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P2P ISLAMIC INVESTMENTS USING BLOCKCHAIN, SMART CONTRACT AND E-NEGOTIATION

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ABSTRACT

Blockchain is receiving an increasing attention from industry and academia as a breakthrough technology that could provide enormous benefits to different sectors. Financial sector is one of those sectors that started to consider applying blockchain. However, it is still in its initial stages. The objective of this paper is to apply blockchain and smart contract technologies in managing investments that implement real Islamic investment policy (profit- loss-sharing agreement), this will result in easier, faster, secure and transparent investment transactions to both investors and entrepreneurs (or businesses). This work proposes a design of middleware infrastructure that implements the real Islamic investment policy (profit-loss-sharing rate) called Musharakah (joint venture), where investors and entrepreneurs share a pre-agreed percentage of profit or loss from the financed project. The platform acts as a trusted third party without the need for another mediator; it will help both investors and entrepreneurs negotiate their terms.

Keywords: *Peer-To-Peer Investment, E-Negotiation, Blockchain, Smart Contract, Islamic Profit-Loss-Sharing Agreement.*

1. INTRODUCTION

Historically, banks often provided investments services, and still are, in a centralized way. However, the advances in information technology are fundamentally changing traditional business models, including investments. For investments purposes, investors and entrepreneurs can find each other directly on peer-to-peer (P2P) investment platforms without the need for intermediaries (a bank standing in between). By 2025, global P2P market is projected to reach $ 820.70 billion [1]. Such financial model will provide new opportunities for both investors and entrepreneurs. Investors will gain a good return on their funds. Entrepreneurs (or businesses), on other side, will have more choices to fund their projects, whether domestically or globally, more flexibility in terms of the funds that are available to them, and ability to eliminate the costs and inefficiencies of third-party intermediaries, like the Swift system and correspondent banks, reducing time and cost of clearinghouse structures and settlement processes.

Investment platform must provide sophisticated financial infrastructure, effective trade and settlement methods, and new ways to generate, share and analyze financial data. This would mean fundamentally changing the financial system. In proposed model, private investors, entrepreneurs, and intermediate platform decide on investment origination.

The current P2P companies do not provide capabilities to predict the creditworthiness of an entrepreneur and require the use of intermediaries (such as issuing banks, trust accounts and other players and factors). These intermediaries may lack reliability and transparency, or be bound by their borders and difficulties in managing investments. Today's P2P platforms can be described as investment models where the investment risk is tied to the funded loans credit rating.

This research will provide the infrastructure of a middleware that applies the real Islamic

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investment policy (profit-loss-sharing agreement) called Musharakah, where economic policies or banks do not decide interest rates. Musharakah is comparable to a joint venture, where an investor and an entrepreneur each agree to accept a percentage of the returns and risks, sharing profits or losses of a project based on their agreed contract. The objective of this paper is to build a Musharakah financing model based on the blockchain and smart contract supported by automated negotiation using agent technology. The main foundations of Islamic financial principles are interest-free investments, sharing risks and profits, prohibiting the investments in businesses illegal by Islamic law, and promoting ethical investments that enhance society. Profit-loss-sharing contract allows investor and entrepreneur (business) to share a pre-agreed percentage of profit or loss from the financed project. One of the most popular contracts used in Islamic finance transactions is Mudharabah (passive partnership). In a Mudharabah contract, profits and loss are shared according to the profit-loss-sharing ratio.

According to Thompson Reuters' Finance Development report presented in 2016, Islamic banking assets would reach $2.7 trillion and total sharia-based assets are aimed to reach $3.5 trillion by the year 2021 [2]. The Islamic finance firms are growing and adapting to technology innovations including mobile and Internet banking, thus exploiting new opportunities that technology has to offer. Current upcoming trend in financial technology is actualizing accessibility for a decentralized environment where all actors of the financial industry can interact in an effective way to achieve better results.

Islamic finance and banking firms are being praised for interest-free operations and its growth in finance sectors such as insurance, capital markets, investment banking, micro-finance, and wealth management. However, it still faces challenges, for example, lack of policies to help small merchants, sharia-compliant options for short-term liquidity, lack of robust risk management frameworks, handling late payments, processing costs and fraud prevention [3], [4]. An Islamic finance transaction can involve a number of parties and contracts between them, which might cause the entire system to uncertainty, requiring high-level administration and legal regulations. Such requirements lead to the increased cost of the system that ultimately needs to be met by the end consumer.

This research considers particular aspects of new Islamic investment model that focuses on P2P investment system employing blockchain and smart contract technologies and based on electronic negotiation between investor and entrepreneur. The underlying concepts of blockchain technology such as transparency, and thus enhanced trust and immutability, will work closely with the core principles of Islamic and sharia-based financial systems. The Islamic finance system is embracing the FinTech (Financial Technology) as a part of financial transformation, which is commonly termed as "faith-based FinTech". The prospect of Islamic Fintech acceptance is quite widespread among financial services and Muslim investors in Islamic world, as it provides opportunities for innovation and can offer cost-effective solution to the financial services [5]. Applying FinTech technology in the Islamic finance context of the profit and loss sharing will reduce the risk and increase productivity [6].

Traditional Islamic banking investment is facing yet another problem, which is efficiency: long trade settlement times, low automation and manual reconciliation that need to be resolved. This study will also explore application of blockchain technology and smart contract in negotiating peer-to-peer investments that use big data analytics and traditional regulatory approaches.

The Islamic investment system is being developed based on relevant technologies. Blockchain connects all parties on a system, so the entrepreneur would be linked directly to the investing institution or person, with full transparency and a real-time view of finances on an immutable ledger. Authors suggest using big data analytics to get as much valid information about the entrepreneur as possible. It will allow investors to make an informed decision based on that valid information. The investment platform will force their entrepreneurs to provide financial information validated by external agencies. The system may also provide an investment service through cooperation with a partnering bank. This could lead to new business opportunities.

