The Potential and Challenges of Decision Support Systems for Islamic Banking and Finance

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Abstract - A Decision Support System (DSS) is a computer system designed to help with decision-making processes. DSS usage is now commonplace in personal and commercial decision-making – including decisions related to the Islamic faith. Simple Applications (Apps) that help with simple decisions – such as ascertaining the halal status of products and proprietors are prevalent. To what extent can DSS facilitate more complicated Islamic decision-making, such as *fiqh* rulings, *Hadith* classifications, and *zakat* or *faraid* computations? This paper aims to review DSS initiatives (academic and commercial) intended for these more complicated Islamic or *Shariah* decision-making processes, and to identify the potential and challenges – particularly in the contemporary *ijtihad* of reviewing and certifying Shariah-compliant status for Islamic finance products and services. The new digital mindset incited by IR 4.0, and accelerated by the Covid-19 pandemic, has paved the way for the potential for Islamic DSS – particularly for the Islamic Banking and Finance industry. Artificial Intelligence (AI) technology makes it possible to represent Islamic knowledge in a computer-processable format and to enable complex *Shariah* decision-making. The main challenge is getting a human Shariah expert who can translate his/her knowledge into said computable format. This has thus far led to a lack of Islamic DSS in the market, which can be utilized to support Shariah-related decision-making.

Keywords - Islamic Decision Support System; Islamic Banking and Finance; Shariah Robo-Advisor

I. INTRODUCTION

The use of computer applications (Apps) that provide decision-making recommendations has become increasingly popular. Such "recommender systems are software tools and techniques providing suggestions" to a user which "are aimed at supporting their users in various decision-making process, such as what items to buy, what music to listen or what news to read" [1]. An example is Google Maps or Waze, that recommend the best routes to a destination, Foursquare that recommends places to dine and TripAdvisor that recommends travel destinations.

Systematic decision making driven by computer systems has also helped commercial organizations to operate more efficiently. For example, Business Data Analytic (BDA) tools enable data driven decision making to predict sales, maintain healthy inventory levels, and to enhance customer relationships – which ultimately leads to increased revenue and profits. According to Lim Kim Heng, the Executive Chairman of Seng Heng (one of the largest electrical appliances chain stores in Malaysia), in his book Sengheng Digital Journey, "BDA goes beyond just looking at numbers to see what has happened; it also endeavours to give insights into why things happen and suggests what actions to take next" [2].

Muslims have some unique decisions to make which are related to the religion of Islam. Familiar examples of simple Islamic DSS Apps are those that often used to determine *Qiblah* (prayer direction), locate halal restaurants and/or determine the halal status of consumer products. A few popular Apps that provide such services are Muslim Pro, Verify Halal, and Zabihah (The original Halal restaurant guide). There have also been numerous efforts to incorporate *Shariah* knowledge into DSS providing some form of technological assistance in decision making for more complex *Shariah* matters, such as *fiqh* rulings, *faraid* computations, *zakat* computations, and *Hadith* classifications, etc. Such innovations have been given various names such as Islamic expert systems, Islamic decision support systems, and Islamic intelligent tools.

While Islam has provided the methodology and the formula for these decision-making processes, some are more complicated than others. For example, *zakat* and *faraid* computations are quite straight forward, however the *fiqh* ruling process requires qualified scholars to perform *ijtihad,* following a prescribed methodology of *usul Al Fiqh* in order to arrive to certain decisions. One of the contemporary *ijtihad* is the *Shariah* approval process of Islamic banking and finance products and services. This serves to certify that these products and services are *Shariah* compliant, before they can be offered to the public.

There have been a few attempts to develop decision support systems intended to assist *fiqh* ruling processes. For example, *El Bayane* (to assist a mujtahid in generating fatwas for new situations by using fatwas issued in past situations) [3], and *Al-*

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Usoly (to automate the very complicated process that usually requires a human mujtahid). Unlike the *El-Bayane* that can only be applied in the field of drinking, the *Al-Usouly* system can be applied to any field in Shariah [4]. Dubai has launched its "world's first Artificial Intelligence fatwa service" [5]. "SKIL Shariah Robo-Advisor (RSA) is claimed to be the first expert system for Islamic finance, whereby users can ask intelligent questions, conduct comparative analyses, deduce from legal maxims, and consult an automated legal advisor, about complex scenarios" [6]. In the study of the technology applied in *Ijtihad* process – particularly artificial intelligence (AI), Ahmed concludes that AI has not reached a level that can replace human *Shariah* scholars, but that AI can help a human *Mujtahid* [7].

