47253
13.22633	11.47565	6.734901	9.644889	18.12912	4.585434	7.589819	6.31499	9.340977	8.846458
5.67426	6.720298	9.269236	13.78074	11.17511	12.13571	5.83075	15.56087	17.2465	18.39728
9.226138	8.760526	8.967708	11.07727	11.52691	8.245876	7.47733	9.628745	11.95636	12.72285

2nd Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
7.206602	7.59641	7.581317	7.60768	8.737988	8.586965	11.4738	14.27441	7.813074	9.769117
8.612026	12.4138	8.231641	11.62267	10.57047	11.86909	6.78457	8.534642	8.118042	12.98202
12.73236	6.908831	6.569536	14.8633	18.15621	6.696203	4.495763	8.775244	11.87757	8.383894
4.601303	6.977181	8.278776	11.42714	8.34148	4.931853	4.699754	7.324651	9.878825	11.70098
9.414647	9.666868	12.6483	9.501737	11.57161	14.27924	4.298273	5.692551	17.48659	14.67137
13.1384	6.463947	8.136801	7.451025	11.62997	7.517996	6.304914	9.761021	12.94282	12.31791
4.191582	7.445487	9.274648	11.70807	14.63096	6.864524	11.43381	7.286782	8.482415	12.39965
12.22449	11.28648	12.2055	11.52602	13.34817	5.649713	6.661349	8.432254	17.10485	18.33542
13.23439	12.86382	7.502634	10.75155	18.67288	4.554567	7.714815	6.849701	9.25278	13.61214
6.159407	4.173272	9.254476	13.42933	11.14155	12.27611	5.615284	14.87073	16.58659	18.4987
9.151521	8.579609	8.968363	10.98885	12.68013	8.322627	6.948233	9.180199	11.95436	13.26712

3rd Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
7.215621	7.637509	7.934634	8.375413	12.77197	8.628789	11.48148	13.92311	7.325648	9.737384
8.591787	11.74747	7.25885	11.69749	8.15046	11.75793	6.598616	7.742772	8.112995	8.402932
12.53059	6.890445	5.83545	15.7253	18.21072	6.879783	4.488587	8.369203	11.29437	13.71018
4.786645	6.865568	7.806606	11.75036	18.50275	4.20512	4.164368	7.269921	9.441364	11.71558
9.423174	9.592725	12.56181	9.270606	12.15039	13.98595	4.300835	9.494902	17.68301	14.63209
12.94938	4.720854	8.193067	7.159862	10.76053	7.145771	6.190044	9.288127	13.83844	12.19739
3.670191	9.30042	8.855372	12.31102	14.30325	8.201619	11.3021	8.196803	8.740364	11.30818
13.13628	12.88656	12.17434	10.69733	12.37504	5.154132	6.289067	8.617927	17.11529	18.18307
13.97925	12.26636	7.737355	7.875118	19.18182	4.122756	6.788787	6.20636	9.125987	13.67779
5.562542	6.469518	9.221416	13.5273	11.13012	12.4485	3.448697	15.13424	16.81347	18.40953
9.184546	8.837743	8.75789	10.83898	13.7537	8.253034	6.505259	9.424337	11.94909	13.19741

4th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
6.900965	6.845203	8.340514	8.119019	8.284583	8.570298	12.33925	14.15421	8.20352	9.772178
8.232746	11.6991	7.731331	11.12284	10.56461	11.83953	6.23018	8.169673	7.640559	8.337001
12.50917	7.610194	5.75586	14.98814	18.29905	6.822016	4.517301	8.462832	10.77839	13.27741
4.772351	8.185296	8.250531	11.86418	8.433851	4.97897	6.759153	7.230583	9.688253	12.10611
9.146746	9.366789	12.44551	9.725923	11.15473	13.95067	6.285616	9.289804	17.44047	13.8404
12.84638	6.417535	8.423012	10.96491	11.60917	7.513185	5.952103	9.176242	13.87459	11.80107
4.263901	9.595988	8.430446	11.28149	15.93479	6.297498	11.55667	8.249226	8.18093	11.94965
13.74465	13.98565	12.45272	10.94277	12.96788	5.934781	6.379907	7.884039	17.88037	18.63796
13.12076	12.90199	7.433401	10.14976	18.94025	4.491026	6.315004	6.402108	8.859262	13.70189
5.682356	6.416934	9.540185	13.42173	10.61905	11.89033	5.158874	15.79922	16.77058	18.25946
9.122002	9.302468	8.880351	11.25808	12.6808	8.22883	7.149405	9.481793	11.93169	13.16831

5th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
7.473968	7.503096	7.277672	8.128578	12.92864	8.94761	11.76762	13.70307	7.744593	9.813009
8.578861	9.544391	7.289182	11.54824	10.529	11.47716	6.663492	8.145218	8.978481	8.316424
12.16103	6.464436	5.927896	14.26169	7.423319	6.707403	4.4927	8.712093	10.59267	13.60485
4.116606	6.54238	8.60746	11.37388	8.237381	4.481498	4.472627	7.237003	9.75478	11.70952
9.947132	10.42419	11.88651	9.551605	11.99592	13.44232	4.153563	5.259338	16.9655	13.23097
12.45125	4.292024	8.311456	7.405426	11.55631	6.723802	6.271301	8.84627	12.28562	7.479075
4.243973	9.559387	9.522206	11.92559	14.69029	6.652993	11.97358	7.642342	8.787199	11.82372
11.58533	12.51493	11.83061	11.32225	12.86224	5.981941	6.799812	8.286883	16.36688	17.63961
13.53528	12.64392	4.247173	9.37199	18.37649	5.37537	4.351291	6.824161	9.388883	8.981291
5.936454	6.580228	8.966029	13.12331	10.80283	11.33498	6.180682	14.23791	16.71104	17.70489
9.002988	8.606899	8.38662	10.80126	11.94024	8.112508	6.712667	8.889428	11.75756	12.03033