One major concern of investors is to be sure that their funds are being used properly. With current P2P platforms, investors are forced to put their trust in those platforms which is risky. This

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problem can be resolved by using the smart contracts. Any investor will know exactly whether their money is used properly and if any third parties tried to change anything.

The study aims at contributing to the following areas:

1) Eliminating the costs and inefficiencies of third-party intermediaries like banks or financial institutions,
2) Providing entrepreneurs with a much smoother and cheaper investment process,
3) Assuring that every transaction is visible,
4) Establishing follow-up procedures that allow all involved parties to see what is happening with a specific investment,
5) Providing the possibility to obtain funding from anywhere in the world.

Proposed blockchain investment system will reduce financial risks, minimize administration and service costs, and improve the efficiency of financial services.

The remainder of this paper is organized as follows. Literature review and related work are presented in Section 2. Background on blockchain and smart contract are discussed Section 3. Section 4 introduces the overall architecture of the proposed P2P investment platform using blockchain smart contract and e-negotiation. Discussion of the proposed e-negotiation model P2P investment negotiation is presented in Section 5 and investment smart contract in Section 6. The Discussion in Section 7 and finally and conclusion in Section 8.

2. LITERATURE REVIEW

At present, several non-Islamic peer-to-peer lending platforms already exist [7]-[9]. Some current P2P platforms help clients obtain P2P loans without providing a collateral. The risk associated with using such platforms is very high; lenders could lose the entire invested amount. There are no official standards for information about borrowers or platforms' credit assessment methods and therefore will make it impossible for investors to assess and compare the risk of platforms.

The potential of the applications built on top of the blockchain technology for financial data management has been discussed in a number of studies. Ethlend [10] provides facilities for decentralized lending, namely collateralized lending, the protocol makes use of Ethereum ERC-20 compliant tokens as collateral [10]. Dharma's whitepaper proposed decentralized uncollateralized lending protocol [11] while a prototype for managing student loan using blockchain and smart contracts was proposed in [12]. Other studies applied deep learning to predict the risk associated with a borrower [13].

A number of startup lending companies are creating platforms to offer secured loans on a blockchain. Some introduces a P2P lending platform on a blockchain built for people who are holding digital assets, such as ethereum and bitcoin, for the long term [14]. Crypto Lending Project [15] presents a P2P lending platform based on the blockchain technology, where a borrower can take a loan without presenting collaterals and his credit status rated using artificial intelligent processes.

Most of the existing studies on blockchain focus on real world implications given the functionality the blockchain provides. For instance, in [16] a discussion on how digital currencies and decentralized ledgers based on blockchain technology may reshape the future of central banking is presented. [17] examines the centralization and decentralization forces in the creation and competition of cryptocurrency-mining activities. An investigation of how decentralization improves consensus effectiveness and how the quintessential features of blockchain reshape industrial organization and the landscape of competition shown in [18]. Other studies proposed a P2P mortgage lending protocol based on artificial intelligence, blockchain, smart contracts and Business-Process-as-a-Service [19].

Even so, some financial industry experts witness the disruptive combination of Fintech and Blockchain, as both technologies have the potential to transform the financial industry and the way that this industry operates [20]. Others, for example, see a strong conjunction between Islamic FinTech, smart contracts, and sharia principles, as in [21]. Smart contract powered P2P blockchain technology is well known in handling dispute settlement among parties thereby making the transactions very reliable at any point in time. Instead of having time-consuming and complicated processes, blockchain technology can be used for speeding settlements of transactions [22].

Antova et. al [4] describes utilizing P2P blockchain-based smart contracts that will be

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analogous and congruent to that of the conditions the sharia-compliant Islamic finance industry imposes. The features of smart contracts, such as transparency, trust, and tamper proofing, are in perfect coherence with that of the laws of the Islamic finance industry. The authors stress the fact that a blockchain-based decentralized ledger technology would add value for risk management in Islamic financing organizations by minimizing credit risks and losses, providing a more reliable and transparent in terms of credit ratings, reducing administration issues and promoting surety of deposits.

All these steps aim to maximize profitability and dependability of shared values, and have a high chance of attracting a greater number of international customers as the features, offered by blockchain-backed Islamic financing, seem to be unimpeachable and have a potential support the process of risk management in Islamic financing institutions. Elasrag [23] highlights the challenges of applying blockchain to Islamic finance such as: underdeveloped ecosystem infrastructure; the fact that some Islamic governments not yet comfortable with usage of blockchain in finance, therefore unclear government regulations; adopting public blockchain in large financial organizations raise potential security and privacy issues and lack of standards.

3. REVIEW OF ENABLING TECHNOLOGIES

In this section, we review some the technologies used in the design of Islamic investment platform, these technologies include: blockchain, smart contract, and P2P.

3.1. Blockchain Technology

Blockchain is a distributed ledger, which is a type of distributed database that is shared, replicated, and synchronized among the members of a network. The distributed ledger records the transactions. Every record in the distributed ledger has a timestamp and unique cryptographic signature, thus making the ledger an auditable history of all transactions in the network.

A transaction contains data about the address of a participant, a transaction value, and a digital signature that grants the authenticity of the transaction. Each transaction is sent to the network for validation. All the transactions conducted are verified, cleared, and stored in a block, which is linked to the preceding block, through the block's signature, thereby creating a chain (Fig.1).

In order to create a block and add it to the blockchain, a miner must solve very complex mathematical problems. To prevent a malicious entity from taking over the blockchain, each block comes with a proof-of-work (PoW) [24], performed by a miner. This ensures that the information is difficult and costly to make, which helps to prevent fraud and malicious activity because of the cost involved in creating the block. The purpose of the PoW protocol is to make sure that the network is safe, sustainable and is resistant to malicious attacks. This property of the PoW protocol is in line with the high objectives of the Sharia law ("maqasid al-Shariah"), as it protects the wealth from being used for wrong purposes [25].