The purpose of this paper is to review decision support system initiatives (both commercial and academic) related to these complicated "Islamic" decisions, and to discuss the potential and challenges therein. This discussion is crucial because the world is going through the 4th Industrial revolution, where technology and automation have become a major part of everyone's life. Humans increasingly depend on smart assistants incorporated with various technologies that could assist them in making guided decisions, in order to be more efficient in this fast-moving digital era. The Financial services industry in particular has been going through a digital transformation facilitated by financial technology. Islamic financial institutions (IFIs) have unique requirements for ensuring that their products and services are *Shariah* compliant.

To be competitive, these IFIs have no choice but to embrace new financial technologies with additional efforts to explore digital innovations, such as decision support systems for *Shariah* related matters in IFIs' operation. Currently the use of systems or tools in *Shariah* review processes in Islamic financial institutions is still limited. An interview with Mr. Mazrul Shahir Md Zuki, a member of *Shariah* Committees (SC) of Malaysian Industrial Development Finance Berhad (MIDF) reveals that at the moment, the *fiqh* ruling process in IFIs are largely manual – except for using simple computer software such as *Jami' Fiqh* that contains database of 100 books in the Islamic field, to locate references related to juristic opinions and resolutions. Other than this, SC members will have to read, digest, analyze, and synthesize the reference materials by themselves. This necessitates greater efforts to develop and promote the usage of decision support systems for Islamic banking and finance, in order to help speed up the decision-making process.

This paper will review relevant literature and media on contemporary digital innovations, including published journals, technical reports, blog posts, online newspaper articles, and YouTube videos. The content of this literature and media will be analyzed to identify the potential and challenges therein. It is expected that the stakeholders of Islamic banking and finance (IBF) will be optimistic about the potential for decision support systems to help make IBF operations more efficient, and any technological innovations available for such systems or tools. However, the supply of these systems or tools are limited because they are challenging to develop, due to the need to not only be well versed in *Shariah* ruling processes, but also be able to represent this knowledge in a computer processable format.

The remainder of this paper comprises a literature review, a methodology, and discussions of the potential and challenges of Islamic DSS solutions, followed by a conclusion.

II. Literature Review

1) Overview of Decision Support System

2) General Shariah related DSS initiatives

3) General Fiqh Ruling or Fatwa Related DSS initiatives

4) Islamic Banking and Finance Related DSS initiatives

A. Overview of Decision Support Systems

Some scholars define decision support systems as "computer technology solutions that can be used to support complex decision making and problem solving" [8]. "Knowledge-based decision support systems are systems designed to ensure more precise decision-making by effectively using timely and appropriate data, information, and knowledge management" [9]. These systems apply artificial intelligence techniques and other applications of information and communication technologies. A DSS can also be understood as "an information system that aids a business in decision-making activities that require judgment, determination, and a sequence of actions" [10].

A DSS can be employed in various knowledge domains such as medical, dietary, pollution detection, drug reaction, and credit scoring, etc. The "knowledge" that drives the decision making can be models, documents, data, or any predefined procedures or rules. In some cases, a DSS can analyse real time data – making the decision-making choices more relevant and up to date. The most obvious advantage of using a DSS is speed and efficiency in decision-making, leading to better quality and more accurate decisions. Other advantages include more systematic ways of making decisions – particularly for structured types of problems that can be automated based on past decisions, or those that are data driven. Where part of the decision-making process is automated, human managers will have more time to focus on tasks that require real human intelligence.

Simpler DSS solve structured problems and make use of explicit knowledge to facilitate decision making. "DSS uses explicit knowledge, stored in digitalized environments to solve the structured part of the problem, meanwhile tacit knowledge is utilized by decision makers to solve the unstructured part of the decision problem" [11]. Explicit knowledge is codified knowledge, such as that found in documents, whereas tacit knowledge refers to non-codified knowledge, which is often personal, or experience based [12]. More sophisticated DSS which apply AI techniques (expert systems, artificial neural networks, intelligent agents, etc.) in their algorithms, incorporate both explicit and tacit knowledge, and have the capability to solve more complex and less structured problems [13].

