

A BLOCKCHAIN BASED HYBRID SYSTEM AND METHOD THEREOF FOR CONSTRUCTION DOCUMENT MANAGEMENT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of Hong Kong Short-Term Patent Application No. 19131504.3, filed on 25 October, 2019, which is incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

[0002] The present disclosure generally relates to a system and a method for managing a construction project, and more particularly relates to a computer-implemented system for managing a construction project and executing received construction documents using a hybrid document management system including a blockchain module and a data repository for maintaining an immutable record of the construction documents.

BACKGROUND OF THE INVENTION

[0003] Although the construction industry is recalled as being slow at adapting to new technologies, the use of information technologies has been proposed in recent years to enhance the efficiency, accuracy, security, and documentation management of a construction project. Particularly, with the increasing complexity in the construction projects and growing demand for higher precision, it is inadequate to handle the building work using the traditional industry practices based on paper documentation, such as design drawings, blueprints, geological data logs, procurement, supply chain management, change orders, equipment logs, and daily progress reports, etc. The construction industry is moving forward to a new era of digitization by using computer-aided construction management tools, which is aimed at delivering a seamless experience on the construction process and comprehensive information on the construction specifications to all stakeholders involved. With the emerging Building

Information Modeling (BIM) technology applied in the design and construction phases, the digital drawings and models, together with other construction information such as schedules, contracts, costs, material, environmental and safety reports, can be exchanged for reducing construction risk and rendering clarity in various construction stages.

[0004] In each construction project, there are different phases of development, such as early-stage planning, design, construction, operation, post-mortem, and maintenance. Depending on the scale of the construction project, the time required may range from a few months for a small project to a few years for building a high-rise building or a major infrastructure. The required project coordination and management can be very complicated, involving many parties such as building owner, project managers, architects, designers, contractors, sub-contractors, specialties, consultants, and facility managers. The construction documents, such as certificates, permits, construction records, and BIM data, may first be created by a document originator (e.g.: architect), and passed around to different contractors, sub-contractors, and engineers. In the construction industry, it is common that the engineers may modify the construction drawings or records by adding remarks thereto. Therefore, the construction document may be modified to a number of different versions after it is created. Each party may store a modified version of the document in their electronic document management system (EDMS), and transmit the modified version to other parties or sub-contractors. The true original version of the document may be difficult to be traced.

[0005] Furthermore, when the construction project is substantially large in scale and takes a long period of time to complete (e.g.: more than one year), some parties may commence their work at a later stage while some other parties may have already completed their tasks by that time. Therefore, the document transfer between the parties may be inaccurate, erroneous, and not in a timely manner. Even if there is an administrator managing and storing all the documents in a database, in view of the number of documents and the scale of the construction project, the process of retrieving a specific construction document and all related revisions of that construction document from the database may be an overly complex operation. In many cases, even the administrator or the project manager may not be able to assure the originality of a document in their database.

[0006] FIG. 1 shows a typical situation of the data communication in a construction project. The project involves architect **11**, project manager **12**, owner **13**, contractor **14**, sub-contractor **15**, consultant **16**, and other parties. Each party may have different EDMS **21-26** for managing the construction documents. For example, when the architect **11** generates a technical drawing, the drawing is stored in the architect's EDMS **21** and transmitted to different parties, such as

the project manager **12** and the contractor **14**. The contractor **14** may then further transmit the document to a sub-contractor **15**. Each party may maintain a different EDMS **21, 22, 24, 25** and a copy of the construction document is stored in each EDMS, which may not be synchronized with each other. This may cause double handling of information and require manual data entry by each party to their own EDMS. This is particularly inefficient in document management and the risk of human error or missing records is unavoidably increased. In some cases, the contractor **14** may modify the drawing before sending the document to the sub-contractor **15**. Therefore, the sub-contractor **15** has no measure to authenticate the originality of the received document and may consider such a revised version as the original version.

[0007] In the event of incompliance in the construction work or other defective issues, the responsibility for such defects is usually difficult to identify. Evidence with respect to the construction records, drawings, and contracts may be difficult to retrieval. The authenticated original version of the construction document may never be appropriately transferred to the front-end parties and engineering teams. The on-site work records may also never properly transferred to the project manager.