6th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
7.497773	6.377734	7.934734	8.139328	8.210512	8.228784	11.46614	14.20605	8.207841	9.1668
8.542898	10.23031	7.647929	11.35404	10.5249	11.81965	6.75951	8.140428	8.142734	7.74696
12.60578	6.817874	5.435094	14.76117	18.21777	6.430227	3.888715	9.329514	10.5251	13.54362
4.446337	7.781583	8.229942	11.89701	8.565242	4.94145	6.147391	6.779813	9.641527	12.44875
9.886414	10.78149	12.96248	9.569309	11.79736	13.83808	6.147209	9.737449	17.47573	13.96707
12.83906	6.430516	7.840555	6.582847	11.55184	7.441007	6.155208	9.878447	13.24907	12.40907
4.190734	9.637445	8.573628	11.67244	14.5939	6.589825	11.52212	7.577949	8.621366	11.86173
12.92472	13.95923	12.30081	11.693	13.51225	6.381414	6.453231	7.803237	17.88231	18.14296
13.72611	13.29615	6.950822	10.26807	16.9694	4.533942	7.370714	5.893861	9.555624	8.972565
5.45698	6.661079	8.598729	13.41987	11.29219	12.4262	5.320583	14.99373	16.43193	17.99944
9.211681	9.197341	8.647472	10.93571	12.52354	8.263058	7.123082	9.434048	11.97332	12.6259

Raw data for Section 4.4.2.6 with 5 active nodes

1st Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
11.99961	11.74504	4.615415	7.719248	8.194655	9.707512	9.663865	3.215903	17.18431	8.900393
6.936956	10.3642	11.21147	7.93955	15.96056	4.487101	6.967939	11.88977	7.987706	9.706037
6.733459	10.93403	13.49545	8.329427	15.34986	10.56074	7.841693	11.34221	9.866459	9.537311
3.230693	10.95879	5.945532	9.971761	16.18812	6.462249	3.87023	7.398243	9.405953	6.373986
5.69076	4.930889	7.161828	13.44246	9.739327	7.816053	7.494269	7.177113	14.66274	16.58755
6.624541	12.12853	13.17898	14.53018	16.56824	9.634778	6.908789	5.125386	13.50982	14.5272
5.740974	4.462831	7.334979	14.30393	18.60326	10.22281	11.96066	13.50899	8.107959	10.65858
5.341489	9.801712	13.23986	5.184304	10.79431	5.707933	9.438223	5.164682	5.303509	16.21665
6.390706	5.746384	13.46533	16.30788	16.16056	4.510232	6.755204	13.27781	4.856095	15.59591
5.328856	11.21208	8.513462	8.998975	15.80929	12.14992	5.593172	8.422994	14.97303	15.68654
6.401805	9.228448	9.81623	10.67277	14.33682	8.125933	7.649404	8.652309	10.58576	12.37902

2nd Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
12.21709	11.2468	4.261019	7.15792	8.544418	9.826116	10.62094	4.503111	16.66842	8.818914
7.374797	10.71553	10.96038	7.777126	15.81554	4.639979	6.7058	12.59453	8.989831	9.515228
6.461245	11.65467	13.82803	8.161253	15.31446	10.59458	7.804854	10.12585	10.29631	9.779055
3.112958	10.1248	5.773814	8.532965	16.25144	6.443162	4.897312	7.631482	8.942046	6.473862
5.391567	4.633867	7.353981	13.37131	9.251671	7.77461	8.638721	7.515588	14.89781	6.391859
6.236695	11.5457	13.38175	14.94165	16.53806	10.23262	7.503446	4.837701	14.60119	14.66111
5.650557	2.797669	7.473591	14.46593	8.227711	10.17552	11.30294	13.30563	7.750461	10.68763
5.253563	9.676555	13.40888	15.58208	10.7622	5.703652	10.39991	4.966019	6.256973	16.52858
6.424884	5.20098	13.38562	5.351461	16.96428	5.121972	6.450074	13.31002	4.643695	15.94865
5.360678	11.92724	8.814792	8.976344	16.14159	12.70825	5.443342	8.834468	15.11898	15.84374
6.348403	8.95238	9.864185	10.4318	13.38114	8.322046	7.976733	8.762439	10.81657	11.46486

3rd Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
11.96095	11.18476	4.571784	7.537541	8.735856	9.768875	9.606464	4.723792	16.58054	8.481
6.917711	10.49541	10.77868	7.473957	16.93595	4.440996	6.963663	11.58546	7.730947	9.249741
6.768749	11.76053	13.26239	8.177492	15.11798	10.52521	7.783968	11.54102	9.818374	9.238084
6.550903	10.82654	6.932562	8.256289	16.29112	6.212424	5.335499	6.805499	8.962193	16.90984
5.642519	4.869662	7.556218	13.45967	18.66037	7.77433	7.533562	7.281616	14.99612	6.304756
6.220691	11.94946	13.5515	14.63654	16.91441	10.35229	7.021851	5.210271	14.61048	14.46002
5.715236	4.587978	7.297692	13.73798	8.435701	9.550387	12.53289	13.19234	8.609384	10.23683
5.224018	9.834215	13.46311	15.11134	10.28438	5.585539	9.442437	4.919825	6.223485	16.27721
6.373157	4.609273	13.34048	6.12475	16.18322	4.658191	6.477698	13.19043	4.369337	15.66427
5.349783	12.37521	7.872207	8.664606	15.99832	12.75268	5.403433	8.326908	15.89057	15.66206
6.672372	9.249303	9.862661	10.31802	14.35573	8.162092	7.810146	8.677716	10.77914	12.24838