The motivation to adopt knowledge management and DSS systems in the business world is the potential to achieve

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superior performance. DSS enhanced by the concept of knowledge management is essential for the success of organizational strategic management. Alyoubi illustrates how data, information and knowledge can be combined, filtered, and understood to formulate strategic knowledge for growth, competitiveness, and objective strategies that can guide decisions and actions, which will lead to superior organizational performance [14].

B. General Shariah Related Decision Support System Initiatives

This section reviews Islamic DSS initiatives that are generally associated with the *Shariah* domain – such as *zakat, waqaf, faraid, Hajj,* and *Hadith* classification etc., but excluding those related to *fiqh* ruling and Islamic banking and finance, which will be discussed in the following two subsequent sections respectively.

A summary of general Islamic DSS initiatives follows:

- A cash *waqaf* distribution system using a Decision Tree (supervised machine learning) algorithm that can generate a list of beneficiaries. The proposed system is a web-based system that helps in the distribution of *waqaf* funds, which allows users to choose the type of *waqaf* that they would like to apply [15].
- An Arabic ontology-based inheritance calculation system that can reduce the time needed to process family data and reduce human efforts in the search for family relationships throughout the process of calculating Islamic Inheritance. The system has the capability to automatically identify heirs' information, such as how many there are, their genders, and their relationship(s) to the deceased [16].
- A mobile app decision support system that allows users to ask simple and advanced questions related to *Hajj* rituals. The proposed system makes use of a dynamic knowledge-based approach that can capture problems and find solutions, preprogrammed by an expert [17].
- An expert system for *zakat* application that can assist in the decision-making process, the identification of the relevant rules, and in doing the calculations. The specific objectives are to determine: if someone is required to pay *zakat*, the unique conditions applied, and the amount applicable for the *zakat* types to be paid [18].
- A system called *Muhadith* was designed to enable a computer to imitate human *Hadith* experts, in order to discriminate authentic *Ahadith* from unauthentic ones. *Muhadith* also includes reasoning capability, that can enable users of the system to look into the classification details. Users can enter the *Hadith* using a Web interface, and the inference engine will return the results, along with the explanation [19].
- An expert system on "Islamic Punishment". The proposed system derives the recommended punishments from a knowledge base created from the *Quran* and *Hadith*. The three motives behind the system includes: to distribute human expertise to this science, to prevent injustice in punishment by applying Islamic laws to this science, and to preserve the punishment laws in Islam from becoming lost or forgotten [20].
- A rule-based Expert Systems on Islamic medication that runs on a mobile platform so that "patients can get treatment anytime and anywhere". The system focuses on both physical and inner illnesses, to derive the recommended cures, treatments, or therapies, from a knowledge base created exclusively from the *Quran* and *Hadith*. The proposed system would have the capability to recommend the most suitable treatment for an illness, with reference to the relevant verses cited in the *Quran* or *Hadith*. It will also recommend the related bodily actions, gestures or acts, to be performed by the patient, in order to treat his/her particular ailment [21].

The examples above covering DSS for *waqaf, faraid, Hajj, zakat, Hadith* classification, "Islamic punishment", and "Islamic medication", demonstrate the extent of how diverse DSS can be implemented to assist in various *Shariah* domains. As observed in these examples, the possibilities are seemingly endless, so long as there is enough creativity to leverage the latest technologies to innovate solutions that can (at least) guide in making *Shariah* related decisions – or potentially fully automate them. Mobile apps related to *waqaf, zakat,* and *faraid* calculations are already commonly used by Muslims globally.

C. General Fiqh Ruling Decision Support System Initiatives

This section reviews *fiqh* ruling DSS in general. *Fiqh* rulings or fatwa are a very serious subject in Islam, which can only be decided by qualified scholars. *Fiqh* rulings may change under different circumstances, and therefore Muslims require continuous guidance. The number of queries typically increase during peak seasons – such as *Hajj* and *Ramadan*. Various attempts have been made to explore how technology can help to address Muslims' *fiqh* ruling needs.

The following contains a summary of initiatives that are either related to, or have attempted to come up with, a computerized system for storing and smartly processing Islamic law, which users could access as a reference for deciding upon *fiqh* ruling related matters:

- The Saudi Arabian Ministry of Islamic Affairs launched a robot-assisted service that can provide fatwas for pilgrims that are performing *Hajj*. The service is available in Arabic, English, French, Hindi, Turkish, Hausa, Indonesian, Bengali, and Amhari [22].
- Dubai launched 'Virtual Ifta', an Artificial Intelligence (AI) fatwa service. The AI-powered Virtual Ifta is able to take live questions via internet chat, and replies accordingly. The service is available 24 by 7 [5].
- Munshi, Al Sabban, Farag, Rakha, AlSallab, and Alotaibi proposed an automated Islamic Fatwa System that provides rapid responses to fatwa related questions – especially during high seasons, such as *Hajj* and

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Ramadan. The authors built "the largest dataset for Islamic Fatwa, spanning the widely used websites for Fatwa" [23].