[0008] Thus, there is a need in the construction industry for a cloud-based solution to enable comprehensive document management. In particular, a cloud-based document management system that can maintain an immutable and non-corruptible copy of the construction documents is preferred. Furthermore, other desirable features and characteristics will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and this background of the disclosure.

SUMMARY OF THE INVENTION

[0009] An exemplary embodiment of the present disclosure provides a system and a method for managing a construction project with an immutable record of construction documents and executing each of the construction documents using live data and tracking codes are provided. The system comprises an attribute extraction module configured to extract one or more pertinent information about the construction document to obtain attributes of the construction document; a blockchain network comprising a plurality of nodes for managing a blockchain comprising a plurality of blocks, each node comprising one or more processors and storing at least a portion of the blockchain; a tracking code generator for generating the tracking code for each block in the blockchain, wherein each tracking code is associated to a particular

construction document and can be used to directly access the block storing said particular construction document; and a data repository, being isolated from the blockchain network, configured to perform real-time management of the live data and the tracking codes for the construction documents in the blockchain. When the construction document is received by the system, the construction document is stored in a block added to the blockchain network. The live data is a changeable record comprising the attributes, thereby the data repository manages the changeable record of the live data and the tracking code for each of the construction documents and provides direct access of the blocks in the blockchain. The construction documents are decentralized in the blockchain network to maintain an immutable and non-corruptible copy of the construction documents.

[0010] In accordance with a further aspect of the present disclosure, the system further comprises a document compiler configured to impart the tracking code to the construction document for obtaining a stamped document, such that the block storing the construction document is accessible by a user in a procession of a printed copy of the stamped document.

[0011] In accordance with a further aspect of the present disclosure, the data repository comprises an authentication unit for performing a user authentication for the access of the data repository. The authentication unit generates an authentication key for a first record in the data repository comprising the tracking code and the live data of the construction document. The authentication key is used by a data requester to access the first record in the data repository for obtaining the tracking code, thereby the data requester can directly access the block storing the construction document. The first record in the data repository is updated to link to a second record when a revised version of the construction document is received with a second tracking code and a second live data for the revised version stored in the second record in the data repository. The authentication key is used by the data requester to access the first record and the second record in the data repository for obtaining the second tracking code, thereby the data requester can directly access the block storing the revised version of the construction document.

[0012] In accordance with a further aspect of the present disclosure, the attribute extraction module receives a digital certificate of the construction document from an independent third party, such that the attributes obtainable from the attribute extraction module comprise a digital key for certifying that the construction document is a true copy.

[0013] In accordance with a further aspect of the present disclosure, the attribute extraction module comprises a file attributes extracting unit; and a data recognition unit.

[0014] In accordance with a further aspect of the present disclosure, the file attributes extracting unit is configured to extract electronic data related to the pertinent information about the construction document to obtain at least a part of the attributes.

[0015] In accordance with a further aspect of the present disclosure, the data recognition unit is configured to, when the construction document is a construction drawing, locate a title block by identifying an orientation and outlines of the title block, and perform word recognition of words inside the title block.

[0016] In accordance with a further aspect of the present disclosure, the data recognition unit is configured to take reference to a database of commonly used terms with terms including the attributes and a dictionary of standard construction terms.

[0017] In accordance with a further aspect of the present disclosure, the block comprises a timestamp, a hash value, and a storage data for storing the construction document.

[0018] In accordance with a further aspect of the present disclosure, the hash value is a Merkle root concatenating hashes of preceding blocks in the blockchain.

[0019] This Summary is provided to introduce a selection of concepts in a simplified form that is further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter. Other aspects of the present invention are disclosed as illustrated by the embodiments hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The appended drawings, where like reference numerals refer to identical or functionally similar elements, contain figures of certain embodiments to further illustrate and clarify various aspects, advantages and features of the present invention disclosed herein. It will be appreciated that these drawings depict only certain embodiments of the invention and are not intended to limit its scope. The system and the method disclosed herein will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

[0021] FIG. 1 depicts a typical situation of the data communication between parties in a construction project.

[0022] FIG. 2 depicts a system diagram of the hybrid document management system in accordance with one embodiment of the present disclosure.

[0023] FIG. 3A depicts the attribute extraction module in the hybrid system of FIG. 2.

[0024] FIG. 3B depicts an exemplary construction drawing for data recognition.

[0025] FIG. 4 depicts a block diagram of a blockchain network and a data repository in accordance with one embodiment of the present disclosure.