Each blockchain participant creates his own block that contains hash of the received previous block, and adds his own transactions. Other parts of the block are Merkle tree root hash, timestamp, nonce and hash of the parent block. Miner verifies the gathered set of pending transactions and solves a hashing problem to find a nonce by trial and error. The consensus is achieved by using PoW mechanism, this mechanism is based on finding a nonce input to the algorithm so that the resulting hash of a new valid block satisfies certain requirements. To find such nonce; a huge amount of computation power is needed. Proof-of-Stake mechanism is an alternative to a PoW, but for validating, not mining. Validators will be required to own cryptocurrency (ether) and in order to validate a block they will be required to put their owned ether on the risk to certify that a block is valid.

Instead of relying on a third party to mediate transactions, nodes in a blockchain network use a consensus protocol to agree on content of ledger.

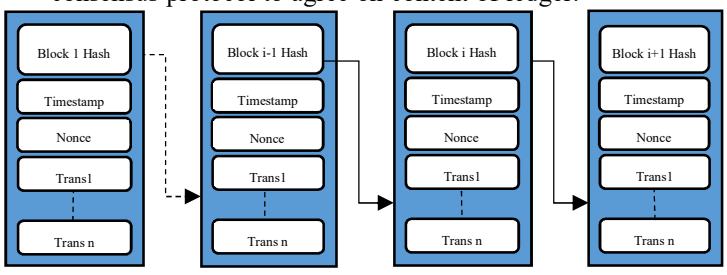

Figure 1: Development of blockchain by creating blocks in the chain where each block carries a set of transactions, timestamp, nonce, and a hash to the previous block

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To ensure the integrity of transactions, blockchain applies cryptographic hashes and digital signatures. Consensus ensures that the shared ledgers are exact copies, thus lowering the risk of fraud transactions, because alterations would have to occur across all nodes of the network exactly the same time. Cryptographic hashes, such as the SHA256 computational algorithm, ensure that any modification to saved transaction results in a different hash value being computed, which indicates potentially attempt to modify the transaction. Digital signatures ensure that transactions originated from senders (signed with private keys) and not imposters.

Blockchain networks can be private with restricted membership, public that is accessible to any person within the network, or hybrid. Public blockchain are fully decentralized and have no single owner; participants can download the software, and start running a full node on their local devices. All users are involved in the consensus process. Ethereum and Bitcoin are examples of public blockchain. Public blockchain means that anyone can view it at any time because it resides on the network, not within a single institution charged with auditing transactions and keeping records. Private blockchain network has more restrictions and is not distributed as public blockchain. It is centrally controlled by a single organization with restricted number of nodes within that organization and is governing the privileges of who can read/write to the blockchain. In private blockchain network, the participants are known and trusted: for example, an industry group, or a group of companies owned by the same organization. Hybrid blockchain network is partially decentralized, all authorized participants store exact blockchain copies. Known servers with certain privileges are controlling the consensus process using an established set of rules agreed upon to by all participants. The right to read the blockchain can be either public or restricted to specific participants.

A blockchain is not a currency. Rather, it is a system for validating, clearing, settling, tracking and recording the ownership of assets as they are traded. The Bitcoin blockchain is just one of those applications.

The main features of blockchain:

1) Secure P2P transactions with no need for a trusted third party.
2) Digital signatures safeguard content and thus the integrity of the data.
3) Helps to improve speed, security, and efficiency of execution of clearing and settlement processes.
4) No data loss, alteration, or distortion.
5) Reduced transactions costs and times.
6) Improve transparency of cross border investment, every transaction is visible on an immutable ledger.

Verifying identity and establishing trust is no longer the right and privilege of the intermediary. Blockchain can be used in many business applications, for example, crypto-currency, international payments, payment settlements, food supply chain management, smart identity, smart property, information sharing, real estate, insurance, copyright, and the legal sector.

Traditional banking faces challenges such as a central fund management, high transactions costs, and multiple intermediates. Using blockchain technology will help eliminate these challenges by solving the trust and security problems in financial industries with its nature of decentralization and autonomy.

Implementation of blockchain within Islamic Finance is a perfect choice. Blockchain can increase the transparency for the Islamic musharakah contract, and therefore reduce the trust gap and inspire investors and entrepreneurs to use musharakah model. By nature, blockchain is distributed, open, and cryptographic, which allows P2P users trust each other and conduct transactions without the need for intermediaries.

3.2. Smart Contract

In the early 1990s, Nick Szabo proposed smart contracts [26]. He explained that smart contracts enable computers to execute transaction clauses. Smart contracts have received increased attention because of the blockchain popularity, and it is the main feature of Ethereum [27]. In addition to data transaction, a blockchain can also hold smart contracts. Such smart contracts could use data from blockchain records as inputs and then generate outputs, which are written to that same or another blockchain. Integrating the features of blockchain with smart contract will improve system's efficiency operations. Since blockchain is essentially immutable, then smart contract based on blockchain cannot be altered after being deployed to it. Smart contracts have been developed on blockchain-based platforms such as Ethereum [28], Hyperledger Fabric [29], Corda

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[30], Stellar [31], and can be executed on any of them.

Smart contracts are digital contracts of an agreement that can be programmed and are capable of automatically executing terms of the agreement to carry out a particular action, events, transaction, etc., at a given time or after a certain set of conditions have been met. They can be developed using a high-level language Solidity [32], and execute exactly what its transitioning parts want to do without the need of an intermediary to interfere. Smart contracts are the ultimate automation of trust and are executed exactly as their originators (investors and entrepreneurs, in our case) have agreed upon. Their use allows for the validation of transactions and verification of counterparties, therefore improving transparency and reducing risk.

Codified contract can be very useful for decreasing errors, preventing fraud, automating the settlement process, and digitizing contracts. They are stored and replicated on a blockchain, executed in parallel by the same network of computers running the blockchain, and all participants can compare the results. The source code of the smart contract is sent to the intended blockchain network where the transaction is configured through this blockchain.