- Khan, Siddiqui, Siddiqui, Saeed, and Touheed proposed an enhanced ontological model for an Islamic jurisprudence system in the form of Question and Answer (QA) ontology, which can simplify the extraction of unambiguous information about Islamic Jurisprudence (fatwa). The answers to users' questions come with supporting *Quran* and *Hadith* references, so users can authenticate and understand the relevant Quranic verses or *Hadith* related to their question [24].
- Mabrouk proposed a model-based semantic network for smart representation and inference of Islamic law. The model comes with a smart deduction engine that provides compact codes of *fiqh* rules and deduces answers to queries relevant to these rules. The main functions comprise the storage and retrieval of *fiqh* rulings, selective browsing to obtain answers, comparative analysis for rulings of different situations, coding and deduction from *fiqh* rules, and fatwa assistance [25].
- Harb and Sharaf proposed an Intelligent Islamic Fatawa Retrieval System, as an agent-based system for information retrieval, based on ontology, that is applied to Fatawa. Each fatwa in Dar Al Eftaa El Mesria database "is annotated by its meaning, so the system locates fatwas based on its meaning and not just keywords". A user looking for a fatwa can submit a new query, and the system will extract the already stored fatwas that semantically match the query [26].
- Amari, Atil, Bounour and Nouaouria proposed an intelligent tool for mufti assistance – an Expert System (ES) that can give fatwas for new situations by using fatwas from past situations. The ES is intended to assist a mufti in generating fatwas from second principle. The system could be also used to retrieve information by any other user that may have questions about the field [27].
- Elhalwany, Mohammed, Wassif, and Hefny proposed an intelligent Fatawa QA system that using Textual Case-based Reasoning (TCBR). The proposed system will respond to fatwa related questions by referring to a knowledge base library of past cases, in order to identify cases with similar situations to that of the posed question. The Fatawa QA System is for text indexing, retrieval and system learning, using a smart approach. The system is expected to be able to overcome the language and domain challenges [28].
- Abdelwahab, Daghbouche, and Shahnan came up with a generic algorithm for deciding *Fiqh* rulings with full transparency and complete algorithmic coverage of Islamic law, to enable and further leverage rule of law (as opposed to rule by law). The objective is to provide legal security, legal equality, and full legal accountability of *fiqh* rulings. The steps in the algorithm involve disentangling and reinstating classic *fiqh*-methodology (*usul al-Fiqh*), as represented by the expressive power of subsets of First Order Logic [29].
- Mutawa and Al-Terkait proposed *Al Usouly*, an expert system in the origins of Islamic jurisprudence domain. A knowledge-based expert system that can automate the generation of fatwa by applying rules deducted from Quranic verses. The intended purposes of *Al-Usouly* are to serve *Shariah* scholars who are not specialists in *Usoul al-Fiqh*, for students or Muslims in general who are interested to understand the intended meaning of Quranic evidence, to understand a fatwa, and "as a tool or a decision support system for a mufti who generates fatwa from extrapolation which determines the hidden relationships and associations among incidents" [4].
- Nouaouria, Atil, Laskri, and Bouyaya proposed El-Bayane, a Case Based Reasoning (CBR) system that can help muftis generate fatwas for new situations by using fatwas of past situations. Being able to 'reuse' past fatwas, the system organizes its knowledge in cases which are collected in a memory, called a case-base. Subsequently, through inference processes, the system will be able to find and reuse the appropriate fatwa and its argumentation [3].

From the above summary, the Robot Fatwa Service operating during *Hajj* in Saudi Arabia and the Artificial Intelligence fatwa service in Dubai, are commercial initiatives for *fiqh* ruling or fatwa related AI decision support systems. The remaining summarized solutions are academic papers. Generally, the authors qualify that their proposed systems or tools are to be used as complementary to human *Shariah* experts. In addition, realizing that there are already databases of fatwas hosted by different parties, and that very often similar questions are asked, and therefore would have been answered in the past, some of these works took the initiative to consolidate fatwa databases and provide the capability to automatically retrieve similar past fatwas that match a user's query. This may help to reduce the number of questions that human fatwa experts need to address, so that he/she can focus on fatwas related to circumstances that have not been dealt with previously.