4th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
11.7527	11.1996	2.292563	7.637811	8.496785	9.510665	9.344706	3.920057	16.45516	8.739801
6.715328	10.21368	10.81674	7.862404	15.67638	4.207873	6.894646	11.59825	8.293167	9.472059
6.769855	11.15294	12.56159	7.9146	15.68125	10.21034	7.770421	11.59712	10.18506	9.895748
6.531393	9.831714	5.985268	8.581448	15.79043	6.40591	3.513894	7.569656	8.669564	5.784743
5.625582	4.872919	7.956651	13.12749	8.111885	6.53426	7.490032	6.910367	14.67209	5.871024
6.269655	10.59528	13.29136	13.63399	16.35664	9.694469	6.996233	4.975568	13.49891	14.31934
5.62807	2.726864	7.111867	13.96341	8.617372	10.19236	11.45665	13.90261	7.904579	10.43648
5.798915	10.19894	13.78239	4.992035	10.79054	5.617547	9.203952	4.682205	5.634746	16.22309
6.107641	4.221077	13.78724	16.26618	16.3121	5.285461	5.895478	13.32287	3.874558	15.15921
5.675192	11.8409	8.578865	8.904037	15.97686	12.44789	6.111174	8.829458	14.97751	15.31588
6.687433	8.685391	9.616453	10.28834	13.18102	8.010678	7.467719	8.730815	10.41653	11.12174

5th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
11.90555	10.8232	14.27704	7.58582	8.681434	9.50648	9.585885	3.360156	16.77965	8.814951
6.963335	10.47196	10.51051	7.795887	15.43762	4.410539	6.956603	11.87245	7.996362	9.478761
6.539128	11.99618	11.93857	7.95216	15.3793	10.56761	7.369843	11.64826	10.14895	9.467583
5.64337	10.13276	5.916041	8.765027	16.21728	6.252145	4.188518	7.727987	8.971207	6.431439
5.568271	4.853898	7.875429	12.36354	18.61087	7.757524	8.342115	6.992198	15.27097	5.902662
5.928075	10.24553	12.97659	14.41471	5.945927	9.314603	6.939846	4.701265	13.77415	14.6224
5.359526	3.974804	7.214736	14.52379	8.535112	9.869001	9.809738	12.89694	8.643163	10.52012
5.334769	11.14329	12.97897	4.48239	10.81079	5.35343	10.50063	4.614538	5.259963	15.99683
6.318056	6.355799	13.31883	5.70137	15.32806	4.889351	5.456008	12.77672	4.460098	15.68386
5.248547	12.2279	8.392236	8.952929	16.10935	12.69586	5.705522	8.283103	14.72649	15.80807
6.480863	9.222532	10.5399	9.253762	13.10557	8.061654	7.48547	8.487361	10.6031	11.27267

Raw data for Section 4.4.2.9 with single node performing Document Query (7 active nodes)

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
361.5501	321.9779	296.8513	288.9975	321.6248	300.7045	291.6251	284.6361	293.0078	314.4867
328.3096	288.428	304.6246	278.6577	291.1331	297.1532	333.1004	285.9932	287.7625	317.6712
290.7664	306.7773	308.1006	294.7269	284.9566	307.1629	256.034	281.7649	280.7085	398.6213
364.0201	296.2914	268.5683	300.2671	276.3719	266.0841	300.1949	287.3013	305.3752	271.5091
329.1722	284.9879	339.6045	308.2748	271.4789	317.9875	294.9599	263.2637	296.5325	295.7916
294.024	303.3484	311.2926	283.0728	311.5203	307.2749	309.714	280.873	275.8628	285.6257
303.3317	316.5503	286.3469	305.986	297.3743	307.8647	303.7185	282.9706	300.5428	282.0309
308.9477	286.298	309.3546	294.2719	275.1136	273.2222	333.0603	334.033	299.8779	274.1863
404.0886	296.3726	276.1675	305.1688	294.6468	293.2474	304.8766	296.5421	289.3705	391.6395
316.9525	302.006	376.3464	276.8336	302.9856	319.8724	278.599	289.6617	340.2034	321.7385
330.1163	300.3038	307.7257	293.6257	292.7206	299.0574	300.5883	288.704	296.9244	315.3301

Raw data for Section 4.4.2.9 with single node performing Document Query (6 active nodes)