[0026] FIG. 5 depicts a flow diagram for storing a new document in the hybrid system of FIG. 2.

[0027] FIG. 6 depicts a flow diagram illustrating the processing of the new document in the hybrid system of FIG. 2.

[0028] FIG. 7 depicts a flow diagram for retrieving a secured document from the hybrid system of FIG. 2.

[0029] FIG. 8 depicts a flow diagram for retrieving a document by a new stakeholder or team member from the hybrid system of FIG. 2.

[0030] FIG. 9 depicts a flow diagram illustrating the processing of a change order in the hybrid system of FIG. 2.

[0031] FIG. 10 depicts a flow diagram illustrating a method for processing a new document in the hybrid system of FIG. 2.

[0032] FIG. 11 depicts a flow diagram illustrating a method for retrieving a document from the hybrid system of FIG. 2.

[0033] Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been depicted to scale.

DETAILED DESCRIPTION

[0034] The following detailed description is merely exemplary in nature and is not intended to limit the disclosure or its application and/or uses. It should be appreciated that a vast number of variations exist. The detailed description will enable those of ordinary skilled in the art to implement an exemplary embodiment of the present disclosure without undue experimentation, and it is understood that various changes or modifications may be made in the function and method described in the exemplary embodiment without departing from the scope of the present disclosure as set forth in the appended claims.

[0035] Aspects of the present invention may be embodied as a system, method or computer program. The present invention may be implemented by hardware, software, firmware, middleware, microcode, hardware description languages, or any combination thereof. When

implemented in software, firmware, middleware or microcode, the program code or code segments to perform the necessary tasks may be stored in a machine-readable medium such as a non-transitory storage medium. A processor(s) may perform the necessary tasks. A code segment may represent a procedure, a function, a subprogram, a program, a routine, a subroutine, a module, a software package, a class, or any combination of instructions, data structures, or program statements. A code segment may be coupled to another code segment or a hardware circuit by passing and/or receiving information, data, arguments, parameters, or memory contents. Information, arguments, parameters, data, etc. may be passed, forwarded, or transmitted via any suitable means including memory sharing, message passing, token passing, network transmission, etc.

[0036] In the specification and the appended claims, “Building Information Modeling” or “BIM” generally refers to object-oriented building development processes using computer-assisted apparatuses or related software applications that utilize multi-dimensional, digital modeling concepts, and information technologies to design, construct and operate a building project. BIM apparatuses can be used by multiple users, and have architectures allowing the multiple users to synchronize changes and use the most current model. “BIM data” is used to refer to a collection of various types of data and computer-aided design (CAD) drawings related to a construction project.

[0037] The term “cloud” is construed and interpreted in the sense of cloud computing or, synonymously, distributed computing over a network unless otherwise specified. “A server” as used herein is interpreted in the sense of computing. The one or more “database” may be, for example, electrical circuits, hard disks and/or other solid-state disks for storing data. Generally, a server is equipped with one or more processors for executing program instructions, and/or one or more storage for storing data. The server may be a standalone computing server or a distributed server in the cloud.

[0038] The term “Internet of Things (IoT) device” is used to refer to any device that has an addressable interface (e.g., an Internet protocol (IP) address, a Bluetooth identifier (ID), a near-field communication (NFC) ID, etc.) and can transmit information to one or more other devices over a wired or wireless connection. An IoT device may have an active communication interface, such as a modem, a transceiver, or the like. An IoT device may be controlled or monitored by a central processing unit (CPU), microprocessor, ASIC, or the like, and configured for connection to an IoT network or the Internet. For example, IoT devices for the present invention may include but are not limited to, position sensors, pressure sensors, temperature sensors, etc., so long as the devices are equipped with an addressable

communications interface for performing data communication. When sensor devices do not have Internet-connectivity, the sensor devices may be connected to communication devices, cell phones, desktop computers, laptop computers, or tablet computers, etc. to form a connected system, such that the connected system can be IoT devices.

[0039] The use of the terms “a” and “an” and “the” and “at least one” and similar referents in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The terms “comprising,” “having,” “including,” and “containing” are to be construed as open-ended terms (i.e., meaning “including, but not limited to,”) unless otherwise noted. The use of any and all examples, or exemplary language (e.g., “such as”) provided herein, is intended merely to illuminate the invention better and does not pose a limitation on the scope of the invention unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the invention.