Some of the works described in the above summary are more advanced than others, where the authors [4][24][25][29] propose systems that would have the capability to recommend solutions derived from Islamic sources of knowledge, such as the *Quran* and *Hadith*. For these works, the authors elaborate upon the technical details of how to derive an ontology (knowledge representation) that can represent Quranic verses and *Hadith* in computer language, and how logics could be programmed atop these ontologies to facilitate *Shariah* related decision making.

These works have demonstrated the possibility to represent Islamic knowledge in computer language. Subsequently, computer algorithms could be programmed to automate the retrieval of relevant past fatwa which match a query. More sophisticated algorithms could provide recommendations for fatwa or *fiqh* rulings for new circumstances.

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D. *Islamic Banking and Finance Decision Support System initiatives*

This section focuses on *Shariah* related decision making DSS initiatives in Islamic banking and finance operations. The most commonly discussed Islamic DSS are digital investment advisors. Some literature also refers to such DSS as Robo-Advisors – a term that started as a disruption in wealth management, whereby investors could proceed with investments following "automated advice" provided by a digital investment platform. Wahed Invest is known as a pioneer in Robo-Advisors, providing *Shariah* compliant investment options [30].

Subsequently, there are a few initiatives to develop *Shariah* Robo-Advisors which refer to DSS which provide recommendations related to *Shariah* matters of Islamic banking and finance. These initiatives are summarized below:

- Obaidullah shared about the "Promise of IRSHAD: The Intelligent Robo *Shariah* Advisor". IRSHAD is currently still under development and will be released in phases. Modules in the pipeline include "*Zakat* Advisor", "Islamic Wills and Inheritance Advisor", and "Investment Advisor for socially responsible Islamic organizations and financial institutions seeking to operationalize the SDGs in the light of the *Maqasid Al-Shariah*". IRSHAD has been developed using various AI technologies such as "rule-based programming", "AI-based text-analysis", "NLP tools for translation and text-to-speech capabilities", and will eventually feature analysis of real time data using "dynamic AI-based models" [31].
- Salim, Abojeib, and Abdul Hamid, in "2020/21 Islamic Fintech in Malaysia – Reality & Outlook" featured a case study on SKIL-RSA, an online platform that utilizes artificial intelligence technology and aims to be a decision-support system for Islamic financial institutions. SKIL-RSA has been referred to as a "Mufti Companion" or "Mujtahid Assistant" which allows users to ask intelligent questions, conduct comparative analyses, deduce from legal maxims, and consult an automated legal advisor about complex scenarios. SKIL-RSA has already been adopted by MBSB Bank Malaysia, and is hosted on the MBSB website, where it is accessible to MBSB employees and customers [5].
- Benlaharche and Nouaouria proposed an expert system that utilizes case-based reasoning to assist in generating fatwas related to new situations in Islamic banking and finance by using fatwas from similar past situations. The proposed system can save past fatwas in a case-based memory, for which the target users of the system are "expert muftis", and "learner muftis". The "Expert Muftis" are given authority to add, update or delete fatwa, whereas both expert and learner muftis can recover a fatwa by "interrogating the system" via a user interface screen where they can enter their queries in the provided fields, following specified criteria [32].
- Che Mohd Salleh and Mohd Nor proposed "a framework of Intelligent Information Retrieval (IIR) for *Shariah* sources using Support Vector Machine (SVM) for *Shariah* decision making in the Islamic Financial Industry (IFI)". SVM is a machine learning technique used mostly for regression, information classification, and outlier detection. The proposed framework will provide "an efficient platform for the *Shariah* scholars, as well as industry players in gathering sufficient information for decision making processes in order to run the Islamic business and also to resolve *Shariah* issues that they encounter" [33].
- Tlemsani, Marir and Majdalawieh proposed a machine learning data mining technique that analyzes *Quran* and *Hadith* texts to validate whether all the activities and data flows in *Murabahah* financing contracts are compliant with the *Shariah* requirements. As part of the project, the proposed technique managed to identify some shortcomings with regards to the compliance level of existing Islamic banks' *Murabahah* financing contracts with *Shariah* law [34].

