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A conceptual framework of decentralized blockchain integrated system based on building information modeling to steering digital administration of disputes in the IPD contracts

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Abstract

Purpose – In the construction industry, various parties are involved in a project. Consequently, claims and disputes are inevitable in this industry. This paper aims to develop Integrated project delivery (IPD) practices including early involvement of stakeholders and multiparty contracts which its combination with advanced technologies such as blockchain can lead to better dispute management and improve the whole construction process.

Design/methodology/approach – Based on literature review, the alternative dispute resolution (ADR) for IPD contacts were identified, and three formats of IPD contracts were selected, and the dispute resolution process of them has been analyzed. Then, based on blockchain review, a conceptual blockchain-based dispute management (BDM) model was generated for ADR in IPD. Model validation was done by an interview. Experts were asked to compare the BDM model with the traditional system regarding the ADR duration.

Findings – Analyses of the collected data from the experts demonstrated that the BDM model has better function in terms of time and cost for ADR process when the project is facing serious and considerable number of disputes. The relation between blockchain technology (BCT) and building information modeling (BIM) has been examined through a framework, and the ability of the proposed model for administrating dispute resolution process has been verified using four different scenarios of construction claims that show the system can run successfully.

Originality – The current study proposes a truthful model, reliable framework to address the problem of project dispute management in IPD contracts. The system combines the ability to being unchangeable and the

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reliability characteristics of BCT with informative and automation aspects of BIM together to improve dispute resolution issue in the IPD system.

Keywords Integrated project delivery (IPD), Project dispute management (PDM), Blockchain technology (BCT), Smart contract, Building information modeling (BIM), Construction project

Paper type Research paper

1. Introduction

Project delivery systems can be considered as the most significant factor affecting the coordination, collaboration, qualitative and quantitative progress update, performance, overall duration and cost of construction projects (Mesa *et al.*, 2019). To tackle the issues and risks associated with traditional delivery methods, researchers and practitioners have introduced the integrated project delivery (IPD) method as a sufficient, collaborative and strong delivery system (Sherif and Abotaleb, 2022). The American Institute of Architects (AIA) has presented the IPD to uplift the usually controversial association among the parties to the contract that frequently occur in the most convention models such as design-build and design-bid-build (AIA, 2007). The utilization of blockchain technology (BCT) in construction projects has been recommended due to the applicability of supplying a practical instrument for conducting and registering alterations to the building information modeling (BIM) by employing smart contracts to discuss editing preferences and saving a fixed public registration of all revisions to the framework (Turk and Klinc, 2017). BIM concept has strongly altered the approach of architects and engineers toward designing, and its usage provides substantial profits in coordination as well as in structural operations (Franz *et al.*, 2020). Project dispute management (PDM) can be considered as one of the most crucial sections of contract management in the construction industry, a domain which burdens remarkable costs to the industry every year. Requirements and characteristics of PDM, like being communication-dependent, requiring detailed documentation and strict legal aspects, make it an area of construction management which can be benefitted from emerging technologies (Faraji *et al.*, 2021b; Le-Hoai *et al.*, 2019; Stamatiou *et al.*, 2019). Available BCT applications are examined on the basis of the project lifecycle. For instance, in the planning stage, smart contracts, as well as construction activities, are labeled as the most important actions of incorporating BCT into the construction industry. The construction sector faced several discords, most of which are associated with contract, risk and responsibility and from the classification of project's governing bodies (Faraji *et al.*, 2021a). There are obstacles to implement such concept in the construction industry due to other effective aspects such as financial, legal, technical and cultural issues. Therefore, to apply the contract, especially from the claim administration and dispute resolution perspective, it is necessary to define new working methods to reduce the practical obstacles. On this basis, this research focuses on development of a model that can be used in the IPD contract to solve some of the technical issues such as how to employ people in the project from the beginning, using automatic platform, sharing information between everyone and making decisions on disputes in a collaborative manner. To resolve the problem of dispute resolution in IPD system, distributed ledger technology called blockchain, which provides transparent ledger of changes, decentralized asset and trusted information, has been proposed. The main aim of the current study is to investigate the capacities of BCT alongside the BIM to establish more reliable platforms of PDM in IPD contracts of the construction industry. It is a considerable point that using advanced technologies such as BIM can play a disincentive role in the context of claims, for instance, from the early phases of a project. As a result, the current

study focuses on the situation where, for example, a claim arises and transforms into an actual dispute, and to propose a model for the administration of such dispute using blockchain and BIM systems. Therefore, the main questions of the study can be stated as follows:

Q1. What are the main dispute resolution mechanisms in IPD contract, and how can they be administered using BCT?

Q2. How can the above dispute resolution mechanisms be established formally using BCT in integration with BIM?

In the rest of the text, first, the main idea and concepts back to IPD, BCT and BIM have been introduced; then, through systematic methodology, using smart contract protocols, a platform has been developed which can automate the digital process of dispute management in IPD contracts.

2. Literature review

Frequent disputes, goal inconsistency, change orders, adversarial relationships, arbitrations and litigations are among the reported problems with traditional construction procurement methods (Ma *et al.*, 2018). In traditional methods, designers only work at the design level, and contractors are only at the construction stage. Consequently, there will be fragmentation in construction which causes several problems (Kahvandi *et al.*, 2019). The problems with communication lead to the division of the construction process to the stages, the significant number of changes and non-operating costs and as a result to the increased project duration and increased costs. The IPD accumulates some of their special features and becomes the next stage in the evolution of the construction industry (Trach *et al.*, 2019). One of the reasons that IPD is being brought into the industry is because these traditional methods of project delivery "suffer because participant success and project success are not necessarily related" (Guide, 2007). The disconnect between the parties can cause a separation between the design phase and the construction phase of a project in the traditional design methods (Jørgensen and Emmitt, 2009).

2.1 Integrated project delivery and building information modeling

Delivery of an integrated project is based on collaboration, comprising of integrating the faculty, the system, the business structure and the practice in entire process. In this process, all members will tackle adequately their abilities and experiences to optimize project performance, increase value to the owner, reduce waste and maximize effectiveness through all the project phases of design, manufacturing and construction (Mei *et al.*, 2023). Early contributions, concentrating on quality, free flow of information and sharing thoughts, are the fundamental variables that add value to the IPD more than any other delivery procedure (Marco *et al.*, 2018). The advantages of using this type of contract are massive in terms of costs, risks, progress and duration (Sherif and Abotaleb, 2022). Some of the most critical issues in application of IPD are integration of information and knowledge management systems, early definition of target goals without fully developed design and unclear BIM standards and practices (Roy *et al.*, 2018). Construction projects include a variety of stakeholders who share considerable volume of data. In contrast of the traditional Information technology solutions, BIM software simplifies the process of documentation, relationship and workflows, permitting the users in various locations to share a common draft of documentation, plans, forms and data in one directory (Faraji *et al.*, 2022). Users can observe and mark files online without the native software and because of its inner audit

trails, the software creates trust, decreases conflicts and mitigates risks (Soltaninejad *et al.*, 2021; Trach *et al.*, 2020; Elghaish *et al.*, 2021). Contractual issues, including uncertainty over the ownership of shared data and the inadequacy of contractual relationships, are currently considered to be the main barrier to the adoption and integration of BIM and cloud computing. BIM is a method for managing physical elements. However, its open standard can be enriched with legal information to manage spatial extent of 3-Dimensional (3D) ownership interests defined inside buildings (Atazadeh *et al.*, 2016). The AIA is one of the few professional organizations in the world that have formalized and documented legal regulations for digital design systems. Section 2.2 of AIA's E202 document states:

> In contributing to content of the Model [BIM], Model Element Author [every participant in BIM integrated system] does not convey any ownership rights in the content provided or in the software used to generate the content. Unless otherwise granted in separate license, any subsequent Model Element Author's and Model User's right to use, modify or further transmit the model specifically limited to the design and construction of the project, and nothing contained in this Exhibit conveys any other right to use the Model for another purpose (AIA, 2008c).

As BIM model is a product of collaboration, ownership of the final output (i.e. the design model) belongs to the client rather than designer's individual ownership of inputs as obtainable in conventional systems. This position is aimed at fostering longer relationship between clients and project teams as extended duty of care not only during construction but throughout the life of the model presumably, beyond project life (Olatunji and Sher, 2010).

2.2 Standard form of agreement for integrated project delivery

The AIA provides agreements for three stages of IPD model which should apply to project proportionately. On this basis, IPD contractual forms organized in five different series with its specific legal terms and conditions (American Institute of Architects [AIA], 2008c). As it was mentioned before, this study focuses on the dispute management in IPD. Therefore, three forms of IPD agreements were selected, which are A295™, A195™ and B195™ that are shown in Figure 1.

A295™ provides the general terms and conditions for two other main documents (American Institute of Architects, 2008b); A195™, Standard Form of Agreement between Owner and Contractor for Integrated Project Delivery (American Institute of Architects, 2008a); and B195™, Standard Form of Agreement between Owner and Architect for Integrated Project Delivery (AIA, 2008c) (Figure 2).