4. THE PROPOSED P2P INVESTMENT PLATFORM ARCHITECTURE

The proposed platform uses several different agents: interface and server agents, user's (entrepreneur and investor) and mediator's mobile agents, and negotiation agents. Agents can control their actions, interact and/or cooperate with other specified agents by controlled interface. Mobile agents are autonomous computational entities capable of performing operations in dynamic environments. Agent deployed in the platform is described below:

Interface Agent: accepts information provided by a negotiating party, either investor or entrepreneur. This information is stored in the user's profile and contains data such as his blockchain name, negotiable attributes' data, for example limitation on investment period, amount to invest, etc. and will be carried by user's mobile agent to and used by a negotiation mediator.

Agent Server: multi-agent, distributed, and intelligent. Agent server provides standard interface to other agents, and manages resources necessary to process requests of the user's agents. Its main tasks include the following:

1) Facilitating migration of agents' code;
2) Generating agents' execution environment;
3) Establishing an execution domain, controlling protection and mechanisms for agents;
4) Monitoring agents' actions;
5) Setting up rules for co-existence of and cooperation between agents working on the same negotiation;
6) Prohibiting direct communications and any interference between agents of investors and entrepreneurs that can lead to sharing confidential information of negotiators on their strategies, concessions, constraints, negotiation status, etc.;
7) Handling communications with other modules such as blockchain and smart contract, and external agency.

Investor's/Entrepreneur's Mobile Agent: represents its owner's interests, delivers the negotiation initiation request to the agent server for processing; usually generated dynamically during the execution, and capable of reconfiguring themselves dynamically as services change. This agent works in the best interest of the users. The architecture has a 2-tier structure involving the users' mobile and fixed devices, and a mediator of investment negotiation modules. Mobile agents facilitate cooperation of each tier with the others. The proposed system distributes the resources across this system architecture.

The components of system architecture are:

1) Investor's/ Entrepreneur's mobile or fixed device. The architecture first tier incorporates users' (entrepreneur and/or investor) devices installed on their devices interface and mobile agents. Module service access facilitated via a mediator by utilizing a mobile agent.
2) The second tier: a mediator module with the following elements:
   - Verification
   - Investor/ entrepreneur negotiation
   - Investment smart contract
   - Blockchain
   - External agency

The proposed system architecture of p2p investment platform is based on the architecture in [33] and shown in Fig. 2.

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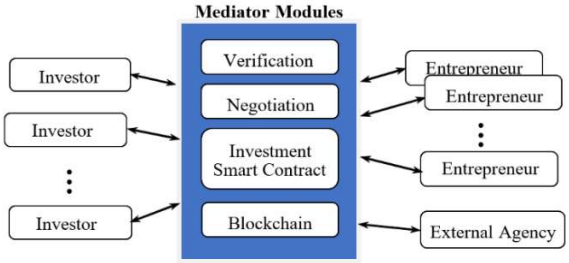

Figure 2. P2P Islamic Investment architecture using blockchain, smart contracts, verification, and negotiation modules.

First tier of the architecture includes investors' and entrepreneurs' mobile or fixed devices. Mobile intelligent agents and interface agents installed on these mobile devices help to communicate with the system and act as personal assistants to prospective investors and entrepreneurs. Mobile users' access to the investment services is facilitated by a mediator, which utilizes a mobile agent.

Verification module contains tools used to support negotiation such as knowledge base (KB) that specify a set of rules to derive an advice for evaluating risks, big data system consisting of data warehouse of investment data and analytic tools integrated with text mining (information extraction, topic identification, etc.) and web mining. Information on past investment instances is stored in the data warehouse, and the classification analytics tool will select an instance that has the highest similarity with current investment situation. The function of the verification module is to assess the underlying risk by conducting its own assessment of the entrepreneur's information. If the risk is acceptable then the second stage of validation done by the external agency module, which will be validating provided entrepreneur's financial information. Example of such agency is Fair Isaac Corporation (FICO) [34]. It makes sensitive information, for example income, real estate holdings, monthly expenses, credit ratings, etc., available to its clients, which helps to decide on soundness of upcoming investments. If the external validation is positive, then the negotiation starts; and if not, then the process terminates.

The functions of entrepreneur's negotiation module are:

1) Accepting entrepreneur's data delivered by an entrepreneur's agent (initial values, negation range for attributed and their weights;
2) Creating an offer;
3) Evaluating offers coming from an investor (investors);
4) Generating offers to continue negotiation.

The functions of investor's negotiation module are:

1) Assigning weight of each negotiation attribute;
2) Evaluating received opponent's offer;
3) Generating offers to continue negotiation.

5. P2P INVESTMENT NEGOTIATION

Investment negotiations may be conducted between two or more parties. For example, it can be done between an investor and an entrepreneur; when an investor (or his representative) wants to create an investment portfolio to multiple entrepreneurs; or when an entrepreneur tries to get funds for a startup business from more than one investor. In general, this is a complicated and time-consuming process. Automation of such negotiations means saving time and effort for all participants.

Investment negotiations can be conducted on one or more attributes, for example: amount of funds, time period, profit-and-loss ratio and type of the business to assure that no prohibited business by Islamic law was a beneficiary of invested funds, etc.

Before the negotiation process starts, an entrepreneur (an individual or a business) describes the purpose of the investment and provides information on his experience, previous projects, and other applicable information. The platform makes sure that the purpose of the investment does not have a conflict with Islamic finance's core principles, for example, not carrying out any prohibited activities. Project and the product offered in an investment must be permitted by Islamic religious laws, source of the money that will be used to finance the project by a potential investor must be legitimate by Islamic law. Then the platform conducts its own assessment and verification of the underlying risk.

The investor's decision strongly depends on the validity of entrepreneur's information. The entrepreneur uploads any relevant verified document according to the applicable legal requirements and regulations in the relevant Islamic jurisdiction. The investment platform forces entrepreneurs to provide financial

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information that have been validated by external agencies. Entrepreneurs' social media profiles, social circles and their interests also can be looked at and big data analytics could be used.