From the above summary, IRSHAD and SKIL-RSA are commercial initiatives, whereas the others are academic papers. Similar to the DSS initiatives for the general *fiqh* rulings, there are attempts to facilitate the retrieval of similar *Shariah* rulings from past cases that are relevant to current situations. The most advanced initiative is SKIL-RSA – which has already been adopted by at least one Islamic financial institution in Malaysia.

An important observation is that these "*Shariah* Robo Advisors" have not reached the level to replace a human yet. At best, they can only function as a smart assistant to a human *Shariah* advisor, in order to speed up his/her work. Literature in this area is quite limited which may indicate that there is not much work has been done in this area yet, and therefore provides great opportunity for both commercial entities and academics to explore further.

III. METHODOLOGY

This paper reviews commercial and academic works related to Islamic decision support initiatives. Since this paper deals with contemporary digital innovation – which is a relatively new subject matter, in addition to published journals, this paper also refers to other sources such as technical reports, blog postings, online newspaper articles and YouTube videos. The need to refer to such contemporary digital content is aptly summarized by Ahmad and Buyong, who notes that in this digital era content analysis is also applied to analyzing data obtained from modern media such as websites, digital version of newspapers, blogs, Facebook, Instagram, and YouTube videos, etc. [35]. This study has utilized content analysis methods to analyze the data collected from the reviews of these journals and media.

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IV. Discussions of the Potential and Challenges for Islamic Decision Support Systems

The discussion in this section is organized into the following two subtopics:

1) *The potential and challenges of Islamic DSS in general*
2) *The potential and challenges of Islamic DSS for the Islamic Banking and Finance sector*

A. The Potential and Challenges of Islamic Decision Support Systems in general

This section discusses the potential and challenges of Islamic DSS in general. For the purpose of clarity, in the context of this paper, potential refers to the positive capacity for Islamic DSS – such as the possibilities, opportunities, available technologies, benefits, acceptance, and enthusiasm for it; whereas the challenges refer to the negative aspects – such as the limitations, practical issues, and objections or rejections, etc.

This review of Islamic DSS uncovers two main potentials. There exists available technological approaches that can assist with *Shariah* related decision making, and there are already multiple commercial and academic initiatives that work on such Islamic DSS. These innovations are not limited to those *Shariah* domains with more straightforward methodologies with calculation formula such as *Hadith* classification, *zakat* computation, and *faraid* determination, but also includes the most complicated ones – namely the *fiqh* ruling process.

As far as demand is concerned, the journey towards greater digitalization in line with 4th industrial revolution (4IR) requires everyone to embrace advance technologies. During the launch of Malaysia National 4IR Policy Science, Technology and Innovation (MOSTI), Minister Khairy Jamaluddin said "this is because advanced technology will be the transformation that covers a wide spectrum and affects all layers of society" [36]. This digitalization initiative has been accelerated by the movement restriction order to curb Covid-19 pandemic. "The rapid development and evolution of Industry 4.0 and the painful Covid-19, has created a new mindset focussed on the future, with a readiness to try new technologies" [1]. The new digital mindset has been amplified by IR 4.0 and Covid-19 is expected to accelerate digital lifestyles globally.

At the moment, most people are already comfortable using a wide variety of apps to seek recommendations and look for options that can help with simple decision making in everyday life. This goes to the extent of making decisions related to Islamic faith – such as determining halal status and finding halal places. Some people have already resorted to digital apps to help with more serious Islamic related decision making, such as calculating *zakat* amounts, determining *faraid* portions, and even looking for some fatwa related answers to their questions. With these growing Islamic digital lifestyle trends, demands towards Islamic DSS are expected to increase, and therefore will further encourage more commercial projects and academic research into Islamic lifestyle digital applications.

As is the case with many digital services, the main benefits of Islamic DSS are convenience, speed, and efficiency in decision making. Another benefit includes the standardization of rules in the decision-making process. This may assist in addressing an inherent challenge in Islamic decision-making processes inherent in multiple scholarly views on certain issues in certain matters, which may result in differing decisions.