[0040] The present disclosure employs blockchain technology to maintain an immutable and non-corruptible copy of the construction documents, such as certificates, permits, construction records, and BIM data. Blockchain is a decentralized peer-to-peer (P2P) network of devices, comprising a plurality of computing devices that are distributed in multiple locations across a geographical area as opposed to a single location such as a data center or a company. In a blockchain, one or more construction documents are integrated together to form a block. The plurality of computing devices forming the decentralized P2P system may operate with each other to manage a blockchain, which may be a data structure used to store information.

[0041] In particular, the blockchain may be a chronological linkage of blocks for storing construction documents therein. When a block is generated, the block is added to the blockchain having a plurality of prior blocks. Each new block added to the blockchain includes a hash value of the prior block, and other information regarding the block. The hash value may be a Merkle root in the header. The Merkle root is a value concatenating all the hashes of the preceding blocks in the blockchain. The Merkle root can speed up data verification and transaction. This can also provide a high level of data integrity. For instance, the data in a previous block in the blockchain cannot be changed without also changing the data in the subsequent blocks, as the hash values of the subsequent blocks depend on the contents of the earlier blocks.

[0042] In certain embodiments, the block generated for a construction document may include an identifier for the document, a timestamp for the time corresponding to the reception of the

document, a hash value for the document, and optionally one or more digital authentication information. The digital authentication information may refer to one or more public key private key cryptographic pairs for the purpose of access verification. A gateway device is provided to interface with the blockchain network directly.

[0043] Although the blockchain technology is most widely known for the use of cryptocurrency, it would be highly advantageous if the benefits of being immutable and non-corruptible in a distributed network can be harnessed for other purposes and tasks other than cryptocurrency. The present disclosure provides a hybrid system comprising a blockchain module for the implementation of a common data environment (CDE) system for managing construction documents in a construction project. In certain embodiments, the CDE can be configured to store and manage BIM data. Unlike a traditional database or a cloud server, the hybrid system is optimized for enhancing the access authentication and providing a permanent, immutable record of documents.

[0044] For illustrating an example system in accordance with at least some embodiments of the present invention, a hybrid system **100** including a blockchain network **110** and a data repository **120** for maintaining an immutable record of the construction documents **41** is shown in FIG. 2. The construction documents **41** is generated by one or more computer devices **201**, portable devices **202**, IoT devices **203**, or any combination thereof. The one or more computer devices **201**, portable devices **202**, and IoT devices **203** include one or more electronic devices having data processing and communication capabilities. In some implementations, the electronic device may include a processor, a memory, a power source, a communication unit, a display, a camera, and a sensor. An electronic device may couple to and communicate with other electronic devices via a network or wired connections (e.g., USB, HDMI, etc.). The construction documents **41** is to be understood broadly and may cover various types of documents pertaining to a construction project, including certificates such as test certificates, completion certificates, payment certificates, check certificates, and maintenance certificates; permits such as environmental permits and road opening permits; operational records and meeting minutes; contracts and tender documentation; specification, floor plans, and other BIM data, such as 2D drawings, CAD models, and mechanical electrical and plumbing (MEP) drawings. Each construction documents **41** may have metadata **51** assigned to it. The metadata **51** is a unique identification associated with the construction documents **41**, which may comprise the document originator, the author, a timestamp, drawing identification (ID), file name, classification, reversion ID, and other information depending on the content of the document. The metadata **51** may be generated from the construction documents **41**

automatically by the computer devices **201**, portable devices **202**, and IoT devices **203**, or alternatively be inputted manually.

[0045] The construction documents **41** and the metadata **51** can be uploaded to a hybrid system **100** through a network **30** by a document originator. The document originator can be any party in the construction project or an IOT device installed in the construction site. The network **30** may be a public or a private wide-area network (internet or intranet). The communication can be wired or wireless in nature, and the data transfer can take place simultaneously when executing the upload instruction, or on a scheduled basis when the construction site is geographically remote without a good wireless communication network. The hybrid system **100** is a blockchain-based document management system for a construction project, and in certain embodiments, the hybrid system **100** may be analogous to a CDE for storing and managing construction documents. In the architecture, engineering and construction (AEC) industry, a CDE is a standard for managing project information when multiple parties are involved. The CDE is defined in accordance with the international standard ISO 19650. With the increasing use of BIM technology and a large number of user interactions with the documents, there is a need for a well-structured system comprising a blockchain network that is accessible by all stakeholders in a construction project.