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
268.0276	265.3609	245.9453	271.9616	259.7435	227.7068	317.7531	242.5082	324.3638	259.3153
328.9966	247.8229	227.501	274.2199	244.3312	236.1076	250.8991	259.5735	247.3868	244.3432
299.2248	274.11	255.9262	269.6838	239.8475	254.482	232.5391	253.6601	240.4672	253.648
374.7789	225.5236	247.2601	233.0254	243.5199	233.2488	251.6095	267.1032	345.0695	246.557
272.8631	229.6714	240.4615	240.268	230.4321	238.6941	246.4226	322.6407	239.9975	240.3194
250.4943	256.1856	255.5754	255.7614	253.0683	236.958	223.8215	243.5601	261.0866	246.2475
320.6808	248.4667	263.9828	238.5144	253.408	250.405	246.7366	240.8086	234.8321	256.5925
285.4259	275.4369	394.7524	265.8119	229.96	252.628	226.2922	234.5004	248.5526	324.4021
241.4117	305.1054	252.2699	230.9686	254.0464	398.703	229.4726	238.1679	237.0607	237.0239
301.7898	348.0238	278.016	248.1817	236.2981	258.0381	217.0407	232.0673	231.2592	241.9768
294.3693	267.5707	266.1691	252.8397	244.4655	258.6972	244.2587	253.459	261.0076	255.0426

Raw data for Section 4.4.2.9 with single node performing Document Query (5 active nodes)

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
308.46	213.119	251.6115	226.0562	251.588	213.7274	207.1724	210.6841	230.9705	239.035
254.3005	218.1801	255.3691	216.1727	253.232	210.5442	229.8264	232.9122	240.0567	231.8378
268.794	252.7787	213.2701	271.3526	255.9362	229.1772	226.8537	215.4272	211.3736	212.4602
243.5577	220.7814	212.2263	217.0492	216.1121	245.1512	276.3456	225.3772	239.1985	235.9969
245.8526	354.2959	367.1489	206.5499	212.6156	208.0041	216.9986	345.4288	206.6457	208.8583
250.5091	361.4257	223.3137	222.5937	247.649	203.5618	211.9606	292.6198	205.2536	203.9049
238.6836	230.8448	216.1977	218.5911	215.2625	211.969	246.8089	212.7906	339.5062	224.3107
236.8231	239.9638	216.7866	213.337	347.0237	246.746	213.1829	209.2884	218.3797	212.5523
325.9434	367.6811	215.3999	212.1498	265.3595	231.5533	251.9602	272.4811	214.1885	207.7829
501.4353	278.327	322.8959	234.489	235.4856	211.8973	282.1467	278.9582	217.9588	204.5583
287.4359	273.7398	249.422	223.8341	250.0264	221.2332	236.3256	249.5968	232.3532	218.1297

Raw data for Section 4.4.2.9 with all nodes performing Document Query (7 active nodes)

1st Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
3.390522	3.511887	6.530878	10.99449	10.61237	4.350477	3.134245	6.167534	7.528751	10.79645
2.32189	4.497387	6.75331	8.270563	13.86853	2.108341	3.985875	6.25374	7.603399	12.2288
2.531248	4.288009	8.775487	8.39996	12.93156	2.741542	4.758375	5.678708	10.42771	11.50749
2.86014	4.847655	6.368652	11.49927	10.35235	3.50814	5.634386	7.917851	8.73277	9.829413
2.514261	3.765682	8.961347	8.552404	11.4894	3.471248	4.243407	6.906487	8.74588	11.37871
2.278206	5.726078	6.853018	8.791724	14.98022	2.874056	5.548	6.627092	11.4785	11.52543
3.873503	5.225531	6.561822	12.11288	15.77293	3.371493	7.435	6.771011	10.31043	13.67478
2.656764	5.720313	9.487013	9.56169	11.94964	2.563447	6.320119	7.424433	9.142878	16.2772
3.621985	5.841046	7.970902	9.792695	11.67776	3.988949	4.127738	7.102822	14.30955	16.30049
2.956556	5.822186	7.852241	12.82029	15.39547	3.932966	7.405085	9.282908	9.975644	11.74011
2.900507	4.924577	7.611467	10.0796	12.90302	3.291066	5.259223	7.013259	9.825552	12.52589

2nd Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
3.376706	2.554612	6.290818	11.11793	10.47045	4.153661	4.413547	5.878998	8.112067	12.78058
2.315073	4.512212	7.17636	8.315211	9.559805	2.269928	3.862305	6.130827	8.493555	12.57032
2.629072	4.254239	7.926938	8.140258	15.55543	3.136865	4.534981	5.937878	10.7705	14.87068
2.822078	4.869543	6.386926	11.77636	11.40199	3.11535	5.370884	7.719165	9.340761	10.47103
3.545231	4.966392	8.99457	9.40386	10.63711	3.164827	4.365233	6.957987	8.827961	10.97903
2.711502	5.703223	7.449167	8.811083	10.38704	1.976233	4.755232	7.710601	9.845017	11.44896
3.88538	6.99889	7.216477	9.130355	10.73139	2.351932	6.787699	7.72083	12.1787	14.45065
3.171251	6.929841	9.823157	11.34255	16.34607	3.833091	6.648049	6.711465	9.376998	16.33114
3.604924	5.778438	7.963567	9.364264	13.74405	3.967539	5.36975	6.719572	17.27446	17.8096
4.168363	6.654443	7.25726	8.879301	11.64519	3.296765	7.304943	9.491217	9.66426	16.10183
3.222958	5.322183	7.648524	9.628117	12.04785	3.126619	5.341262	7.097854	10.38843	13.78138