There are not many challenges with respect to Islamic DSS for simple decision making – such as finding *Qiblah* direction, determining halal status, or locating halal places. Such applications are quite easy to develop as long as the data is available and accessible by the systems. However, it can be extremely challenging with more complex *Shariah* decision making – particularly with *fiqh* ruling matters. *Fiqh* rulings are an extremely complicated process that requires qualified *Shariah* experts, and which follow a strict methodology. The rulings must be deduced by a reasoning process that refers to *Shariah* sources of knowledge, such as the *Quran, Sunnah, Ijma', Qiyas*, and a few other secondary sources – such as public interest, customary practices, objectives of *Shariah*, etc. In the computer world, *Shariah* knowledge is classified as tacit knowledge which requires human know-how, intuition, and experience to interpret before the knowledge can be converted into a computer readable format.

Fortunately, an AI technology branch known as Knowledge Representation, specifically ontology, makes it possible to represent a human expert's interpretation of tacit knowledge as explicit knowledge that can be codified and processed by computers. The interest in computer processing of knowledge from Islamic texts such as *Quran* and *Hadith* has motivated quite a number of researchers [37][38][39] to work on the ontology of Islamic knowledge. These works prove that it is possible for computers to process *Shariah* knowledge and provide some kind of recommendations.

The main challenge is to get a human *Shariah* expert who is capable of translating his/her knowledge into computer readable format – which requires said person to be well versed in both *Shariah* and information technology. Unfortunately, there are a very limited number of individuals with this combined skillset. In addition, while some objective tacit knowledge from the primary sources of *Shariah* – such as the *Quran* and *Hadith* can be codified, more subjective aspects such as public interest, customary practice, and the *Maqasid* (objectives of *Shariah*) are extremely challenging to codify into computer language. If these challenges can be overcome, it could create huge opportunities for commercial entities to penetrate this space, as there is currently a very limited supply of Islamic DSS on the market which can be utilized for *Shariah* related decision making – particularly for *fiqh* rulings.

B. The Potentials and Challenges of Decision Support Systems for Islamic Banking and Finance

The general potential and challenges discussed in the previous section are also applicable to Islamic DSS for Islamic banking and finance (IBF). This section shall discuss additional potential and challenges relevant to IBF perspectives.

Digital transformation of financial services has created huge demand for digital solutions in the Islamic financial

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services industry. Digital solutions that are able to expedite *Shariah* decision making processes in Islamic financial institutions (IFIs) are very much needed to facilitate speedier resolutions by the *Shariah* committees of these IFIs. As AI technology is known to have the capability to enable innovations for complex decision making, there are high hopes that AI technology could be leveraged to assist in the *fiqh* ruling process.

A few high-profile stakeholders such as the General Council for Islamic Banks and Islamic Finance Institutions (CIBAFI), and the Islamic Development Bank Institute (IsDBI) have openly shared their optimism about the application of Artificial Intelligence technology to help bring the IBF industry to the next level. In Malaysia, there is a conscious effort to encourage more innovations with AI applications that could assist in *Shariah* decision making processes. This initiative is known as iConnect Fintech in Islamic Finance. One of the problem statements of iConnect Fintech in Islamic Finance is "how might we develop artificial intelligence-based and other innovative tech-based solutions that could help with some level of automation in the *Shariah* review process within Islamic financial solutions" [40]. iConnect is a Malaysian Collaborative Network Platform for Disruptive Innovation programs under the Ministry of Science, Technology, and Innovation (MOSTI) and the Academy of Sciences Malaysia (ASM).

AI enabled systems designed to assist with the *fiqh* ruling process are commonly identified as a *Shariah* Robo Advisors. Professor Dato' Dr. Mohd Azmi Omar, President and CEO at INCEIF, mentioned in his keynote address at the Islamic Fintech Leaders Forum 2021 that "we would like to see globally more *Shariah* Robo Advisory focusing on *Shariah* compliance, *Shariah* decision making, *Shariah* ruling and so on…" [41].

Only limited literature can be found describing how Robo *Shariah* advisors could help in *Shariah* decision-making in the IBF industry. For example, Sa'ad, Alhabshi, Mohd Noor and Hasan are of the opinion that Robo *Shariah* advisors could help to save time and effort in the iterative *Shariah* review process and could facilitate timely and more robust *Shariah* opinions on Islamic products and services. Since these Robo-Advisors are allegedly speedier and more precise in supporting human judgement, this could help the design and delivery of Islamic financial services to be more timely, effective, and efficient [42]. In addition, Fazmi suggests that *Shariah* Robo Advisors can act as "Smart Muftis" to evaluate the sources of *Shariah* and provide recommendations based on past fatwas [30].