After completing all formal procedures including underlying risk assessment, information verification, etc., the negotiating parties start the negotiation. At the beginning, entrepreneurs and investors assign negotiable range of each negotiation attribute (starting $A_i(0)$ and expected $A_i(1)$ values) and their weights that indicate the importance of these particular items for negotiating parties, choose the concession strategy (anxious, careful, or greedy type), and submit them to their negotiation agents. Attributes' data of each participant are unknown to the other side. Agent carries a negotiating party's data to the opponent. Assuming k is the number of negotiable attributes, they all will be processed in sequence from 1 to k on each round. If the starting values of i-th negotiable attribute on the both sides are equal, no negotiation is necessary, it is skipped and the next attribute is processed. Otherwise, opponent's negotiation agent evaluates the received offer and decides whether to accept or reject the offer. If the offer is accepted, negotiation on this particular attribute is concluded. In case of rejection, the opponent changes his bid thus showing his motivation to compromise, and negotiation is continued; and so on for all attributes of the round. The negotiation process continues round by round until attributes' values reach a balance where both sides agree upon the values of all negotiable attributes. If value of at least one attribute reaches limits of the predefined range without consensus from both parties, the negotiation is considered failed.

Negotiation objects that could be investment attributes are:

1) Fund amount: an amount of money the investor wants to provide;
2) Entrepreneur's experience (number of years) in the given investment project or related projects;
3) Profit-loss-sharing (PLS) rate, which is a ratio used to distribute profits as well as to split any losses, usually given as a percentage of the total profits or losses. For example, if an investment has chance A of gaining profit P% and chance B of losing L%, then the expected return ER = A* P% - B x L%. Assuming that profit and loss are different ratios, the investor return value RV for the total fund amount is equal to ER*Fund. The expected return based on historical data, and therefore, is not certain.
4) Reputation of the prospective entrepreneur;
5) Project period, the time required to finish the investment project.

Profit-loss-sharing rate, funds amount, concession rate and project period priorities are the most important of these features. Each attribute (i) has an asking or starting value $A_i(0)$ and an ending or expected acceptable value $A_i(1)$. These attributes' values will be used in the calculation of concessions. Both entrepreneur and investor define the weight of each attribute according to their preferences.

Two sets of equations are used – for an investor and an entrepreneur.

For an investor: an attribute $A_{i,t}$ value in round t is calculated as follows:

If $A_i(0) \geq A_i(1)$ then a new offer $A_{i,t}$ is:

$$A_{i,t} = A_i(0) - [A_i(0) - A_i(1)] * t * c, \quad (1)$$

where $A_{i,t}$ is value of the i-th attribute at round t; and c is a concession rate (0 to 1) specified by each negotiating party. Utility of i-th attribute on round t $U_{i,t}$ (2) is derived as:

$$U_{i,t} = A_{i,t}/A_i(0) \quad (2)$$

If $Ai(0) \leq Ai(1)$, a new offer $A_{i,t}$ and utility ($U_{i,t}$) of i-th attribute on round t is derived as:

$$A_{i,t}(0) + [A_i(1) - A_i(0)] * t * c, \quad (3)$$

$$U_{i,t} = \{A_i(1) - [A_{i,t} - A_i(0)]\}/A_i(1) \quad (4)$$

Total Utility (U) of an attribute A_i for either negotiating party calculated as:

$$U_t = \sum U_{i,t} * w_i \quad (5)$$

Degree of investor's content C_{inv} with reached agreement measured as ratio of total utility of investor at the start of negotiations to total utility of investor at round t:

$$C_{inv} = \left(\frac{U_{inv}(0)}{U_{inv}(t)}\right) * 100\% \quad (6)$$

If no consensus for all negotiable attributes has not been reached by round n = 1/c, the negotiation is considered a failure and the process stops.

For an entrepreneur, if $A_i(0) \geq A_i(1)$ then a new offer and utility of i-th attribute on round t ($U_{i,t}$) is:

$$A_{i,t} = A_i(0) - [A_i(0) - A_i(1)] * t * c \quad (7)$$

$$U_{i,t} = \{A_i(0) - [A_{i,t} - A_i(1)]\}/A_i(0) \quad (8)$$

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And if $A_i(0) \le A_i(1)$ a new offer and utility of i-th attribute on round t ($U_{i,t}$) derived as:

$$A_{i,t} = A_i(0) + [A_i(1) - A_i(0)] * t * c \quad (9)$$

$$U_{i,t} = A_{i,t}/A_i(1) \quad (10)$$

Degree of user content with reached agreement measured as ratio:

$$C_{ent} = \left(\frac{U_{ent}(t)}{U_{ent}(0)}\right) * 100\% \quad (11)$$

If a chance of gaining profit is 0.6 and chance of loss is 0.4, then return value (RV) rate is:

$$RV = F * (0.6 * P - 0.4 * L), \quad (12)$$

where F is fund amount, P is percentage of profit, and L is percentage of loss.

Negotiation is considered finished when the following termination conditions are met:

1) For the investor: if at round t the following conditions hold: investor's $A_i(0)$ less than or equal $A_i(1)$ and $A_{i,t}$ greater than or equal entrepreneur's $A_{i,t}$; or $A_i(0)$ greater than or equal $A_i(1)$ and $A_{i,t}$ is less or equal entrepreneur's $A_{i,t}$, then the investor accepts the offer of the entrepreneur.
2) For the entrepreneur: if at round t the following conditions hold: $A_i(0)$ less than or equal $A_i(1)$ and $A_{i,t}$ less than or equal of the entrepreneur $A_{i,t-1}$; or $A_i(0)$ greater than or equal $A_i(1)$ and $A_{i,t-1}$ greater than or equal $A_{i,t}$, then the entrepreneur accepts the offer of the investor.
3) In case when the investor and the entrepreneur reached the predefined boundaries and no agreement has been attained, the negotiations are considered failed.

5.1 Experiment

In order to test this negotiation model, we designed the test data according to the above negotiation model, which simulates the actual operations of negotiation agents. Based on the definitions of the proposed negotiation model, we conducted three different tests:

1) One investor with one entrepreneur. Table 1 shows the attributes' values and weights used to test the model.