3rd Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
3.359575	2.846034	6.63363	11.4605	10.803	4.148629	4.401846	6.204644	7.930992	11.98853
2.290723	3.32274	7.128934	8.110319	13.83621	2.251959	3.926594	5.974306	9.183399	11.8613
2.472812	3.371812	6.884892	7.549024	12.24069	3.162513	4.820855	6.396592	10.89477	10.61561
2.648355	4.546817	6.731572	8.307771	10.705	3.479499	4.182541	7.897507	8.718105	11.14131
3.554054	5.182226	7.415785	10.63007	13.42183	3.624919	4.606702	6.282937	8.867163	11.47553
2.286794	5.249533	7.349557	8.682031	15.61166	2.744622	5.207107	7.73273	11.42209	12.31685
3.900147	5.444076	6.935079	8.575596	11.34599	3.448684	5.345363	7.406583	11.64466	14.18216
2.374372	5.330323	6.977092	9.751603	11.86479	3.463509	6.311036	7.376775	9.565673	10.74334
2.592275	5.412576	7.7068	10.99742	11.42771	3.748345	5.115747	8.305874	15.57061	11.45464
3.214262	5.979845	7.43499	9.772839	15.90619	3.955153	7.268599	8.963725	9.788574	11.44101
2.869337	4.668598	7.119833	9.383716	12.71631	3.402783	5.118639	7.254167	10.3586	11.72203

4th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
3.257408	3.698596	6.798668	11.19785	10.16809	4.126975	3.600681	6.22199	8.860706	12.30579
2.123788	4.527123	6.470344	8.32112	14.71011	1.981998	3.780491	6.15416	8.332192	10.2233
2.619293	3.629009	8.483824	7.815642	11.85132	3.154653	4.811789	5.857058	10.78326	15.4935
2.803616	4.891185	6.266166	8.800763	10.72815	3.43861	4.443033	7.90547	8.3012	14.7036
3.336056	5.112802	6.505024	10.66916	11.20254	3.563663	4.562032	6.347701	8.455669	13.96971
2.835991	5.500392	7.48831	8.250461	15.93333	2.231731	5.542128	7.638315	11.31852	10.21577
2.913843	6.376917	7.738814	8.246641	13.53682	3.435345	7.140586	7.817673	9.215395	11.61867
3.150116	5.921261	9.861115	9.170577	11.52236	3.314746	6.301297	7.300854	9.562098	16.9191
3.398209	5.583657	7.851536	11.20302	11.23062	3.996207	5.347855	8.35625	14.78174	16.25994
3.847172	6.286947	7.558556	9.436151	10.89388	3.380662	7.551	7.683568	9.94591	16.59872
3.028549	5.152789	7.502236	9.311138	12.17772	3.262459	5.308089	7.128304	9.955669	13.83081

5th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
3.396755	3.415237	6.513366	8.421119	10.72987	4.134583	3.916006	5.648054	8.106647	12.43905
2.300575	4.308979	7.309817	8.24371	14.38052	1.472715	3.341825	6.116102	8.523378	10.38266
2.361178	4.21255	7.359834	11.53458	13.40461	2.943063	4.766359	5.993188	10.71985	15.16516
2.807302	3.571478	6.183632	10.78858	10.1663	1.939075	5.387721	7.46795	8.459516	14.10633
3.564864	4.95265	8.296956	8.907771	10.38827	3.583683	4.41782	7.352533	7.870742	10.62775
2.474958	5.680959	7.85077	8.537195	14.1139	2.414239	5.592199	6.850465	8.471326	10.96804
3.861882	5.735062	8.593937	11.68183	13.1954	2.868865	7.313562	7.77498	12.28506	14.2038
3.998785	6.439127	7.263116	9.437486	10.82379	2.88868	5.837489	7.284289	9.556719	15.20939
3.594735	5.845317	7.49816	9.577481	11.63989	3.835076	5.301915	7.323442	16.52692	16.39059
4.192396	6.483722	9.714933	12.57857	14.88714	4.311523	6.251056	9.572236	9.38872	15.87379
3.255343	5.064508	7.658452	9.970831	12.37297	3.03915	5.212595	7.138324	9.990887	13.53665

6th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
3.366898	3.338335	6.468986	7.575463	10.82105	4.121355	4.285091	6.214604	8.102071	11.34006
1.48831	4.533101	6.530484	8.228496	13.62999	1.663439	3.536769	5.81145	9.990537	11.13727
2.598308	3.852423	7.982203	10.44305	14.22747	3.145089	4.834649	5.98715	8.49231	15.12839
2.841157	4.912549	6.380767	9.560065	9.972159	2.309679	5.410391	7.912492	8.68228	13.49894
3.561451	5.138074	9.323618	9.471068	11.15345	2.6423	4.583289	6.99789	9.580672	11.45552
2.954024	5.709072	7.207049	8.816399	15.26204	2.830997	4.939336	7.83258	11.21484	11.50627
2.447236	6.640358	7.813543	11.91001	16.2475	3.564486	7.13023	7.126235	8.824264	10.92206
3.23085	6.134455	9.673882	9.778236	11.99065	3.705403	6.173575	6.936356	9.58469	16.64859
3.613226	5.829411	7.948093	9.853715	11.66371	3.893919	5.292338	8.905098	13.77711	15.82152
4.271778	6.459357	7.703361	9.141104	16.39605	3.549236	6.998789	7.941331	10.77116	15.78886
3.037324	5.254713	7.703199	9.477762	13.13641	3.14259	5.318446	7.166518	9.901994	13.32475