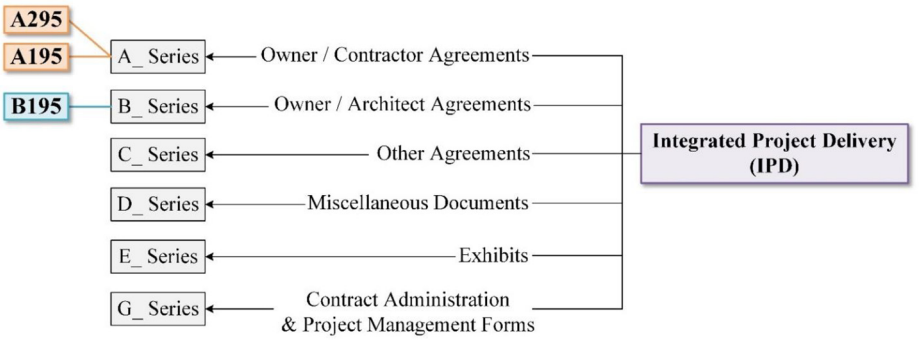


Figure 1. Different series of IPD contractual forms of AIA (IPD contract)

Based on the three forms of IPD agreement mentioned above, when the parties involved in a contract face a dispute over the fulfillment of the obligations under the contract, the process of responding starts. According to Figure 3, the first step is called initial decision-maker which has been applied to resolve the differences between the two parties. In the case of reaching to no compromise, the second stage begins. At this stage, a person as a mediator will be assigned to contract and will examine the claim. If the first and second stages do not lead to the resolution of the claim, the contract enters the third stage, and accordingly, an arbitrator will be involved into the resolution procedure. If none of these steps work, the claimant may pursue his claim through the courts and higher level of legal actions (AIA, 2008c).

2.3 Blockchain technology

BCT surrounds cryptography and peer-to-peer networks to secure a distributed database of historical timestamped transactions (Teisserenc and Sepasgozar, 2021). In BCT, transactions

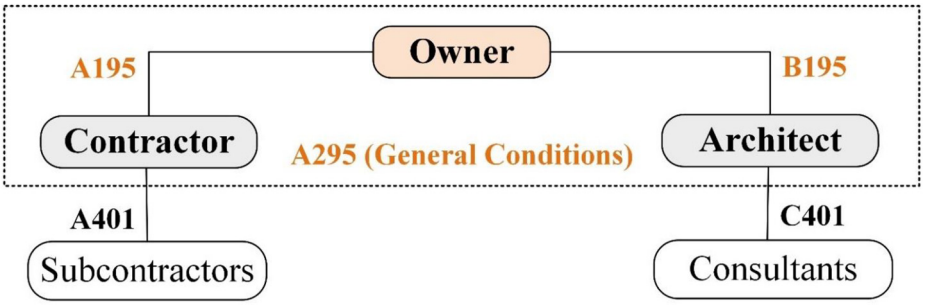


Figure 2.
Functional relations of A295, A195 and B195 forms of agreement based on the AIA documents (IPD contract)

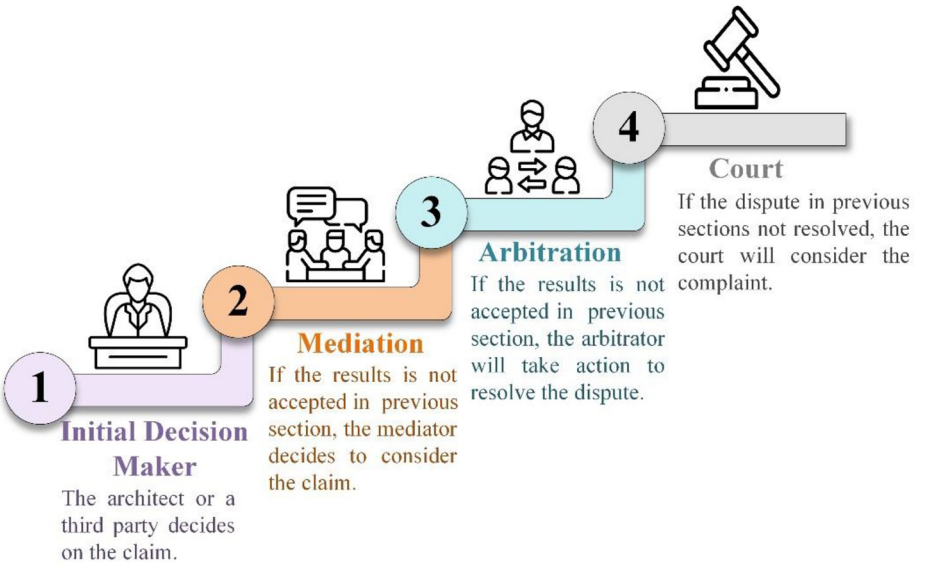


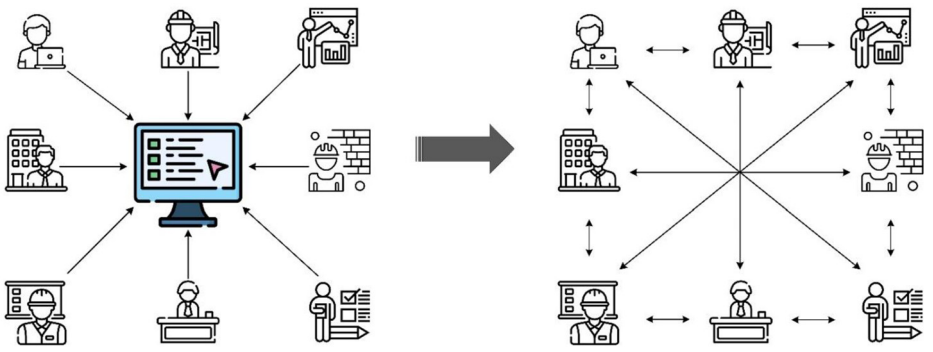
Figure 3.
Different levels of ADR based on the content of IPD contract

Notes: Extracted from the IPD contract (A295, A195, B195)

are recorded in an unaltered publicly shared ledger; whenever transactions are performed on the concerned system, each connected node stores a copy of the (Singh *et al.*, 2023). The data which is recorded in a blockchain, are immutable, cryptographically secured and traceable. According to Figure 4, blockchain conventions are decentralized and do not depend on any centralized trusted third party. Which means this decentralization guarantees that the information tied down in a blockchain are not controlled by any single entity (Teisserenc and Sepasgozar, 2021). The drivers of BCT in construction basically come from their capacity to dispose of realness confirmation, encourage automated procurement and payment and improve the transparency and traceability of construction supply chains (Wang *et al.*, 2017). BCT characteristics may help:

- reduce disputes related to payment, equipment leasing, etc.;
- advance effectiveness in workflow, time and cost; and
- progress transaction transparency, trust and security (San *et al.*, 2019; BRE Group, 2018).

Liu *et al.* (2023) highlighted the construction industry's growing exploration of how BCT can tackle various challenges in quality management, compliance checking, and more. They emphasized the necessity for further research to effectively merge blockchain with construction practices. This integration is crucial for achieving strong collaboration and Integrated Project Delivery (IPD) (Liu *et al.*, 2023). BCT guarantees to make strides proficiency through automation and to upgrade trust, collaboration, data sharing and effectiveness within the construction 4.0. (Teisserenc and Sepasgozar, 2022). Teisserenc and Sepasgozar (2021) discussed benefits and drivers of BCT in construction management. The results showed that BCT improves the trust of construction logbooks, work progress and material quantities. It enables resource sharing and leasing of construction equipment via smart contracts without intermediaries. BCTs simulate, analyze and optimize the construction and optimize construction with internet of things devices. Moreover, task completion log and automate payments by smart contracts is another benefit of using BCT in construction. Smart contracts refuse external substances from interferometer with peer-to-peer contracts and empower atomic transactability. The codified terms of a smart contracts are straightforward and open for inspecting, which permits transacting parties to confirm agreements for consistency (Singh *et al.*, 2023). Harichandran *et al.* (2021) developed



Source: Kim *et al.* (2020)

Figure 4.
Comparison between centralized (left) and decentralized structure (right)

a framework to execute economic management in an IPD system. This framework allows IPD contracts to be integrated into center components of project teams for automating all financial transactions associated with IPD projects (i.e. reimbursements, benefit and cost savings) (Harichandran *et al.*, 2021).