Table 1: Experimental Attribute Values of One Investor with One Entrepreneur

User	Fund		Weight	Profit Rate		Weight	Loss Rate		Weight
	Start	Max		Start	Min		Start	Max	
Investor	5000	7000	0.1	20%	12%	0.6	5%	9%	0.3
	Start	Min		Start	Max		Start	Min	
Entrepreneur	6000	4500	0.4	8%	15%	0.4	10%	7%	0.2

2) One investor with several entrepreneurs: in case if an investor conducting negotiations with a number of entrepreneurs at the same time, he adjusts his offers based on the overall information received from all entrepreneurs' agents. Table 2 shows the attributes' values and weights that used to test the model. The negotiation policy as in the first case.

Table 1: Experimental Attribute Values of One Investor with Many Entrepreneurs

User	Fund		Weight	Profit Rate		Weight	Loss Rate		Weight
	Start	Max		Start	Min		Start	Max	
Inv	5000	7000	0.1	20%	12%	0.6	5%	9%	0.4
	Start	Min		Start	Max		Start	Min	
Ent 1	6000	4500	0.3	8%	13%	0.6	20%	10%	0.4
Ent 2	8000	5500	0.3	13%	17%	0.5	13%	11%	0.5
Ent 3	7000	6000	0.4	7%	9%	0.7	15%	12%	0.3

3) One entrepreneur with several investors. In this case, an entrepreneur conducts at the same time negotiation with a number of investors. Table 3 shows the attributes' values and weights that used to test the model.

Table 3: Experimental Attribute Values of one Entrepreneur with Many Investors

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Table 4:

User	Fund		Weight	Profit Rate		Weight	Loss Rate		Weight
	Start	Min		Start	Max		Start	Min	
Entrepreneur	20000	18000	0.5	7%	17%	0.4	15%	11%	0.1
	Start	Max		Start	Min		Start	Max	
Investor1	14000	17000	0.2	18%	12%	0.5	8%	15%	0.3
Investor2	15000	20000	0.1	20%	10%	0.6	12%	17%	0.3
Investor3	12000	16000	0.1	17%	15%	0.7	9%	20%	0.2

The negotiation aims of the investor: to minimize the amount of fund and the percentage of loss, while maximizing the profit margin. The objectives of the entrepreneur: to maximize the amount of received funds and the percentage of loss while minimizing his profit incurred by investor.

In the first case, the entrepreneur's agent negotiates with the investor's agent on three attributes: amount of fund, profit and loss rate. Concession rates for participants has been set for investor c = 0.2, and for entrepreneur c = 0.1.

In the first round, the entrepreneur agent initialized according to the recommendations from their business analytics systems that use big data analytics. In this example we consider the scenario in which investor is using business analytics while entrepreneur does not. In case if the entrepreneur is provided help from web-based negotiation support system, he will be in a better negotiation position. In each round, investor takes advantage of the information received from negotiations with the entrepreneur to adjust his offer and counteroffers. At the end of round one, investor did not accept the initial proposal of the entrepreneur, and further negotiation is needed. If the termination conditions for any attribute's value have been met, then this value is fixed and will not be calculated on the following rounds. Based on the weight of each attribute, entrepreneur and investor adjust the proposal values of funds amount, profit and loss. The proposal calculations of attributes' values for each negotiation round displayed in Table 4.

Negotiation continues until a consensus has been reached for all negotiable attributes. At this point, the results are accepted by negotiating parties.

Descriptive Statistic Results from the Negotiation Process for Case 1.

	Investor			Entrepreneur		
Round	Fund	Profit	Loss	Fund	Profit	Loss
1	5000	0.200	0.050	6000	0.080	0.1
2	5800	0.184	0.066	5700	0.094	0.094
3	6200	0.168	0.074	Accept	0.101	0.091
4	6600	0.152	0.082		0.108	0.088
5	7000	0.136	0.090		0.115	0.085
6	7400	0.120	0.098		0.122	Accept
7	7800	0.104	0.106		Accept	

Next step will be generating a smart contract and other formalities based on the output of the negotiations.

Negotiations considered a failure if:

1) No consensus has been reached on the value of negotiable attributes, after comparing PLS ratios of negotiation parties;
2) Preset values of negotiable attributes are outside the predefined value range for any attribute(s);
3) Number of rounds exceeded 1/c for either of, or both participants.

After the sixth round of negotiations, the investor accepts the proposal of the entrepreneur with attributes values: funds $5700, profits 12.2%, and losses 8.5% with ER =3.9%

In the second case, negotiations are held between single investor and three entrepreneurs. Such situation can occur when an investor is trying to find the best way to invest his money, or if he wants to create an investment portfolio. Negotiations are conducted with each entrepreneur separately. Participants' agents negotiate on the same attributes. Concession rate has been set 0.2 for all parties. Starting attributes' values assigned to agents at the beginning of negotiations based on suggestions of their

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business analytics systems, provided by web-based negotiation support system or knowledge base. The negotiations are conducted similarly to the previous case. One side sends the other party its offer, offer can be accepted if the termination conditions are met; rejected if sent offer has not been accepted, but the opponent is willing to continue the negotiation process; or if no consensus has been reached, or the value of received offer is outside of predefined range negotiations is considered failed. The proposal calculations of attributes' values for each negotiation round shown in Table 5.

After the 6th round of negotiations, the investor and first entrepreneur received the attributes values: funds $5400, profits 13%, losses 8% with ER = 4.6%; with the second entrepreneur after 7th round attributes', values are: funds $6000, profits 15.4%, losses 10.2% with ER = 5.16%; and with entrepreneur 3 attributes' values after round 9 are: funds $6200, profits 8.6%, losses 10.2% and ER 1.8%. The best choice for investing money will be entrepreneur 2, then entrepreneur 1. Calculations of entrepreneur 3 resulted both in the lowest margins of profit, high losses and the worst RLS rate. If the investor is choosing the best option for investment, then it will be entrepreneur 2.

Table 5. Descriptive Statistic Results from the Negotiation Process for Case 2.