7th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
1.234128	3.454373	6.251508	8.104641	10.81605	1.400079	4.485064	6.256532	7.746677	11.64679
1.250227	3.637082	7.593896	7.791091	13.89235	1.203835	3.971302	6.138461	8.119476	10.82876
2.614311	4.128309	7.165908	11.98715	12.54709	3.444802	3.532556	5.808246	10.69651	14.41989
1.606974	4.940609	6.372999	8.59141	10.56287	3.458977	5.391397	7.817841	8.696411	14.27507
3.572466	5.149023	6.943703	9.115145	10.79851	3.50085	4.599141	6.608929	8.113131	10.35671
2.925707	5.584754	7.464215	10.75982	15.1481	2.934319	5.481148	7.197411	8.13338	10.54517
3.605322	6.143197	8.700585	8.759052	16.27038	2.61313	7.367732	8.579743	12.21646	11.37313
2.877236	5.550845	6.716161	9.819221	11.11023	3.103013	6.270515	7.363265	9.420631	15.67024
3.626741	5.692745	7.98043	9.796325	11.49004	3.976463	5.323603	7.131202	16.77193	16.44208
4.119145	6.110166	9.616153	12.63953	11.30947	3.819016	7.327951	9.516432	9.969358	11.47959
2.743226	5.03911	7.480556	9.736339	12.39451	2.945448	5.375041	7.241806	9.988396	12.70374

Raw data for Section 4.4.2.9 with all nodes performing Document Query (6 active nodes)

1st Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
2.654888	3.35046	4.787399	6.221234	7.131696	2.472153	2.9215	6.42194	5.870857	8.197565
2.720944	3.880945	5.955715	6.28506	9.31828	1.80531	2.266482	4.573992	5.840188	7.760105
2.482988	3.100774	5.434404	7.532666	8.987145	2.142579	3.336317	5.342185	6.473656	10.79971
2.632306	2.941063	5.829377	6.833587	7.46124	2.272002	3.722424	4.694125	6.669032	8.492552
2.696839	3.246174	5.365901	8.233309	11.26844	1.830104	4.420528	6.290065	8.613781	8.611536
2.374205	3.963169	5.759996	6.463462	9.767065	2.70991	4.161261	5.425868	6.550149	9.248049
2.36213	3.755479	5.447565	8.183898	8.844637	2.342689	3.854664	5.425425	6.797555	11.11352
2.402177	4.586823	6.708735	7.661688	12.47168	2.208642	4.457714	5.763975	8.674059	8.174775
2.573116	3.279424	5.827675	8.460572	11.80591	2.275373	5.297846	5.833766	7.263633	9.12552
3.560727	4.414525	6.223531	7.121953	9.295292	2.290133	4.59401	6.835055	9.720446	8.657645
2.646032	3.651884	5.73403	7.299743	9.635138	2.23489	3.903275	5.66064	7.247336	9.018098

2nd Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
3.74377	3.516155	4.637018	6.1337	8.067416	2.921235	2.174467	6.153936	6.164877	8.127032
2.178489	4.12105	5.288586	6.853726	9.523446	2.209338	2.94473	4.892378	5.993837	8.707047
2.441053	2.415542	5.821756	6.814526	8.326438	2.318654	3.102307	5.516218	6.326094	7.936595
2.511588	2.660859	5.277185	7.833717	7.935173	2.152355	2.928506	5.304117	6.840341	8.722488
2.6202	2.588483	4.943312	6.990334	11.10026	2.576412	3.845356	6.381744	8.632075	9.462806
2.457643	4.440317	5.454504	7.119246	9.406876	2.56802	4.153095	5.481119	6.439485	10.57743
2.751243	3.492632	5.672891	9.236356	8.551239	1.88402	4.15583	5.264592	7.437628	8.647685
2.105207	3.64091	6.115801	7.970943	11.97213	2.795521	4.324014	5.314157	8.606731	9.269559
2.314038	4.158904	5.595444	7.471145	11.95985	2.513821	5.318544	5.573926	7.418479	10.68582
3.41056	3.46445	6.137172	7.617896	9.743869	3.225369	4.370522	6.648808	7.976052	12.20641
2.653379	3.44993	5.494367	7.404159	9.658669	2.516475	3.731737	5.6531	7.18356	9.434287

3rd Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
2.96794	3.794937	4.764752	6.756437	8.916519	2.946127	2.409014	6.484606	5.817787	7.852801
1.8175	4.129976	4.688292	7.187556	7.658367	2.193869	2.689833	4.898349	5.890904	7.959613
2.503867	2.669413	5.246091	6.639964	8.351608	2.457676	2.552205	5.798195	6.176519	10.72323
2.646914	3.337814	4.924992	8.150302	8.923149	1.370654	3.175727	4.803033	6.42334	8.313684
2.460327	3.234211	5.257442	7.43783	7.990517	1.612254	4.841341	6.950426	8.602224	8.122559
2.504233	3.21259	5.606116	7.428723	8.718095	2.700624	4.170764	5.239947	6.244072	9.491968
2.868498	4.572363	5.662741	9.373926	10.31007	2.794533	4.165754	5.761283	7.145551	10.91725
2.993521	4.581874	5.529264	7.225124	8.355435	1.970324	4.576209	5.537786	8.383414	8.899636
3.909527	4.388141	5.821011	7.999355	8.571044	2.978393	5.350397	5.850165	7.606286	8.872258
3.545287	4.438926	6.837929	8.774814	9.705411	2.572899	3.68796	6.401785	9.693964	12.13747
2.821761	3.836025	5.433863	7.697403	8.750022	2.359735	3.76192	5.772558	7.198406	9.329047