2.4 Gap study: Integration of integrated project delivery, blockchain technology and building information modeling to project dispute management

The current study aims to integrate four effective domains of research including IPD, BCT, BIM and PDM. IPD as a collaborative project delivery approach that uses the talents and insights of all project participants has powerful capabilities to apply in construction industry. IPD itself has inherent conceptual connection with BIM and is recognized as the legal wing of this technological advancement. On the other hand, the construction industry needs more efficient methods for PDM, and BCT, as a decentralized system, could provide a suitable solution for PDM. This technology can help the construction industry to establish more transparent relationships in any type of contract and transaction in a construction project (Faraji, 2019). There is emerging trend of research which is studied application of the BCT in combination of other technologies to solve current construction management challenges. BIM and BCT are mostly occurring together because the first manages data, and the second is the predominant source of data in new-fashioned construction (Darabseh and Martins, 2020). This combination of two technologies can minimize the gap between three-dimensional BIM models and legal paper documentation (Elghaish *et al.*, 2020). BCT–IPD models seek to enhance the three constraints of cost, time and quality by aligning the objectives and incentives of the project team as well as administering a shared rewards and risks approach, early engagement and a multilateral contract agreement (Viana *et al.*, 2020). Table 1 summarizes the main features of relevant previous research as part of the gap analysis stage and outlines a clear aim for the study. As it is shown below, previous researches have analyzed the connection between two out of four mentioned domains, and one of the researches has connected three of the domains to generate an automatic financial model for reimbursed costs, profit and cost saving. In the past, studies have examined the relationship between some of the four mentioned domains. One research linked three domains to create an automated financial model for reimbursed costs, profit, and cost-saving. However, no research has yet analyzed all four domains together as a comprehensive solution to the problems in the construction industry.

3. Methodology

To achieve the purposes of the research, according to Figure 5, four phases were considered. At first using literature review, the alternative dispute resolution (ADR) for IPD contacts was identified. Second, based on blockchain review, a conceptual blockchain-based dispute management (BDM) model was generated for ADR in IPD, which is run in Ethereum platform. Afterwards, for evaluating the effectiveness of the generated model in comparison with the traditional system, an interview was conducted. In the third phase, the extracted data from the interview with experts was analyzed for model validation from two aspects, which are time and cost. In the last phase, an integrated framework with BIM is proposed. This framework specifies the impacts of dispute resolution by BDM method on various project's plan such as work breakdown structure (WBS), time schedule and cost.

3.1 Model development

To develop the model, first, the hierarchy of resolution methods were extracted considering the relevant clauses from the text of contracts A195, A295 and B195. Regarding the different

Table 1. Comparative study of the most related previous research and the current research

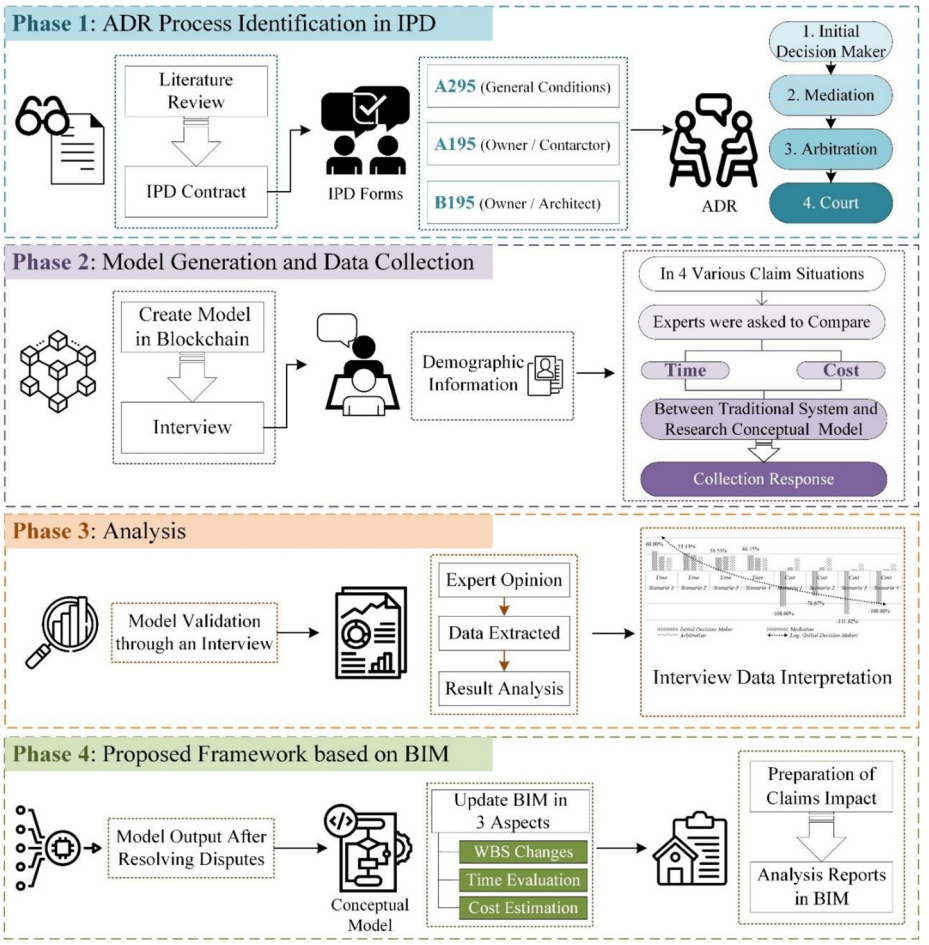
Ref.	Year	Research objective	Research methodology	Major findings	Scope and techniques of the study PDM	BCT	IPD	BIM
Zhang and Qian (2016)	2016	Exploring collaborative relationships between owner, designer and contractor group in IPD	Analysis of focus group and acquisition of opinions of 17 experts	Identification of four main categories of interaction, stakeholders' characters, contract and organization	√	–	√	–
Saygili *et al.* (2022)	2022	To be either prevented effectively by proper contract and payment execution or resolved efficiently with enhanced resolution processes	Literature review, A blockchain-based generic ODR platform	Identifying the issues of generic ODR tools regarding the characteristics and needs of the construction industry	√	√	–	–
Marzouk *et al.* (2018)	2018	To predict potential claims and quantification	Literature review, claim and delay analysis	5D BIM model for visualizing and predicting projects' claims	√	–	–	√
Elghaish *et al.* (2019)	2019	To exploit the capabilities of earned value management (EVM) techniques coupled with BIM	Using activity based costing (ABC) method to optimize the cost structure for IPD projects	Automating and optimizing the process of IPD risk/reward sharing through developing an EVM-Web grid	–	–	√	√
Ortolani (2019)	2019	To study the impact of BCT on dispute resolution	Futurology of BCT in the *Law* through analytical investigation of previous research	The pros and cons of application BCT in the dispute resolution	√	√	–	–
Tao *et al.* (2022)	2022	A confidentiality-minded framework (CMF) for blockchain-based design collaboration	Development of a CMF	An illustrative design example validates the feasibility and performance of the proposed CMF, which has acceptable latency and storage cost	–	√	–	√
Elghaish *et al.* (2020)	2020	To propose a framework using BCT technology in IPD projects	Smart contracts, Hyperledger network (IBM® Blockchain Cloud Beta 2)	Automatic financial model for reimbursed costs, profit and cost saving	–	√	√	√

(*continued*)

Table 1.

Ref.	Year	Research objective	Research methodology	Major findings	Scope and techniques of the study PDM	BCT	IPD	BIM
Celik *et al.* (2023)	2023	A Blockchain-based BIM data provenance model to support information exchange in construction projects	By testing the solution in a real-world bridge construction scenario, it has been shown that the approach can recognize the levels of competence and can improve the process of BIM implementation	Provides a cost analysis to evidence the implications of using Blockchain for BIM data provenance through an experimental framework supported by an Ethereum public test network	–	√	–	√
The current study	*To develop a model for project dispute*	*management using smart contract protocols*	*Data acquisition, system design and model development*	*A BCT based, enabled with BIM software to PDM in IPD*	√	√	√	√

Notes: ODR = online dispute resolution; 5D = 5-Dimensional
Source: Created by author

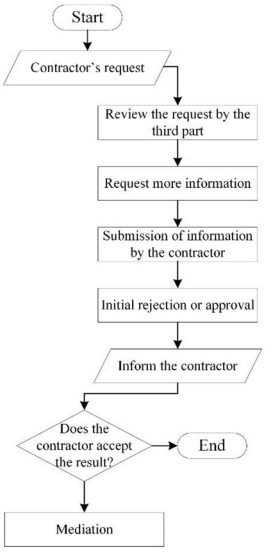


Source: Created by author

Figure 5.
Schematic view of the sequential steps of research methodology

roles of stakeholders defined in each ADR to resolve the arisen claims in project and to programming purposes, the order of the relationships is clearly displayed. The process of dispute resolution and the flow of information can be described in Figures 6, 7 and 8. Therefore, in this stage, the BCT side of the proposed framework has been developed in smart contracts, and all roles and responsibilities of key stakeholders in the process of dispute resolution have been converted to the BCT language, using a systemic approach.