[0046] The hybrid system **100** comprises a gateway device **130**, a blockchain network **110**, a data repository **120**, an attribute extraction module **150**, and a tracking code generator **160**. The gateway device **130** is a hub connecting to the network **30** for receiving new construction documents **41**, corresponding metadata **51**, and instructions such as change orders. The attribute extraction module **150** is a module for automatically extracting one or more pertinent information about the construction document **41**. The parameters associated with each construction document **41** are obtainable by the attribute extraction module **150** as attributes **52**. In certain embodiments, the metadata **51** is received by the attribute extraction module **150**. Therefore, together with the metadata **51**, complete knowledge of each construction document **41** is available to the hybrid system **100** in the form of data entities, preferably stored in tables.

[0047] In certain embodiments, the attribute extraction module **150** may receive a digital certificate of the construction document **41** from an independent third party for certifying the originality of the construction document **41**. The independent third party should not be any one of the stakeholders in the construction project. Generally, the independent third party can be an independent laboratory, audit firm, law firm, or other companies with the capability in verifying and certifying the originality of a document presented by the document originator. The independent third party has the privilege to provide a digital key to the hybrid system **100**

indicating the originality of the construction document 41. Upon receiving the update from the independent third party, the attributes 52 obtainable from the attribute extraction module 150 comprise a digital key for certifying that the construction document 41 is a true copy.

[0048] As shown in FIG. 3A, the attribute extraction module 150 may further comprise a file attributes extracting unit 151 and a data recognition unit 152. The file attributes extracting unit 151 is configured to extract electronic data related to the pertinent information about a construction document 41 to obtain at least a part of the attributes 52. The electronic data include but be not limited to the file name, the last update information, the file size, author, Internet Protocol (IP) addresses. Generally, the electronic data extracted can compensate for any insufficiency in the metadata 51. If the construction document 41 is a construction drawing 44 or BIM data, such as a design sketch, MEP drawing, the data recognition unit 152 is used to extract information from the title block 45 and record the information as attributes 52. FIG. 3B shows an exemplary construction drawing 44 for performing data recognition. In certain embodiments, the data recognition unit 152 locates the title block 45 by identifying the orientation and outlines of the title block 45 for each construction drawing 44. If necessary, the located area is rotated such that the outlines form one or more rectangular shapes. Next, the information within the outlines, such as the title, company name, revision history, drawing numbers, and drawn date, are identified by word recognition methods. A number of computer-assisted word recognition methods are readily available, which can be implemented to enable the extraction of attributes 52. However, the construction industry has struggled to provide an efficient and accurate word recognition method from the construction drawings 44, as the drawings may be scanned and uploaded to the hybrid system 100 with a lower resolution. In order to improve the accuracy of the word recognition, a database of commonly used terms 153 for each construction project is provided in the present disclosure. The database of commonly used terms 153 may include the names of the parties (such as architect, contractor, sub-contractors) involved in the construction project, the metadata 51 received from the gateway device 130, and a dictionary of standard construction terms. The database of commonly used terms 153 can effectively minimize the chance of recognition error yielding irrelevant context. Similarly, if the construction document 41 is a test certificate, a site instruction, the database of commonly used terms 153 can also improve the accuracy of word recognition when the data recognition unit 152 is extracting attributes 52 therefrom.

[0049] Refer back to the FIG. 2, the metadata 51 received from the gateway device 130 and the attributes 52 extracted by the attribute extraction module 150 are used to generate a live data 80 associated with the construction document 41. The live data 80 is a changeable record,

and the content may including “document ID”, “revision number”, “revision date”, “title”, “author”, “type of document”, and other information. The live data **80** can facilitate the access and search for a construction document **41** in the hybrid system **100**.

[0050] The gateway device **130** is configured to interface with the blockchain network **110**, and the data repository **120** directly. The blockchain network **110** is a decentralized and distributed file system comprising a plurality of nodes. The nodes comprise one or more processors, which can be a plurality of computing devices, including one or more servers, desktop computers, laptop computers, tablet computers, smartphones, other suitable electronic devices, or any combination thereof. The computing devices are distributed in multiple locations across a geographical area as opposed to a single location such as a data center or a company. Therefore, there is no single point of failure for the information in the blockchain network **110**. In certain embodiments, one of the computer devices may comprise the gateway device **130** and a node belonging to the blockchain network **110** such that the computer device can, at the same time, receive data from the network **30** and be a portion of the distributed system of the blockchain network **110** for storing a copy of the entire blockchain of documents.