4th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
3.871839	2.243291	4.747602	6.213694	7.470563	2.930227	2.942821	5.875751	6.679185	8.316717
2.165065	4.135975	4.84513	6.685728	7.389282	1.965973	2.521743	4.779706	5.696682	8.22004
2.167458	3.173469	5.454578	7.478633	9.837212	2.46191	3.120291	5.787877	6.463969	10.67991
2.63595	3.440564	5.269326	6.720815	7.732376	2.259234	4.620199	4.881823	6.998318	8.688903
2.572416	2.852253	5.158379	6.776588	7.720128	2.589045	4.450955	7.341753	8.617242	8.9168
2.600241	3.917985	5.241738	8.256701	10.6005	2.718542	3.965882	5.315794	6.563813	10.82655
2.768552	4.482064	5.244386	8.773088	8.159103	2.125147	4.134446	5.918719	7.765231	8.999809
3.282246	4.564166	6.993277	8.317283	8.872983	2.92841	4.56729	5.82663	8.183942	9.325475
2.719742	4.409962	5.782154	8.689787	11.87964	2.707205	5.168496	5.435053	7.132023	9.191088
3.31657	4.50745	6.23989	7.409005	9.488853	2.979357	4.60317	6.528303	9.534991	12.11392
2.810008	3.772718	5.497646	7.532132	8.915063	2.566505	4.009529	5.769141	7.36354	9.527922

5th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
3.117554	3.583557	4.468895	5.846742	8.503834	2.952451	3.124609	6.434816	5.954665	8.335547
2.152531	3.29337	5.211695	6.540257	9.870639	2.682732	3.237832	4.923346	6.500344	8.205045
1.959563	2.843004	5.315704	7.385005	7.477705	2.379589	2.831963	5.629957	6.388186	10.33019
2.409419	3.119321	5.299152	6.461871	8.230518	2.278809	3.362848	5.452601	7.328987	8.707958
2.714674	3.693872	5.38877	8.644757	11.28604	2.566883	3.390446	5.791338	6.608687	8.927107
2.608021	3.47452	5.858082	6.801536	9.161168	1.805045	4.621294	5.525496	6.536367	8.77927
2.543954	4.242221	5.554173	8.589682	8.437376	2.612119	3.974529	5.517556	6.638727	11.13999
2.608986	4.609737	5.733696	9.472274	11.79427	2.92001	4.597986	5.951131	8.694739	8.680861
3.212858	4.400367	4.727901	8.392364	11.59223	3.484813	4.275487	5.635232	8.169994	9.176504
3.570473	4.43513	5.972933	7.910937	9.720165	3.557694	4.64627	6.663831	7.589741	11.7739
2.689803	3.76951	5.3531	7.604542	9.607394	2.724015	3.806326	5.75253	7.041044	9.405638

6th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
3.106263	2.51256	4.759258	6.153825	7.688512	2.818019	2.557947	6.452047	5.686955	8.308422
1.968455	3.177638	4.913354	7.647393	9.502538	2.23513	2.988714	4.708409	5.977592	8.693973
2.51288	3.36691	5.424452	6.984432	7.882576	2.483188	3.149307	5.783981	6.481728	10.89984
2.559699	3.741782	5.149498	7.499644	8.340473	2.290182	3.884917	5.8113	6.986323	7.930358
2.725351	3.453532	5.397313	7.780157	11.30255	2.416846	4.531158	7.733115	8.493189	8.746801
2.58242	4.508323	5.74969	6.692441	10.16446	2.690991	3.816529	5.431687	6.588761	10.66086
2.821155	4.500024	5.684037	9.409232	8.877528	2.666715	4.550787	5.678544	6.900858	11.12469
3.403331	4.386612	5.866268	8.673178	12.28924	2.905933	4.441269	5.651849	7.730214	9.306115
2.943643	4.380949	5.793261	7.313822	11.79647	2.935816	5.365434	5.767328	7.583556	8.399577
3.447974	4.262802	6.214532	7.843816	9.586402	2.765924	4.615204	6.177025	9.787181	12.89086
2.807117	3.829113	5.495166	7.599794	9.743075	2.620874	3.990127	5.919528	7.221636	9.696149

Raw data for Section 4.4.2.9 with all nodes performing Document Query (5 active nodes)

1st Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
1.524183	2.403166	4.504402	4.970039	5.876511	2.120256	1.732865	2.627339	4.246456	5.225678
1.91293	2.498573	3.882456	5.786951	5.351035	2.573556	1.682977	3.908525	5.707306	5.508714
1.933187	2.288704	3.639104	4.493895	5.753101	1.754635	2.654766	3.583957	5.459522	5.181516
2.355647	2.742955	4.232347	5.868593	6.902569	2.80506	2.974443	4.277824	4.188638	5.399628
2.408008	2.336764	3.739222	5.770746	6.764383	1.967892	2.435545	4.276457	4.849627	6.337028
2.261176	3.703564	4.218324	5.120975	5.862353	1.55723	2.570496	3.981837	5.151319	6.395634
1.844571	3.118514	4.76122	4.812683	6.926422	2.127272	3.459156	3.992836	4.677056	5.573132
2.231398	2.464123	4.744039	5.74341	6.380425	1.449465	2.656385	3.813241	5.378192	5.577316
1.653158	3.428921	4.418735	5.863688	8.881429	1.562995	3.30259	4.45691	4.952795	6.502261
2.514627	2.863563	5.700335	4.981216	6.151939	1.589787	3.590348	4.149036	6.250473	7.778255
2.063888	2.784885	4.384018	5.34122	6.485017	1.950815	2.705957	3.906796	5.086138	5.947916