Figure 6 shows the process of resolving a dispute in *initial decision-maker*. This process is explained as below. First, the contractor submits his claim and sends a description of his request and reasons to the architect as the initial decision-maker, and a copy of this request is sent to the owner. Second, for response to the contractor's claim, if the architect wants to consult with experts, to coordinate and pay, he informs the owner and get his approval. Third, the architect can respond to the claim made by the contractor by requesting more



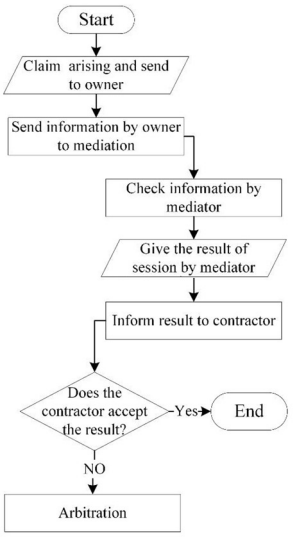

```
pragma solidity ^0.5.12;
contract IPD {

    string public show_result;
    string public show_Claim;
    string public show_Decision;
    string public show_Decision1;
    string public show_morInfo;
    string public show_ExpertsInfo;
    string public INfo1;
    string public INfo2;
    string public show_Endresult;
    string public show_mediationmode;
    constructor () public
    {
        }

    function Contractor_Request (string memory _claim) public
    {
          show_Claim = _claim;
          emit sendData_toArchitect( _claim);
      }
    event sendData_toArchitect (string _claim);

    function ReviewRequest_Architect( uint8 _Did) public returns (bool) {
if ( _Did == 0) {
   show_Decision = " Request more information from The contractor";
} else if (_Did == 1) {
  show_Decision1 = " initial rejection ";
  emit sendData_toContractor( show_Decision1);
  return false ;
} else if (_Did == 2) {
    show_Decision1 = " initial approval";
    emit sendData_toContractor( show_Decision1);
    return true ;
} else {
    show_Decision = " consult with experts ";
    emit sendData_toExperts( show_Decision);
}

    }

event sendData_toContractor (string show_Decision1);
event sendData_toExperts (string show_Decision);

    function Contractor_Decision  (uint8 _des , string memory _morInfo) public returns ( string memory) {
          if ( _des == 0) {

          show_morInfo = _morInfo;
          return show_morInfo;
          emit sendmorInfo_toArchitect( show_morInfo);
          } else {
                show_morInfo = "Do not send more information";
                return show_morInfo;
          }
      }
       event sendmorInfo_toArchitect (string show_morInfo);

    function Condult_Experts  ( string memory _ExpInfo) public returns ( string memory) {

          show_ExpertsInfo = _ExpInfo;
          return show_ExpertsInfo;
          emit sendInfo_FromExperts( show_ExpertsInfo);
      }
       event sendInfo_FromExperts(string show_ExpertsInfo);

    function Architect_Decision  (uint8 _Enddes) public returns ( string memory) {
       //  INfo1 = Condult_Experts (_ExpInfo);
       //  INfo2 = Contractor_Decision (0 ,_morInfo);

          if (_Enddes == 0)
          { show_Endresult = 'rejection' ;
          } else {
                show_Endresult = "approval";
          }
                return show_Endresult;
      }

function contractor_Decision  (uint8 _Contdes) public returns ( string memory) {


          if (_Contdes == 0)
          { show_Endresult = 'rejection decision' ;
          show_mediationmode = "transfer to Mediation mode";
          emit Mediationmode (show_mediationmode);

          } else {
                show_Endresult = "approval decision";
          }
                return show_Endresult;
      }
       event Mediationmode (string show_mediationmode);
}
```

Figure 6.
Flowchart and illustration of programming page of initial decision-maker in the first step

Source: Created by author

information from the contractor, rejecting the claim in whole or in part, confirming the claim, offering some advices to compromise or advising the parties that the original decision-maker is not able to resolve the claim. Fourth, after the architect, as the initial decision-maker, makes his decision to consider the contractor's claim, he informs the contractor the result, and a copy of the decision will sent to the owner. Fifth, if the contractor accepts the decision, the claim is terminated, but if he does not accept, the claim enters the next stage, i.e. mediation. The contractor's decision is also informed to the owner.

Figure 7 represents the resolving process of a dispute in *mediation*. The process is described as below. First, the contractor, who did not accept the results of the previous stage, again provides evidence of his claim in the records and sends a copy to the mediator. The owner also sends his information to the mediator, including the specifications of the project, the existing conditions, a description of the reasons for non-acceptance in the previous stage and so on. Second, the mediator reviews the information received from the contractor and the owner and



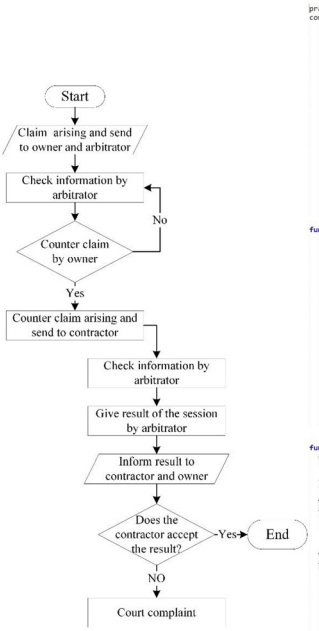

```
pragma solidity ^0.5.12;
contract IPD {

    string public show_Claim;
    string public show_HearingInfo;
    string public show_Endresult;
    string public show_Arbitrationmode;

    mapping (string => address) public IpdMember ;
    mapping (string => string) public boxes ;

    constructor () public
    {
        }

    function Contractor_Request (string memory _addr1, string memory _addr2, string memory _claim) public
    {
        show_Claim = _claim;

        Ipd_Send(_addr1, _claim);
        Ipd_Send(_addr2, _claim);

    }

function Ipd_AddNode (string memory  _name) public
  {
    IpdMember[_name] = msg.sender            ;

  }

  function Ipd_Send ( string memory receiver, string memory msg) public
  {
    boxes[receiver] = msg ;
        }

  function Ipd_ReadMSG (string memory addr) public returns (string memory)
  {
    return boxes[addr] ;
    }

    function Hearing_Session  ( string memory _HearingInfo) public returns ( string memory) {

        show_HearingInfo = _HearingInfo;
        return show_HearingInfo;
        emit sendInfo_ToMediator( show_HearingInfo);
      }
       event sendInfo_ToMediator(string show_HearingInfo);

    function Mediator_Decision  (uint8 _Enddes) public returns ( string memory) {
       //  INfo1 = Condult_Experts (_ExpInfo);
       //  INfo2 = Contractor_Decision (0 ,_morInfo);

          if (_Enddes == 0)
          { show_Endresult = 'rejection' ;
          } else {
                show_Endresult = "approval";
          }
                return show_Endresult;
                emit sendmorInfo_toContractor( show_Endresult);
      }
      event sendmorInfo_toContractor (string show_Endresult);

function contractor_Decision  (uint8 _Contdes) public returns ( string memory) {

          if (_Contdes == 0)
          { show_Endresult = 'rejection decision';
          show_Arbitrationmode = "transfer to Arbitration mode";
          emit Arbitrationmode (show_Arbitrationmode);

          } else {
                show_Endresult = "approval decision";
          }
                return show_Endresult;
      }
      event Arbitrationmode (string show_Arbitrationmode);

}
```

Source: Created by author

Figure 7.
Flowchart and illustration of programming Webpage of mediation in the second step

reviews the reasons of both parties online or over the course of the coordinated meeting. After the meeting, the mediator makes his final decision. Third, after preparing a report from the meeting, the mediator informs the contractor and sends a copy to the owner. Fourth, if the contractor accepts the decision, the claim will be terminated, but if he does not accept the result, the claim will enter the next stage. The owner is also informed about the contractor's performance.

Figure 8 The process unfolds in the following manner: Initially, the contractor disputed the outcome of the prior stage, providing additional supporting evidence for their claim within the records of the arbitration meeting, subsequently forwarding a copy of this evidence to the arbitrator. The owner also sends his information to the arbitrator. Second, the owner can file a counterclaim if he does not agree. If he requests a counterclaim, he must register it. Third, after completing the above steps, the arbitrator will review the request of the parties, the documents and the reasons during an online meeting. Fourth, the arbitrator makes his decision to respond to the




```
pragma solidity ^0.5.12;
contract IPD {


    string public show_Claim;
    string public show_HearingInfo;
    string public show_result;
    string public show_Arbitrationmode;
    string public show_Endresult;
    mapping (string => address) public IpdMember ;
    mapping (string => string) public boxes ;

    constructor () public
    {
        }

    function Contractor_Request (string memory _addr1, string memory _addr2,string memory _addr3 ,string memory _claim) public
    {
          show_Claim = _claim;

          Ipd_Send(_addr1, _claim);
          Ipd_Send(_addr2, _claim);
          Ipd_Send(_addr3, _claim);
      }
function Owner_Decision  (uint8 _Cont ,string memory _ContClaim, string memory _addr1,string memory _addr2 ) public returns ( string memory) {

          if (_Cont == 0)
          {
           Ipd_Send(_addr1, _ContClaim);
           Ipd_Send(_addr2, _ContClaim);

          } else {
                show_result = "Send information by owner to arbitrator";
          }
                return show_result;
                emit sendmorInfo_toarbitrator( show_result);
      }
     event sendmorInfo_toarbitrator (string show_result);

      function Submit_AAA (string memory _addr1, string memory _claim) public
    {
          show_Claim = _claim;

          Ipd_Send(_addr1, _claim);
      }

function Ipd_AddNode (string memory  _name) public
  {
    IpdMember[_name] = msg.sender            ;

  }
  function Ipd_Send ( string memory receiver, string memory msg) public
  {
    boxes[receiver] = msg ;
        }

  function Ipd_ReadMSG (string memory addr) public returns (string memory)
  {
    return boxes[addr] ;
    }

    function Hearing_Session  ( string memory _HearingInfo,string memory _addr1, string memory _addr2) public returns ( string memory) {

          show_HearingInfo = _HearingInfo;
          Ipd_Send(_addr1, _HearingInfo);
          Ipd_Send(_addr1, _HearingInfo);

          return show_HearingInfo;
          emit sendInfo( show_HearingInfo);
      }
       event sendInfo(string show_HearingInfo);

function contractor_Decision  (uint8 _Contdes) public returns ( string memory) {


          if (_Contdes == 0)
          { show_Endresult = "rejection decision";
          show_Arbitrationmode = "transfer to Court complaint";
          emit Resultmode (show_Arbitrationmode);

          } else {
                show_Endresult = "approval decision";
          }
                return show_Endresult;
      }
      event Resultmode (string show_Arbitrationmode);

}
```