[0051] The plurality of computing devices functioning as nodes of the blockchain network may operate collectively to perform the document management function. At least the gateway device **130** is configured to receive a construction document **41** and generate a block storing the construction document **41** with the hash value of the preceding blocks and add the block to the blockchain network **110**. Each computer device participating in the blockchain network **110** typically maintains a copy of the entire blockchain, although in some cases the computer device may only maintain a portion of the blockchain. The blockchain network **110** may be configured as a public blockchain or a private blockchain. A public blockchain may refer to a blockchain of a decentralized public system that any computing devices may be permitted to act as nodes in a decentralized public network and have access to the blockchain network **110**. In some instances, the public blockchain may be viewable and/or accessible by computing devices that are not participating as nodes within the decentralized public network. A private blockchain may refer to a blockchain network **110** of a decentralized private system that only authorized computing devices are permitted to act as nodes in a decentralized public network and have access to the blockchain. In some instances, the private blockchain may be viewable and/or accessible by authorized computing devices that are not participating as nodes within the decentralized private network.

[0052] The tracking code generator **160** is a module for generating a tracking code **70** uniquely assigned for accessing each block in the blockchain, wherein the tracking code **70** can

be imparted to the construction document 41 for obtaining a stamped document 71. Preferably, the tracking code 70 is associated with a particular construction document 41 and can be used to perform direct access to the block holding the construction document 41 in the blockchain network 110. The tracking code 70 may be a machine-readable code, such as a QR code, to facilitate quick scanning and entry into a computer or a mobile device for accessing the construction document 41 in the hybrid system 100. The tracking code 70 may be added to the construction document 41, preferably at the header or the footer of each page, and concatenated to obtain a stamped document 71. A user may use the tracking code 70 to access the construction document 41 directly. Practically in the construction industry, full-fledged digitization of a construction project is rare and not particularly beneficial. The engineers and construction workers generally use printed copies of the construction documents 41 on-site. It is not convenient and impractical to bring along a portable device or a laptop computer for accessing the construction documents 41. Therefore, the present disclosure is not trying to change the data management for a construction project to full-fledged digitization, but to bring convenience to the user by providing direct access to the construction documents 41 in the hybrid system 100 whenever necessary. In particular, the stamped document 71 has a tracking code 70 imprinted for quick and direct access to the electronic copy of the same document. If a user is in a procession of a printed copy of the stamped document 71, the digital copy of the same construction document 41 should be freely accessible by the user conveniently. There is no risk of a security breach as the tracking codes 70 for the plurality of documents are uniquely assigned without correlation even if they are in the same blockchain network 110. Thereby, the authenticated original version of the construction document 41 can be transferred to the front-end parties and engineering teams.

[0053] The data repository 120 is a separated database infrastructure optimized particularly for the use in the construction industry for performing real-time management of the blockchain network 110 and the tracking code 70 for each construction document 41. The data sets stored in the data repository 120 are isolated from the blockchain network 110, such that the data can be mined for analysis and information retrieval. The access of the data repository 120 is limited to the relevant parties, and may require an authentication key 140. In certain embodiments, a summary can be generated from the data repository 120 for sharing and reporting. The size of the data stored in the data repository 120 is significantly smaller than the construction document 41 stored in the blockchain network 110. A user can obtain some parametrical data, identify relevant documents, and track the revision history using the data repository 120, without the need to access the blockchain network 110 and download the construction document 41 one by

one. Therefore, a user can efficiently perform real-time management of the blockchain network **110** and use the tracking codes **70** to access each block. When a construction document **41** is requested, the user can retrieve the tracking code **70** from the data repository **120** and directly access the block storing the construction document **41**, which may be transmitted to a document compiler **161** before sending or displaying the construction document **41** to the user. Responsive to a request for a construction document **41** by a user, the document compiler **161** is configured to impart the tracking code **70** to the construction document **41** for obtaining a stamped document **71**.