	Investor			Entrepreneur 1			Entrepreneur 2			Entrepreneur 3		
t	Fund	Profit Rate	Loss Rate	Fund	Profit Rate	Loss Rate	Fund	Profit Rate	Loss Rate	Fund	Profit Rate	Loss Rate
1	5000	0.20	0.05	6000	0.080	0.2	8000	0.13	0.13	7000	0.07	0.15
2	5800	0.168	0.066	5400	0.100	0.16	7000	0.146	0.122	6600	0.078	0.138
3	6200	0.152	0.074	Accept	0.110	0.14	6500	0.154	0.118	6400	0.082	0.132
4	6600	0.136	0.082		0.120	0.12	6000	Accept	0.114	6200	0.086	0.126
5	7000	0.12	0.09		0.130	0.1	Accept		0.11	Accept	0.09	0.12
6	7400	0.104	0.098		Accept	0.08			0.106		0.094	0.114
7	7800	0.088	0.106			Accept			0.102		0.098	0.108
8	8200	0.072	0.114						Accept		Accept	0.102
9	8600	0.056	0.122									Accept

In the third case, another situation was tested: one entrepreneur negotiates with three investors. The same requirements have been applied to data and termination conditions. Concession rates are set 0.1 for entrepreneur and first and third investors, and 0.2 for investor 2. Calculations of consequent offers shown in Table 6.

Table 6: Descriptive Statistic Results from the Negotiation Process for Case 3.

	Entrepreneur			Investor1		Investor2			Investor3			
t	Fund	Profit Rate	Loss Rate	Fund	Profit Rate	Loss Rate	Fund	Profit Rate	Loss Rate	Fund	Profit Rate	Loss Rate
1	20000	0.07	0.15	14000	0.18	0.08	15000	0.2	0.12	16000	0.17	0.09
2	19600	0.118	0.142	14600	0.168	0.094	17000	0.16	0.14	16600	0.166	0.112
3	19400	0.142	0.138	14900	0.162	0.101	18000	0.14	Accept	16900	0.164	0.123
4	19200	0.166	0.134	15200	0.156	0.108	19000	Accept		17200	0.162	0.134
5	19000	0.19	0.13	15500	Accept	0.115	Accept			17500	Accept	0.145
6	18800	0.214	0.126	15800		0.122				17800		Accept
7	18600	0.238	0.122	16100		0.129				18100		
8	18400	0.262	0.118	16400		Accept				18400		
9	18200	0.286	0.114	16700						18700		
10	18000	0.31	0.11	17000						Accept		
				No consent								

Two investors (second and third) successfully completed negotiations. The entrepreneur accepts investors offer. The second investor attributes' values are: funds $ 19000, profit 14%, losses 14% and ER 2.8%, and the third: funds $18700, profit 16.2%, losses 14.5% and ER 3.9%. All participants of negotiations must agree on results. Profit-loss-sharing ration used to determine the best choice for an investment. Thus, the investor makes his selection following the Islamic principles of sharing losses and profits in investments.

Negotiation between investor 1 and the entrepreneur failed because negotiating parties did not reach to consensus on funds before termination conditions have been exceeded. It is obvious that no consensus on funds have been reached in this case due to the wrong choice of the initial values of the attributes; the ranges of the negotiable attributes do not overlap.

6. INVESTMENT SMART CONTRACT

Smart contract powered P2P blockchain technology is well known for its capability to handle dispute settlement among parties thus making transactions very reliable. Islamic financing is more complex as it has more contracts of "profit-loss-sharing agreements, agency agreements and partnership-based contracts" [8], [35].

The contingency provided by blockchain will help the Islamic Fintech industry to govern a fair,

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congenial and transparent transaction between the entities involved in a financial transaction. Smart contract transactions are immutable and trackable. Using smart contracts as replacing the traditional financial contracts will dramatically reduce the cost of transitions.

The core concept of Islamic financing institutions is similar to the P2P blockchain-based smart contract except for the fact that contract must not be signed for carrying out major prohibited activities. Smart contracts and sharia-based Islamic financing can act hand in hand in activities concerning cash and trade financing, reimbursement, reducing the need for centralized regulation, managing counterparties' risks, compiling legal documentation, and reducing processing time [36]. The resulted smart contract will ensure the preservation of the contractual agreement between the investor and the entrepreneur for the sake of mutual benefit.

Solidity language can be used to generate investment negotiation agreement based on the positive negotiation agreement between investor(s) and entrepreneur(s). The platform collects the funds (from investor's bank account or cryptocurrency) and transfers them to the entrepreneur's account. In the proposed P2P investment platform, once the investment smart contract generated, it is published on the blockchain. The platform managed in a decentralized way in the blockchain and without the intervention of intermediaries. All transactions, both entrepreneur's and investor's, will be encrypted and put into the blockchain. All data is updated and synchronized to all computers in the network.

The investment smart contract has to include the following: entrepreneur's verification information, the agreed negotiation terms and conditions. Both entrepreneur and investor sign the final contract using their digital signatures before it is deployed in the blockchain. Initially, the smart contract must be registered, the public key, or the ethereum address identity, or identity registration, is assigned to each entrepreneur and investor so that the participant's identification strings can easily identified in the contract. Then smart contract is stored in the blockchain. Using their identity, entrepreneur or investor will be able to track their transaction records history and current arrangement. The contract has a unique address so it can be traced easily. Each peer of the network will reach a common agreement regarding the execution's results of the investment smart contract. The network will update the distributed registries to record the execution of the smart contract and will handle the compliance according to the agreed upon terms of the contract. This will ensure data integrity, which means that the manipulation of data and transactions is impossible. Over its lifetime, the smart contract automatically debits funds from the entrepreneur's account and simultaneously extinguishes liability in the smart contract blockchain. It acts as a trusted intermediate, which is responsible for holding and releasing the funds to the entrepreneur. When payment is due, the entrepreneur receives a notification and transfers the payment to the contract. The investor receives it. In case if the entrepreneur fails to pay on time, smart contract holds the responsibility to take an agreed action, for example a bad reputation record is to be generated for the entrepreneur in the system. The record will be updated when the money is repaid.