Figure 8.
Flowchart and illustration of programming Webpage of arbitration in the third step

Source: Created by author

existing claim and dispute and informs the contractor, and a copy of it is sent to the owner. Fifth, if the contractor accepts the result of the arbitration, the claim is terminated, but if he does not accept, he must pursue his complaint through the court and legal authorities. In this step, it is not possible to handle the claim with this process due to the terms of the contract.

3.2 Interview

After programming and creating the model, its effectiveness should be evaluated. To this purpose, it was planned to examine previous real construction claims using the conceptual model development based on expert views and to compare the needed time and cost as the objective indices. Consequently, for evaluating the efficiency of the proposed model in the model development phase, three experts who are experienced in the construction contracts with more than five years of experience, two experts of in project management and one expert in BCT were asked to simulate the dispute resolution process. Table 2 shows the demographic characteristics of the eligible experts for the interview's purpose.

Thus, to test the model, four previous resolved disputes have been adapted from valuable data base of Ministry of Land, Infrastructure, Transport and Tourism of Japan (Central Construction Work Disputes Committee, 2000). The available data on the formal Webpage is relatively complete and include the description of claim, the result and the time spent for dispute resolution. Four of the claims that occurred in the past during the four projects were selected to be implemented in the BDM model. To prove that the online system reduces the time and cost of resolving disputes, it was necessary to separately compare it with the traditional system which is a physical process that resolves the disputes by bureaucracy and holding face-to-face meetings. Each claim needs to be addressed three times: first in the initial decision-making process, then during mediation, and finally in arbitration. Table 3 shows four disputes which were asked from experts to estimate the time of dispute resolved in minutes and the cost of it in Iranian Rial (IRR) in both systems.

4. Analysis

To have a quantitative index for comparing the conceptual model based on expert views to traditional methods, two factors of cost and time of the processing procedures have been considered. The purpose of implementing these claims in the model is to prove the improvement of the workflow process and increase the speed of processing claims at a lower cost. To do this and ensure the efficiency of the model, the above described scenarios must be performed once with traditional conditions and in the form of bureaucracy and then executed with intelligent conditions and in the form of a programmed model. Experts estimated the time

	Age	Gender	Expertise field	Years of experience
Expert No.1	43	Female	Project management	17
Expert No.2	55	Male	Project management	23
Expert No.3	37	Male	BCT	5

Source: Created by author

Table 2. Demographic characteristics of the experts

Scenarios		Ref.
1	A counter-dispute in which the contractor claimed that must be paid 9m JPY to payback, and the client claimed for 130m JPY due to the poor quality of work	(Nr. 11, 1999 and Nr. 3, 2000).
2	The contractor of a housing complex project claimed that is entitled to receive 490m JPY and the client stated that the company went bankrupted and payments must be made in two years installments	(Nr. 6, 2000)
3	The contractor of a housing construction claimed that the client must pay 13m JPY for the remaining works and 1.5m JPY for additional tasks. On the contrary, the employer has acknowledged that ordered works have not been finished yet, delivered works have not desired quality, there are not contractual article for additional payments, contractor faces many delays and its company is bankrupted	(Nr. 14, 1999)
4	The client of new house construction claimed that the contractor lied about terms of agreement in contrast of mutually agreed contents and therefore the contract must be cancelled and 1m JPY paid sums must be returned	(Nr. 8, 2000)

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Table 3. Four previous resolved disputes scenarios asked from experts

and cost of dispute resolving once in traditional system and once for BDM model. In each of these situations, each claim is executed three times. The first time in stage 1 (initial decision-maker), the second time in stage 2 (mediation), the third time in stage 3 (arbitration) the stated claim is resolved. According to this mechanism, obtained costs and times of each stage were recorded and compared with traditional methods. Elapsed time which its unit is minute includes the sum of the time that individuals are involved in providing evidence, coordination, holding meetings and conclusions to resolve a claim. It should be noted that the costs that were asked to determine in the traditional system contains expenditures to collect documents, using experts to review documents and holding meetings. In addition, expenditures of BDM system are the sum of expenses incurred to programming and running-improvement of the designed system and required hardware in million Iranian Rials. Figure 9 compares the time and cost for each stage (initial decision-making, mediation, arbitration) when resolving a claim in both systems.

As it is shown in Table 4 and based on experts opinion, using BDM model for resolving disputes take less time in every three stages. In another aspect which is cost, except the initial cost required to running the BDM system, the superiority and efficiency of the developed system is proved in other stages. While in the traditional method, the costs are repeated with each claim and at each stage, in the developed system, the budget needed for system establishment can be considered as investment for future administrations. Due to that, if the number of claims is limited or the claim can be resolved in the first stage, using the traditional systems is reasonable. However, if the occurred claims in the projects are considerable or must be resolved in stage two or three, using the BDM model has a better economic justification. Thus, in all three stages of claim settlement, the use of BCT performs better indices, and one of its most important features is the reduction of dispute resolution time in the project.

5. Conceptual framework of blockchain technology–building information modeling to project dispute management

One of the most effective solutions to the trust problem in construction systems is the use of BCT and its integration with BIM. Using BCT whenever the terms of the contract are fulfilled, the smart contract is automatically executed and completed. According to what has been achieved so far, the arisen claim has been settlement in the BDM intelligent system, and its consequences on project's various aspects should be ascertained. Therefore, at this stage, the

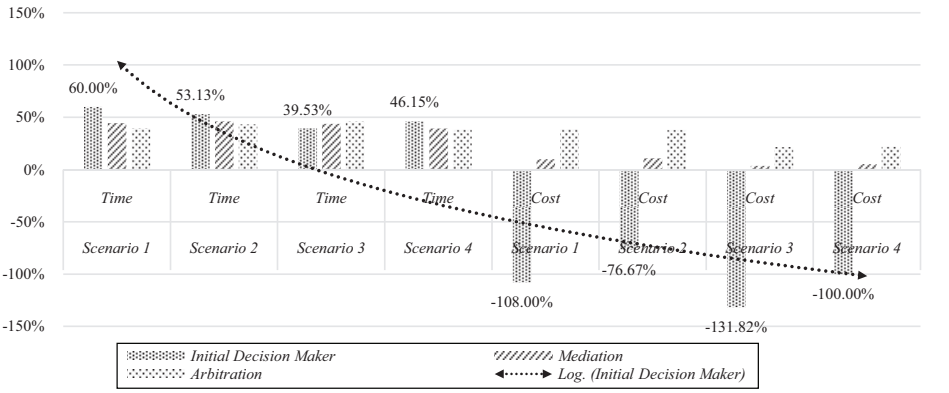


Figure 9.
Illustration of time and cost variation of the both methods

Source: Created by author

Table 4. Summary of the time and cost needed in developed model and traditional method

Scenarios	Comparison criteria	Initial decision-maker			Mediation			Arbitration		
		BDM	Simulation	Variation (%)	BDM	Simulation	Variation (%)	BDM	Simulation	Variation (%)
Scenario 1	Time (min)	32	80	*60.00*	100	180	*44.44*	171	282	*39.36*
	Cost (IRR)	52	25	*−108.00*	55	61	*9.84*	59	96	*38.54*
Scenario 2	Time (min)	45	96	*53.13*	118	219	*46.12*	199	350	*43.14*
	Cost (IRR)	53	3	*−76.67*	58	65	*10.77*	67	10.8	*37.96*
Scenario 3	Time (min)	26	43	*39.53*	58	103	*43.69*	98	181	*45.86*
	Cost (IRR)	51	22	*−131.82*	53	55	*3.64*	58	74	*21.62*
Scenario 4	Time (min)	30	52	*46.15*	74	122	*39.34*	125	203	*38.42*
	Cost (IRR)	52	26	*−100.00*	56	59	*5.08*	64	82	*21.95*