[0054] The authentication of a user may also be performed using the data repository **120**. The access of the data repository **120** is password protected and limited to a particular group of authorized parties. A client login authentication procedure is required for accessing the data repository **120**. Advantageously, the data repository **120** is a changeable record comprising the tracking code **70** and the live data **80** of the construction documents **41**. Therefore, even with the immutable nature of the blockchain network **110** for storing the construction documents **41**, the problem of inflexibility can be compensated using the data repository **120**. Once an authorized party login to the data repository **120**, that party can access various versions of the construction document **41** even if the tracking code **70** is not possessed.

[0055] The block diagram of the blockchain network **110** and the data repository **120** is depicted in FIG. 4. In the exemplary system, the blockchain network **110** comprises six nodes **111-116**. The computer device of the project manager **12** serves as one of the nodes **113** and stores a copy of the entire blockchain comprising a plurality of blocks **310a-310e**. Each block comprises a timestamp **311**, a hash value **312** and the storage data **313**. The timestamp may be a time corresponding to the addition of the block **310a-310e** to the blockchain. The hash value **312** may include the hash values of the preceding blocks in the blockchain. In some embodiments, the hash value **312** may be a Merkle root concatenating all hashes of the preceding blocks in the blockchain. The use of the hash value **312** can ensure the immutability of the blockchain, as any modification to the hash value or the data stored therein necessitates changing of all the hash values **312** of the subsequent blocks in all nodes in the blockchain network **110**.

[0056] For each block **310a-310e** in the blockchain, corresponding records of the live data **80** and tracking code **70** are provided in the data repository **120**. The tracking code **70** provides direct access to the block. If the content in the block is not encrypted, a user may access the storage data **313** directly with the tracking code **70**. The data repository **120** further comprises an authentication unit **90** for authenticating the user and determining the access rights of the

user. One or more authentication key **140** may be required for security purposes. The authentication unit **90** may have a plurality of security levels. In one example, a first level of authentication may comprise an account login process for accessing the data repository **120**. Each party in the construction project may setup their own account for accessing the data repository **120**. In another example, a second level of authentication may comprise a designated IP address for accessing the data repository **120**. In yet another example, a third level of authentication may comprise one-time password verification via short message service (SMS) to a designated phone number. In yet another example, a fourth level of authentication may require an authentication key **140** for accessing a particular block in the blockchain network **110**. A higher level of authentication is usually needed for accessing a hybrid system **100** comprising a private blockchain or a highly confidential construction project.

[0057] FIGS. 5-9 depict flow diagrams illustrating other implementation details of the hybrid system in accordance with the present disclosure. In a construction project, multiple parties are involved. For example, in the following exemplary implementation, the project involves architect **11**, project manager **12**, owner **13**, contractor **14**, sub-contractor **15**, and consultant **16**.

[0058] Now refer to FIG. 5, when a document originator, such as the contractor **14**, creates a new construction document **41**, the contractor **14** can store the construction document **41** in the local document system **20** of the contractor **14**, and upload the same construction document **41** to a hybrid system **100** through a network **30**. The gateway device **130** receives the construction documents **41**, and may use the attribute extraction module **150** to obtain a live data **80**. The gateway device **130** generates a new block **310** storing the construction document **41** and adds the block **310** and the live data **80** to the blockchain network **110** and the data repository **120** respectively. A tracking code **70** can be generated to provide a direct access of the block **310** storing the construction document **41**. The authentication unit **90** in the data repository **120** generates an authentication key **140** for each record in the data repository **120** comprising the tracking code **70** and the live data **80** of the construction document **41**. The document originator may also determine the access rights of the block **310** and pass out the tracking code **70** for other parties to access. Preferably, the tracking code **70** is imparted to the construction documents **41** for obtaining a stamped document **71** using a document compiler **161** when the construction document **41** is requested.

[0059] As shown in FIG. 6, when a new version of a construction document **41**, such as a new drawing, a new site instruction, or a new certificate, is received from a document originator at the gateway device **130**, a live data **83** and a block **310** with the document (revision C) **74**

are generated for the data repository 120 and the blockchain network 110. Previous versions of the document are stored in the blockchain, for example, the revision A 72 and the revision B 73 are stored in blockchain network 110 at block 310d and block 310e respectively. The revision C 74 is assigned to a new block 310, whereas the corresponding live data 83 is stored at a first record in the data repository 120. For the previous revisions, the corresponding live data 81, 82 at the other two records in the data repository 120 are also updated to reflect the inclusion of a new revision of the same document. Therefore, when a data requester holding a hard copy of the revision B 73 or revision A 72, the data requester can use the tracking code 70 or the authentication key 140 to access the corresponding block 310e or 310d, and at the same time, the data requester may use the live data 83 in the data repository 120 to link to the record of live data 83 for the latest revision C 74. The user is not required to have the tracking code for revision C 74, as the tracking code is stored in the data repository 120.