2nd Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
1.959161	2.986955	4.344513	5.782628	5.894591	2.637136	2.387756	3.544513	4.901047	5.875025
1.79923	1.888101	3.89578	5.6425	5.483851	2.607203	2.393586	3.74539	5.250366	7.317592
2.659432	2.973867	3.77359	4.615575	6.736215	1.651981	1.844528	2.881114	5.930545	6.168054
2.314375	2.162584	3.893644	5.465496	6.231234	2.131936	2.802566	3.918911	4.564461	5.585637
2.17261	2.271978	3.8418	5.951358	8.277172	2.127562	2.889096	4.193926	4.968222	5.714692
2.398316	3.423077	4.914054	6.926447	5.969525	2.231812	2.638855	3.819922	4.948251	5.821366
1.70078	2.64929	3.920048	5.924012	5.662368	2.252289	3.773189	4.153627	4.881534	8.49926
2.412446	2.851928	5.73043	6.726139	7.684445	1.657147	3.734893	3.99707	4.786513	5.740267
1.883484	3.586536	4.550099	5.275945	5.990053	2.310034	3.420355	4.834205	5.328898	5.946989
1.602504	2.652544	5.556497	6.859561	8.726477	2.432183	3.900428	4.15528	5.426678	7.580193
2.090234	2.744686	4.442045	5.916966	6.665593	2.203928	2.978525	3.924396	5.098651	6.424908

3rd Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
1.616605	1.720336	4.539449	4.887758	5.384397	2.794232	2.746169	3.52597	4.414216	5.501197
1.930042	2.154988	3.719634	5.415006	5.22429	1.973925	1.903165	3.893078	5.448152	6.936841
1.984711	2.812232	3.764154	4.723741	6.260625	1.831975	2.558443	3.414394	4.985068	5.530869
2.335247	2.793182	3.756892	5.803964	5.876934	2.202442	2.658267	4.272976	4.382584	6.79265
2.122258	2.614249	3.598606	5.599315	7.770778	2.13156	2.58936	4.26689	4.599645	5.265474
2.378067	3.627939	5.119414	5.778167	5.712686	2.302636	2.690054	4.195671	4.638115	6.246079
2.726647	3.366448	4.258536	5.292827	6.765987	1.47146	3.74382	4.387382	4.809996	8.258318
2.491118	2.691921	5.129013	6.582533	6.233247	1.796952	2.509085	3.922567	4.897275	5.82338
2.132546	2.743887	4.715348	5.673623	6.33576	1.786884	3.403644	4.354132	5.44583	7.767586
1.841254	3.632318	5.74917	6.939247	8.772526	1.87523	3.801192	4.28547	4.953755	6.285131
2.155849	2.81575	4.435022	5.669618	6.433723	2.01673	2.86032	4.051853	4.857464	6.440753

4th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
2.209482	1.960589	3.317023	5.157796	5.597856	2.801233	1.94453	3.296879	4.504218	6.257027
1.841332	2.458429	3.586298	5.17994	5.395041	1.741933	2.242362	3.627018	5.86804	5.147646
2.720555	2.609685	3.780155	5.120293	6.589697	1.910774	2.397001	3.56678	5.229747	7.519228
2.318604	2.513422	4.443964	5.142034	6.690971	2.215738	2.292283	4.671212	4.56925	5.191094
2.242539	2.646861	3.832461	5.95981	5.541611	1.349933	2.206654	4.381669	4.751854	5.518161
2.153668	2.965077	4.418398	5.537235	6.618996	1.899641	2.242199	4.187449	4.841752	6.529739
1.49499	2.413031	4.158585	5.76604	6.338742	2.259123	3.75461	4.417529	4.973345	6.212246
2.48779	3.117689	4.474345	5.431183	6.562137	1.98073	2.309445	4.763621	4.97073	7.307902
2.909579	3.344692	4.752497	6.386481	7.916063	2.422561	3.411055	4.18708	5.22508	5.743566
2.213323	3.643092	4.809487	5.575312	6.382456	2.477966	3.907515	4.195621	5.662171	7.958946
2.259186	2.767257	4.157321	5.525612	6.363357	2.105963	2.670765	4.129486	5.059619	6.338556

5th Node

Tx01	Tx02	Tx03	Tx04	Tx05	Tx06	Tx07	Tx08	Tx09	Tx10
1.780226	2.325712	4.543236	4.689452	5.780648	2.786189	2.261661	2.845231	4.802391	5.710802
1.71977	2.272898	3.802075	5.512396	5.469207	1.912464	2.208956	3.815961	5.559586	5.72772
1.851797	2.960119	3.643168	4.841528	6.475506	1.944923	2.203386	3.587602	5.607324	5.774979
1.287928	2.367682	3.955483	5.348245	6.823981	1.975272	2.445833	4.164185	4.446574	6.6751
2.301442	2.419046	3.697852	5.835942	7.852061	2.146134	3.746729	4.365759	5.240736	5.944428
2.303258	2.733277	4.644349	5.437479	6.109837	1.764369	2.403891	4.927061	4.961614	6.42789
2.620808	3.301315	4.241848	5.453539	5.864716	2.266276	2.805622	4.222135	4.96875	5.795954
2.367253	3.271972	4.909391	5.301663	8.768766	2.158946	3.841745	4.951618	5.753558	5.974405
2.115294	3.602833	4.609901	5.533994	6.1627	2.431262	2.675191	4.668935	6.435096	7.610098
2.824877	3.463722	5.200654	5.195943	8.561149	2.35736	3.735326	4.277272	5.218462	6.286061
2.117265	2.871858	4.324796	5.315018	6.786857	2.174319	2.832834	4.182576	5.299409	6.192744

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