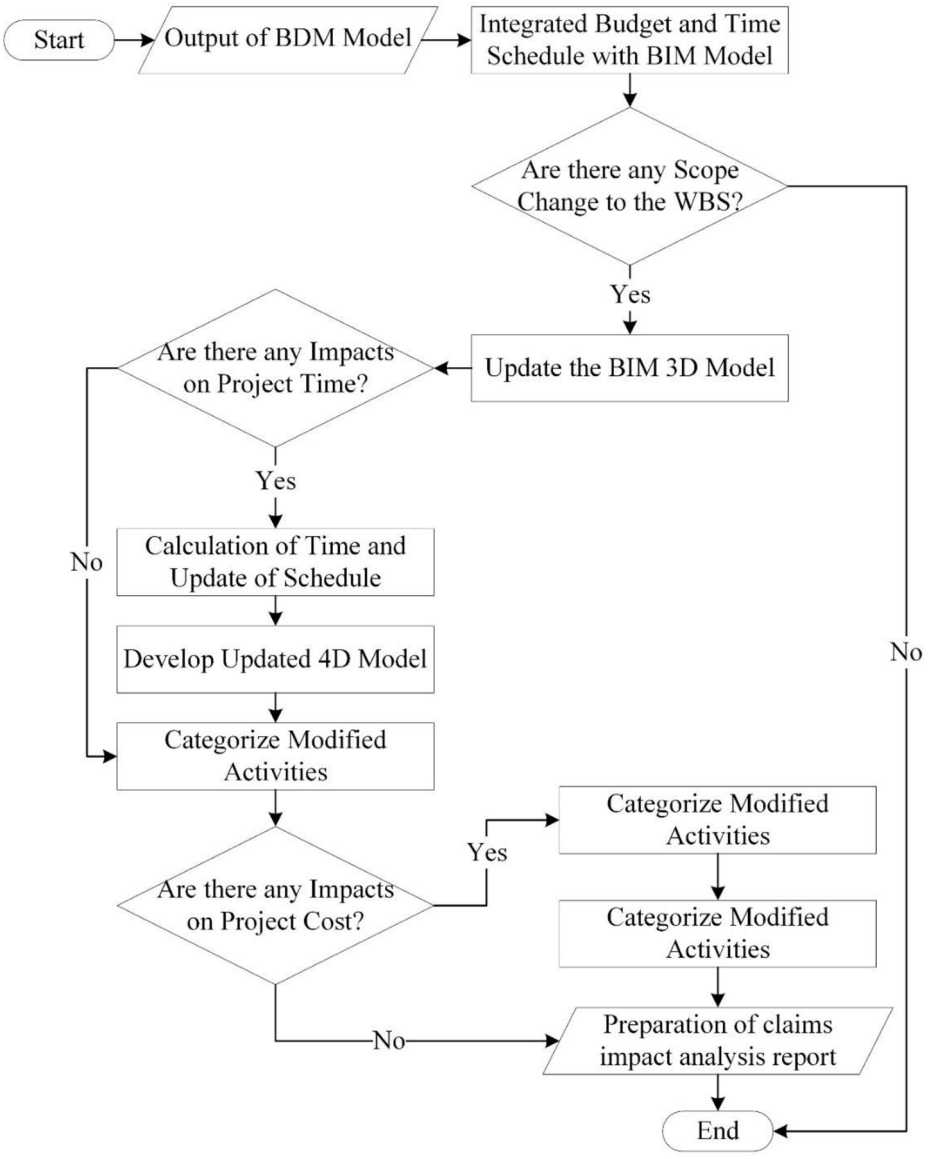
Source: Created by author

procedure in the previous stage has been ended with determination of resolution method which is stated in one of the forms of initial decision-making, mediation or arbitration. And the result may lead to changes in various dimensions of the project including scope, time and cost. Final decision based on the previous stage may have time impact, fiscal impact and/or scope changes on the project, and as the IPD system is run based on the BIM, it is feasible to update the project model and information based on the requests from the previous stage. Therefore, there is a need for a platform to calculate, record and update the current plan based on these changes, as well as to examine the effects of the claim on various project parameters. As regards BIM is a digital environment for visualizing all aspects of a project, including the body of the building (third dimension), the timeline (fourth dimension) and the budget plan (fifth dimension), it is the best tool for evaluating and recording the effects of claims. Therefore, in the current step, by adding and uploading codes and contract intelligence programs using BIM, scope of work, time and costs will be updated due to the resolution of disputes by integrating with the WBS, schedule and budget of project. If the result of the dispute resolution procedure leads to changes in WBS and therefore in the time dimension of project, the extensions will be calculated, its effects on the overall time will be evaluated and stored in the form of a report of the changes. The same algorithm should be followed when the resolution process leads to changes in the project budget. Thereby, the time extensions and amount of costs will be loaded as the fourth and fifth dimensions, respectively, of the BIM model. Figure 10 illustrates how to record the effects of dispute solution method from BDM in BIM. Accordingly, in the case of the dispute resolution process leads to effects on the WBS, the 3D model of the project should be updated, and it is necessary to examine these changes in two dimensions of time and cost. However, when the claim changes the project schedule, the time delays can be calculated first and then the schedule be updated accordingly as the fourth dimension of BIM, and subsequently, the cost changes should also be evaluated as the fifth dimension of BIM.

According to the described interconnection of BDM intelligent system to BIM, in the final step, results of one of the abovementioned scenarios expressed in BDM, which is mediated in the initial decision-making step, have been considered as the input to update the building information. This input led to changes in three factors of the project plan: 3D model, time plans and cost calculations (Figure 11). Available developed model of building created in the Navisworks was considered in this regard. Subsequently, by evaluating the WBS of project, it has been found out what extent the final verdict has caused changes in the project scope of work. Changes that occur in the WBS, which are due to the changes in activities' characteristics or rework tasks, can simply be recognized by system based on the WBS codes. In the sample under review, WBS also included changes in the time and cost of the entire project due to the reworking of the underground operations section and the critical path of the activities in this section (Earth works code 2.1). After making the necessary adjustments to the WBS, the time required to replicate the activities in the underground operations section has been calculated. Accordingly, soil mapping, excavation by machine, hand excavation and leveling require more 7 days, 4 days, 12 days and 12 days, respectively, accomplishing. This adjustment alters the project completion date of Gantt chart and updates the overall critical path of project. On the other hand, extension of time and tasks' variations means increase in resource allocation and thus impose more costs on the project. Therefore, in the next section, the costs are calculated, the result of which is a comparison of the initial costs and the costs imposed on the project as a result of the claim in two columns.

6. Conclusion

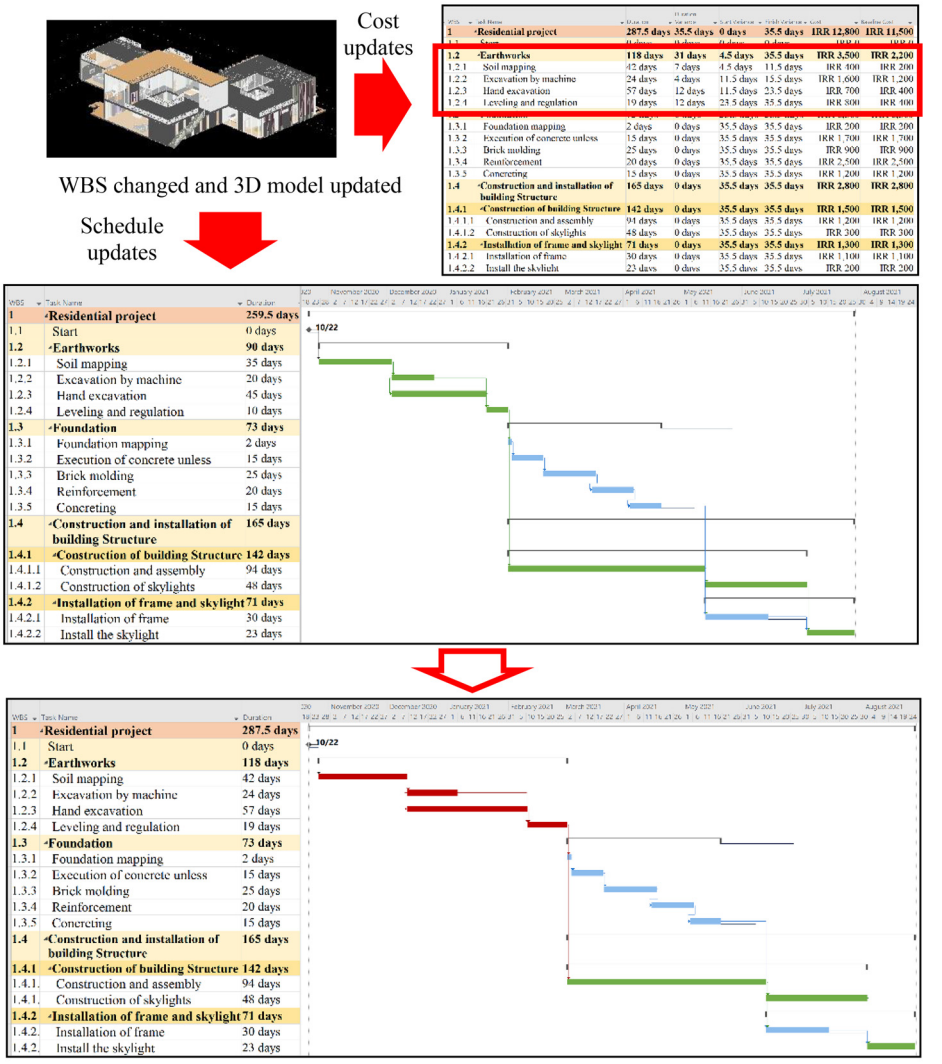
In general, IPD implementation barriers are divided into four categories: technical, legal, financial and cultural. Dispute management can be considered as one of the foremost