[0060] FIG. 7 shows another embodiment with respect to the retrieval of a secured document 42 from the hybrid system 100 by a data requester. The secured document 42 is stored in the blockchain network 110 and only some of the parties (e.g.: project manager 12, contractor 14, and sub-contractor 15), as referred to as a data requester, in the construction project have the authentication key 141 for accessing. The data requester is required to access the gateway device 130 for login to the hybrid system 100, and use the authentication key 141 for accessing a particular record in the data repository 120. When the authentication is completed and the access right is verified, the party can obtain the tracking code 70 for the block storing the secured document 42.

[0061] In FIG. 8, the document transfer to a new party 17 or team member is demonstrated. When a construction project is substantially large in scale and takes a long time to complete (e.g.: more than one year), the new party 17 may commence the work at a later stage while some other parties may have already completed their tasks by that time. The document transfer between the parties may be inaccurate, erroneous, and not in a timely manner. In accordance with the present disclosure, the project manager 12 can setup an account for the new party 17, and provide the authentication key 142 to the new party 17 for accessing the documents 43. The new party 17 may access the data repository 120 through the gateway device 130, and obtain the tracking code 70 for the block storing the documents 43.

[0062] FIG. 9 shows another embodiment of the present disclosure for handling a change order. As the blockchain network 110 maintains an immutable record of construction documents 41, individual block in the blockchain may not be removed or amended once it is created. Therefore, the present disclosure allows setting an individual live data 80 in the data

repository **120** to obsolete or amended. Consider that a document revision B **46** is to be obsoleted, the gateway device **130** receives the instruction and change the corresponding live data **85**, by adding remarks and/or removing the tracking code **70**.

[0063] FIG. **10** depicts a flow diagram illustrating a method for processing a new document in the hybrid system **100**. A document originator **401** creates a new document **411**, which can be a new test certificate, a new site instruction, or a new BIM data. The document originator **401** may input, or otherwise be automatically generated, metadata **412** corresponding to the new document created. The document originator may store the new document in the originator's document system **413**. Through the network and a gateway device, the document originator can upload the new document to the hybrid system **402**.

[0064] In the hybrid system **402**, the document originator **401** is required to access the project account **421** by the authentication process, such as account login. Once the document is uploaded to the gateway device, the attributes are extracted **422** and a live data is generated **423** using the extracted attributes and the metadata. A block storing the new document with the hash value of the preceding blocks and add the block to the blockchain network **424**. A direct line to the block is also obtained for generating a tracking code **425**. The document originator **401** may receive the tracking code **414** for future access. The data repository is also updated **427** to store the live data and the tracking code. In certain embodiments, an encryption key is also generated for authentication purposes and the document originator can receive the same **415**.

[0065] Now referring to FIG. **11**, assuming a document requester **403** would like to access the document. The document requester **403** may first receive the tracking code **441**. The document requester **403** can use the tracking code to directly access the document in the blockchain **428**. In certain embodiments, the document requester **403** may first receive the encryption key **442**. The document requester **403** can login the data repository **429** for access the hybrid system **402**. An encryption key may be required to gain access to the documents. By checking the live data, the latest version of the document can be identified **430**. The tracking code can then be obtained **431**, and the document can be retrieved **432**.

[0066] Preferred embodiments of this invention are described herein, including the best mode known to the inventors for carrying out the invention. Variations of those preferred embodiments may become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for the invention to be practiced otherwise than as specifically described herein. Accordingly, this invention includes all modifications and

equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context.

[0067] While exemplary embodiments have been presented in the foregoing detailed description of the invention, it should be appreciated that a vast number of variations exist. It should further be appreciated that the exemplary embodiments are only examples, and are not intended to limit the scope, applicability, operation, or configuration of the invention in any way. Rather, the foregoing detailed description will provide those skilled in the art with a convenient road map for implementing an exemplary embodiment of the invention, it being understood that various changes may be made in the function and arrangement of steps and method of operation described in the exemplary embodiment without departing from the scope of the invention as set forth in the appended claims.