Since the agreement is based on profit-loss-sharing, blockchain will store all smart contract transactions, inflows and outflows, details of outstanding bills, and so on, therefore it is easy to calculate the real cost, price and the real profit in relation to the PLS rate as stated above in the negotiation model. Since the blockchain will store investment history, this data will be added to the knowledge base, and therefore a future investment decision making becomes much easier and faster based on the stored historical data. Through information distributed in the blockchain, investors could monitor real-time credit information of entrepreneurs, therefore making sure that their money are not misused for wrong purposes.

7. DISCUSSION

The Introduction of smart contract and blockchain technologies in the Islamic financial industry will improve its services efficiency and deal with the existing challenges and opportunities [5], [37]. These technologies guarantee data privacy and security and provide data transparency and immutability. The implementation of Musharakah (profit-loss-sharing) concept based on these technologies will be an innovative approach in the Islamic financial services. Such approach could create partnerships or joint ventures of investors with entrepreneurs seeking funding instead of merely becoming creditors.

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In this work, we introduced peer-to-peer Islamic investment platform based on blockchain and smart contract technologies supported by automated negotiation between agents representing both investor and entrepreneur.

This innovative model facilitates faster verification and authentication and the use of blockchain lowers transactions cost. The proposed system offers an electronic negotiation module to conduct negotiations on behalf prospective investors and entrepreneurs. Negotiations conducted using multiple negotiator agents representing specific interests of each party.

The negotiation model has been tested for three cases: one investor to one entrepreneur, one investor to three entrepreneurs, and one entrepreneur to three investors in order to investigate different situations. Data for the tests were selected randomly, for small and moderate investments.

Amount of funds, profit and loss values were taken as negotiable attributes. Participating parties should consider using the profit-loss-sharing ratio in accordance with the Islamic principles. The higher the ratio, the more likely investor will consent to the negotiated deal, but it is important that both sides agree on the conditions of the arrangement.

More importantly, the proposed platform can be extended to other forms of Islamic contracts such as Sukuk. Sukuk or sharia-compliant bonds are one of the recent and most significant developments in the Islamic finance sector, and the fastest growing financial instrument in the Islamic finance [38], which can be used for sharia-compliant Islamic fundraising structures. Sukuk represents a stable approach of financing to institutions seeking different sources to their financing.

There is perception that P2P Islamic investment has more superior social value than traditional banking, therefore, achieving socio-economic justice.

Main features of the proposed P2P investment platform:

1) Eliminates costs and inefficiencies of third-party intermediaries like banks or financial institutions.
2) P2P investment platform matches investor(s) with entrepreneur(s) directly through online negotiation system. Based on the results of negotiations, the platform generates a smart contract, which helps investors secure their funds and increases the efficiency of transactions.
3) Proposed platform will provide an infrastructure of a middleware for applying a real Islamic investment policy (profit-loss-sharing agreement), where economic policies or banks should not decide the rates. Risk and Profit Sharing contract will allow investors to share a pre-agreed percentage of profit or loss from the financed project.
4) Investment negotiation process becomes very smooth and less expensive.
5) More liquidity will become available for the investment market.
6) Transparency gives regulators the ability to get direct access to the ledger and see the entire history of a transaction; every transaction is visible, follow on what is happening, where it initiated, its ownership and attributes.
7) The possibility to conduct an investment from anywhere in the world.
8) Entrepreneurs and investors should make decisions on rules and conditions, which will become part of the smart contract.

8. CONCLUSION

It is obvious that the characteristics of blockchain technology are similar to the principles and spirit of the Islamic sharia as the decentralized Islamic finance executes values of transparency, trust, fairness in operation, and increased dependability on the system. This study will positively contribute to the understanding of Islamic peer-to-peer investment based on technologies like blockchain, smart contract and automated negotiation from the Islamic perspective, for the investors, entrepreneurs, academia, industry, regulators, and other related users.

By applying blockchain and smart contract technologies for a real decentralized P2P investment platform the conditions will be created for enabling investors to conduct their activities with entrepreneurs directly. Unlike banks, this investment platform does not receive deposits or lend funds, entrepreneurs will often be able to gain access to funds quickly based on the agreed profit-loss-sharing rate. It is the practice of

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matching entrepreneurs and investors through online negotiation. Based on the outcomes of negotiation, the platform generates an investment smart contract, which makes the whole process legal. This platform enables investors to invest in all cryptocurrencies.

The benefits of these technologies will motivate decision makers of Islamic banking sector to consider them as solution to their current investment problems (long trade settlement times, low automation and manual reconciliation), transform their current business models and become more like a web-based financial intermediaries, hence optimizing banks operations. The presence of Islamic Fintech companies can help the startups in an effective way [39], especially young graduates who need support with Islamic compliance financing.

This study has some limitations, which make both investors and entrepreneurs uneasy and hesitant when considering implementation of blockchain technology. These obstacles and challenges include the following:

1) Part of the world's population do not have adequate access to the Internet. Moreover, some of those, who have it, lack skills necessary to take full advantage of the proposed system, and therefore, there is a limited pool of investors at the current stage.
2) Adoption of blockchain technology is still at its early stage of development. There are some questions about its scalability and performance. Therefore, it will take time to attract investing participants and to realize system's full benefits [40], [41].
3) Smart contracts are not yet regulated by governments in many countries around the world where Islamic financing is available. Islamic-based contracts are more complex than the traditional finance contracts. Therefore, policymakers and regulators must consider the benefits and threats of the adoption and acceptance of Islamic FinTech [42]. The adoption of smart contracts will require major regulatory, economic and social changes. Islamic lawyers and regulators need to gain deep understanding of these technologies.
4) Automated validation and verification of smart contracts running over blockchain represents a challenging issue [43].
5) Some investors are not sure whether such investments are worth undertaking in Islamic fintech [5].

As part of future work, we would like to implement it in practice to enhance the current peer-to-peer investment data management.

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