Source: Created by author

Figure 10.
Proposed conceptual framework based on BIM

significant sections of contract administration within the construction industry which burdens exceptional costs. The current study investigated the capabilities of BCT to enhance dispute resolution process of the IPD contracts in the construction industry. The proposed model focuses on technical rights; the development and evaluation of the model is based on a proposal to reduce technical barriers. To this purpose, the anticipated dispute



WBS	Task Name	Duration	Work	Start Deviation	Finish Deviation	Cost	Baseline Cost
1	Residential project	287.5 days	35.5 days	0 days	35.5 days	IRR 12,800	IRR 11,500
1.2	Earthworks	118 days	31 days	4.5 days	35.5 days	IRR 3,500	IRR 2,200
1.2.1	Soil mapping	42 days	7 days	4.5 days	11.5 days	IRR 800	IRR 200
1.2.2	Excavation by machine	24 days	4 days	11.5 days	15.5 days	IRR 1,600	IRR 1,200
1.2.3	Hand excavation	57 days	12 days	11.5 days	23.5 days	IRR 700	IRR 400
1.2.4	Leveling and regulation	19 days	12 days	23.5 days	35.5 days	IRR 800	IRR 400
1.3	Foundation	73 days	0 days	35.5 days	35.5 days	IRR 3,800	IRR 3,800
1.3.1	Foundation mapping	2 days	0 days	35.5 days	35.5 days	IRR 200	IRR 200
1.3.2	Execution of concrete unless	15 days	0 days	35.5 days	35.5 days	IRR 1,700	IRR 1,700
1.3.3	Brick molding	25 days	0 days	35.5 days	35.5 days	IRR 900	IRR 900
1.3.4	Reinforcement	20 days	0 days	35.5 days	35.5 days	IRR 2,500	IRR 2,500
1.3.5	Concreting	15 days	0 days	35.5 days	35.5 days	IRR 1,200	IRR 1,200
1.4	Construction and installation of building Structure	165 days	0 days	35.5 days	35.5 days	IRR 2,800	IRR 2,800
1.4.1	Construction of building Structure	142 days	0 days	35.5 days	35.5 days	IRR 1,500	IRR 1,500
1.4.1.1	Construction and assembly	94 days	0 days	35.5 days	35.5 days	IRR 1,200	IRR 1,200
1.4.1.2	Construction of skylights	48 days	0 days	35.5 days	35.5 days	IRR 300	IRR 300
1.4.2	Installation of frame and skylight	71 days	0 days	35.5 days	35.5 days	IRR 1,300	IRR 1,300
1.4.2.1	Installation of frame	30 days	0 days	35.5 days	35.5 days	IRR 1,100	IRR 1,100
1.4.2.2	Install the skylight	23 days	0 days	35.5 days	35.5 days	IRR 200	IRR 200

WBS	Task Name	Duration
1	Residential project	259.5 days
1.1	Start	0 days
1.2	Earthworks	90 days
1.2.1	Soil mapping	35 days
1.2.2	Excavation by machine	20 days
1.2.3	Hand excavation	45 days
1.2.4	Leveling and regulation	10 days
1.3	Foundation	73 days
1.3.1	Foundation mapping	2 days
1.3.2	Execution of concrete unless	15 days
1.3.3	Brick molding	25 days
1.3.4	Reinforcement	20 days
1.3.5	Concreting	15 days
1.4	Construction and installation of building Structure	165 days
1.4.1	Construction of building Structure	142 days
1.4.1.1	Construction and assembly	94 days
1.4.1.2	Construction of skylights	48 days
1.4.2	Installation of frame and skylight	71 days
1.4.2.1	Installation of frame	30 days
1.4.2.2	Install the skylight	23 days

WBS	Task Name	Duration
1	Residential project	287.5 days
1.1	Start	0 days
1.2	Earthworks	118 days
1.2.1	Soil mapping	42 days
1.2.2	Excavation by machine	24 days
1.2.3	Hand excavation	57 days
1.2.4	Leveling and regulation	19 days
1.3	Foundation	73 days
1.3.1	Foundation mapping	2 days
1.3.2	Execution of concrete unless	15 days
1.3.3	Brick molding	25 days
1.3.4	Reinforcement	20 days
1.3.5	Concreting	15 days
1.4	Construction and installation of building Structure	165 days
1.4.1	Construction of building Structure	142 days
1.4.1.	Construction and assembly	94 days
1.4.1.	Construction of skylights	48 days
1.4.2	Installation of frame and skylight	71 days
1.4.2.	Installation of frame	30 days
1.4.2.	Install the skylight	23 days

Figure 11.
Illustrated WBS updating and subsequently project's time and cost update

Source: Created by author

resolution procedures stated in different clauses of standard contracts A195, A295 and B195 were extracted through a literature review. Then, a conceptual model based on expert views was generated. Limitations of this phase are the lack of experts with experience in IPD contracts and blockchain technologies and restrictions on access to confidential project documents such as claim request form. However, three experts were selected to assess four occurred claims in construction industry for validating the model. The opinion of experts was asked according to their expertise and work experience to calculate the time spent and the cost paid in the traditional system and BDM model. This article developed a perceptual framework of how disputes can be managed using novel technologies. However, the

proposed developed conceptual model has been tested to evaluate the effectiveness in actual applications. Results show that decentralized integrated system can performs better and improve the administration processes of dispute management. Based on the results obtained, the developed model offers numerous benefits. These include intelligently transferring and configuring specific aspects of the construction contract. It enables all involved parties to engage in the contract online. The model ensures the creation of high-quality documentation, essential for effective contract management. Additionally, it enhances collaboration within the IPD system by providing a connection platform for key industry sectors. Moreover, the system instills confidence in financing entities and other involved parties by outlining precise dispute resolution procedures. Due to the development of the Industry 4.0, and introduction other smart tools, the use of other technologies for implementing IPD is recommended. Future research work could concentrate on how to tackle other barriers of IPD implementation such as promoting a method in terms of its legal implications. By continuing this process and smartening other contract clauses and linking BCT networks in the BIM platform, the constraint of semi-automatic data links can also be overcome. As the soft sides of project management skills like contract administration are highly kept far from novel technologies, it seems that such investigations can moderate the rigid traditional view to these project management aspects.

References

AIA (2007), *Integrated Project Delivery: A Guide*, American Institute of Architects, CA.

American Institute of Architects (AIA) (2008a), "Document A195 TM-2008", *Standard Form of Agreement Between Owner and Contractor for Integrated Project Delivery*, No. 10, pp. 1-11, available at: https://zdassets.aiacontracts.org/ctrzdweb02/zdpdfs/aia-a195-2008-free-sample-preview.pdf

American Institute of Architects (AIA) (2008b), "Document A295 TM – 2008", *General Conditions of the Agreement for Integrated Project Delivery*, pp. 1-45, available at: https://content.aia.org/sites/default/files/2016-09/AIA-A295-2008-Free-Sample-Preview.pdf

American Institute of Architects (AIA) (2008c), "Document B195 TM – 2008", *Standard Form of Agreement Between Owner and Contractor for Integrated Project Delivery*, No. 10, pp. 1-8, available at: https://zdassets.aiacontracts.org/ctrzdweb02/zdpdfs/aia-b195-2008-free-sample-preview.pdf

Atazadeh, B., Kalantari, M. and Rajabifard, A. (2016), "Comparing three types of BIM-Based models for managing 3D ownership interests in multi-level buildings comparing three types of BIM-based models for managing 3D ownership interests in multi-level buildings", October: 183-98.

Celik, Y., Petri, I. and Barati, M. (2023), "Blockchain supported BIM data provenance for construction projects", *Computers in Industry*, Vol. 144, p. 103768.

Central Construction Work Disputes Committee (2000), "Examples of dispute resolution." ministry of land, infrastructure, transport and tourism, Japan", available at: www.mlit.go.jp/sogoseisaku/1_6_hf_000146.html

Cooper, H. (2018), "Blockchain feasibility and opportunity assessment", *BRE Trust*, available at: https://bregroup.com/wp-content/uploads/2018/02/99330-BRE-Briefing-Paper-blockchain-A4-20pp-WEB.pdf

Darabseh, M. and Martins, J.P. (2020), "Risks and opportunities for reforming construction with blockchain: Bibliometric study", *Civil Engineering Journal*, Vol. 6 No. 6, pp. 1204-1217, doi: 10.28991/cej-2020-03091541.

Elghaish, F., Abrishami, S. and Hosseini, M.R. (2020), "Integrated project delivery with blockchain: an automated financial system", 114, 10.1016/j.autcon.2020.103182.

Elghaish, F., Abrishami, S., Hosseini, M.R., Abu-Samra, S. and Gaterell, M. (2019), "Automation in construction integrated project delivery with BIM: an automated EVM-

Based approach", *Automation in Construction*, Vol. 106, p. 102907, doi: 10.1016/j.autcon.2019.102907.

Elghaish, F., Abrishami, S., Abu Samra, S., Gaterell, M., Hosseini, M.R. and Wise, R. (2021), "Cash flow system development framework within integrated project delivery (IPD) using BIM tools", *International Journal of Construction Management*, Vol. 21 No. 6, pp. 555-570.

Faraji, A. (2019), "Smart contract based conceptual model for optimizing risk distribution in construction industry".

Faraji, A., Rashidi, M., Khadir, P. and Perera, S. (2021a), "A risk analysis-best worst method based model for selection of the most appropriate contract strategy for onshore drilling projects in the Iranian petroleum industry", *Buildings*, Vol. 11 No. 3, p. 97.

Faraji, A., Rashidi, M., Tezangi, M.R. and Perera, S. (2021b), "Multihybrid dispute resolution framework for projects of downstream sector of petroleum industry", *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, Vol. 13 No. 4, p. 4521026.

Faraji, A., Rashidi, M., Meydani Haji Agha, T., Rahnamayiezekavat, P. and Samali, B. (2022), "Quality management framework for housing construction in a design-build project delivery system: a BIM-UAV approach", *Buildings*, Vol. 12 No. 5, p. 554.

Franz, B., Asce, M., Molenaar, K.R., Asce, M. and Roberts, B.A.M. (2020), "Revisiting project delivery system performance from 1998 to 2018", *Journal of Construction Engineering and Management*, Vol. 146 No. 9, pp. 1-11, doi: 10.1061/(ASCE)CO.1943-7862.0001896.

Guide, A.I.A. (2007), *Integrated Project Delivery: A Guide*, American Institute of Architects, *CA*.

Harichandran, A., Raphael, B. and Mukherjee, A. (2021), "A hierarchical machine learning framework for the identification of automated construction", *Journal of Information Technology in Construction (ITcon)*, Vol. 26 No. 31, pp. 591-623.

Jørgensen, B. and Emmitt, S. (2009), "Investigating the integration of design and construction from a 'lean' perspective", *Construction Innovation*, Vol. 9 No. 2.

Kahvandi, Z., Saghatforoush, E., Mahoud, M. and Preece, C. (2019), "Analysis of the barriers to the implementation of integrated project delivery (IPD): a meta-synthesis approach", *Journal of Engineering, Project, and Production Management*, Vol. 1, doi: 10.2478/jeppm-2019-0002.

Kim, K., Lee, G. and Kim, S. (2020), "A study on the application of blockchain technology in the construction industry", *KSCE Journal of Civil Engineering*, Vol. 24 No. 9, pp. 2561-2571, doi: 10.1007/s12205-020-0188-x.

Le-Hoai, L., Dang, C.N., Lee, S.B. and Lee, Y.D. (2019), "Benchmarking claim causes against contractors in emerging markets: empirical case study", *International Journal of Construction Management*, Vol. 19 No. 4, pp. 307-316.

Liu, H., Han, S. and Zhu, Z. (2023), "Blockchain technology toward smart construction: review and future directions", *Journal of Construction Engineering and Management*, Vol. 149 No. 3.

Ma, Z., Zhang, D. and Li, J. (2018), "A dedicated collaboration platform for integrated project delivery", *Automation in Construction*, Vol. 86, pp. 199-209, doi: 10.1016/j.autcon.2017.10.024.

Marco, A.D., Karzouna, A., Marco, A.D. and Karzouna, A. (2018), "ScienceDirect ScienceDirect assessing the benefits of the integrated project delivery method: assessing the benefits of the integrated project delivery method: a survey of expert opinions a survey of expert opinions CENTERIS – International conference", *Procedia Computer Science*, Vol. 138, pp. 823-828, doi: 10.1016/j.procs.2018.10.107.

Marzouk, M., Othman, A., Enaba, M. and Zaher, M. (2018), "Using BIM to identify claims early in the construction industry: case study", *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, Vol. 10 No. 3, doi: 10.1061/(ASCE)LA.1943-4170.0000254.

Mei, T., Zhong, S., Lan, H., Guo, Z. and Qin, Y. (2023), "Configuration analysis of integrated project delivery principles' obstacle to construction project level of collaboration", *Sustainability*, Vol. 15 No. 4, p. 3509.

Mesa, H.A., Molenaar, K.R. and Alarcón, L.F. (2019), "Comparative analysis between integrated project delivery and lean project delivery", *International Journal of Project Management*, Vol. 37 No. 3, pp. 395-409, doi: 10.1016/j.ijproman.2019.01.012.

Olatunji, O.A. and Sher, W. (2010), "Legal implications of BIM: model ownership and other matters arising", *Proceeding of the18th CIB World Building Congress*, Salford, UK.

Ortolani, P. (2019), "The impact of blockchain technologies and smart contracts on dispute resolution: arbitration and court litigation at the crossroads", *Uniform Law Review*, Vol. 24 No. 2, pp. 430-448.

Roy, D., Malsane, S. and Samanta, P.K. (2018), "Identification of critical challenges for adoption of integrated project delivery", no. May.

San, K.M., Choy, C.F. and Fung, W.P. (2019), "The potentials and impacts of blockchain technology in construction industry: a literature review", *IOP Conference Series: Materials Science and Engineering*, IOP Publishing, Vol. 495.

Saygili, M., Mert, I.E. and Tokdemir, O.B. (2022), "A decentralized structure to reduce and resolve construction disputes in a hybrid blockchain network", *Automation in Construction*, Vol. 134, p. 104056.

Sherif, M. and Abotaleb, I. (2022), "Application of integrated project delivery (IPD) in the Middle east: Implementation and challenges", pp. 1-14.

Singh, A., Prasath Kumar, V.R., Dehdasht, G., Mohandes, S.R., Manu, P. and Pour Rahimian, F. (2023), "Investigating the barriers to the adoption of blockchain technology in sustainable construction projects", *Journal of Cleaner Production*, Vol. 403, p. 136840.

Soltaninejad, M., Faraji, A. and Noorzai, E. (2021), "Recognizing the effective factors in managing fire incidents to reduce the collateral damages and casualties", *Facilities*, Vol. 39 Nos 13/14, doi: 10.1108/F-03-2020-0030.

Stamatiou, D.R.I., Kirytopoulos, K.A., Ponis, S.T., Gayialis, S. and Tatsiopoulos, I. (2019), "A process reference model for claims management in construction supply chains: the contractors' perspective", *International Journal of Construction Management*, Vol. 19 No. 5, pp. 382-400.

Tao, X., Liu, Y., Wong, P.K.-Y., Chen, K., Das, M. and Cheng, J.C.P. (2022), "Confidentiality-minded framework for Blockchain-Based BIM design collaboration", *Automation in Construction*, Vol. 136, p. 104172.

Teisserenc, B. and Sepasgozar, S. (2021), "Project data categorization, adoption factors, and non-functional requirements for blockchain based digital twins in the construction industry 4.0", *Buildings*, Vol. 11 No. 12, p. 626.

Teisserenc, B. and Sepasgozar, S.M.E. (2022), "Software architecture and non-fungible tokens for digital twin decentralized applications in the built environment", *Buildings*, Vol. 12 No. 9, p. 1447.

Trach, R., Pawluk, K. and Lendo-Siwicka, M. (2020), "The assessment of the effect of BIM and IPD on construction projects in Ukraine", *International Journal of Construction Management*, Vol. 22 No. 10, pp. 1-8.

Trach, R., Polonski, M. and Hrytsiuk, P. (2019), "Modelling of efficiency evaluation of traditional project delivery methods and integrated project delivery (IPD)", *IOP Conference Series: Materials Science and Engineering*, Vol. 471 No. 11, doi: 10.1088/1757-899X/471/11/112043.

Turk, Ž. and Klinc, R. (2017), "Potentials of blockchain technology for construction management", *Procedia Engineering*, Vol. 196, pp. 638-645, doi: 10.1016/j.proeng.2017.08.052.

Viana, M.L., Bonaventura, H.W., Hadikusumo, M.Z., Mohammad. and Zahra, K. (2020), "Integrated project delivery (IPD): an updated review and analysis case study", *Journal of Engineering, Project, and Production Management*, Vol. 10 No. 2, pp. 147-161, doi: 10.2478/jeppm-2020-0017.

Wang, J., Wu, P., Wang, X. and Shou, W. (2017), "The outlook of blockchain technology for construction engineering management", *Deakin University. Journal Contribution*, available at: https://hdl.handle.net/10536/DRO/DU:30133867

Zhang, L. and Qian, Q. (2016), "Exploring the factors for collaborative relationships in IPD projects", *Construction Research Congress 2016*, ASCE Library, pp. 1886-1996, doi: 10.1061/9780784479827.188.

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