According to Sultan, *Shariah* Robo Advisors can help validate basic *Shariah* requirements in Islamic finance products and services, such as ensuring proper offers and acceptance. A few specific examples of how *Shariah* Robo Advisors can help validate basic *Shariah* requirements in Islamic finance products and services include: (i) in sale contracts, the subject matter and price are well defined and not uncertain; (ii) in partnership contracts (*Mudharabah* or *Musharakah*), the PSR (profit-sharing ratio) is valid and therefore any partner does not get eliminated at any time from receiving profits (if there are any). Capital contributions are also well defined to apportion if there is any loss; and (iii) to validate if the product meets specific objectives (*Maqasid*) of *Shariah* [43].

Digitalization in the financial services industry, and the obvious optimism from stakeholders creates a huge potential for DSS for *Shariah* review processes in IBF. *Shariah* Robo Advisors with consolidated collections of *Shariah* rulings of IBF products and services by various authorities globally, could assist *Shariah* committee members to speedily identify relevant pronouncements to the specific case that he/she is working on. Some level of standardization is also possible with a Robo-Advisor's recommendations for the relevant rulings.

However, based on the review in section six above, there are huge gaps in supply. This provides a significant opportunity for those who would like to venture into this space. In order to fill this gap, human capital with skill in *Shariah*, Islamic finance, and information technology are required. The ideal scenario would be to have people with all the three skills – however such individuals are rarities. This opens up opportunities for collaborations between those with relevant skills to develop and commercialize decision support systems as smart assistants for *Shariah* committees of Islamic financial institutions.

V. Conclusion

Global societies are at a stage where a lot of decisions are guided by recommendations from purpose-built computer systems. This includes simple personal decisions such as which routes to take, or which restaurants to go to, as well as more complicated decisions by commercial organizations, such as how much inventory to keep, or what products to sell.

These computer systems are known as a Decision Support Systems (DSS), which are designed to facilitate more precise decision-making by effectively using timely and appropriate data, information, and knowledge management leveraging on artificial intelligence techniques and other applications of information and communication technologies. A DSS can be employed in various knowledge domains – such as medical, dietary, pollution detection, drug reaction, banking and finance, and even for faith matters – such as those related to the religion of Islam.

Mobile Apps that provide halal information are already prevalent to help users to ascertain halal status before deciding to go to a restaurant or to consume a product. There are also various DSS initiatives for more complicated Islamic disciplines – such as *fiqh* rulings, *Hadith* classifications, and *zakat* and *faraid* computations. The most complicated Islamic DSS are those related to *fiqh* rulings. Based on various studies, *fiqh* ruling DSS could only function as a *Mujtahid* assistant, which means the DSS could provide recommendations; however the final decision must be made by a human *Mujtahid*. At best, a *fiqh* ruling or fatwa DSS could provide recommendations for new situations based on some similar past situations that are available in the knowledge repository of the DSS.

Concerning the objectives of this paper, the potential and challenges for DSS for Islamic Banking and Finance (IBF) –

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and particularly those for *Shariah* decision-making aspects, the potential can be summarized as:

- Digital transformations of the financial services industry, including Islamic Banking and Finance, create huge demands for such DSS;
- Technological approaches leveraging sophisticated technology – in particular AI, are available to facilitate *Shariah* decision-making processes;
- Stakeholders in the IBF industry are optimistic about AI's capability to bring the industry to the next level;
- There are already a few commercial and academic initiatives working on DSS for *Shariah* decision-making;
- The benefits of DSS for IBF include convenience, speed, efficiency, and the ability to standardize the rules in the decision-making process.

While the potential is very promising, there are also challenges, which are summarized below:

- The *fiqh* ruling process in *Shariah* decision-making is a very complicated process that requires qualified and experienced Shariah scholars' expertise;
- *Shariah* is a tacit knowledge that requires human expertise to convert the knowledge into a computer-processable format;
- Convert *Shariah* knowledge into computer processable format requires an engineer who is well versed in both *Shariah* and technologies;
- There is a limited supply of DSS in the market that can assist in *Shariah* decision-making.

In summary, the new mindset created by the evolution of Industry 4.0 and the painful Covid-19 has paved the way for promising prospects for digital innovations, including Islamic DSS. With more research applying AI technologies in Islamic-related use cases, the future is bright for more sophisticated Islamic DSS – particularly in Islamic banking and finance. The main challenge remains to get *Shariah* expertise who can transform *Shariah* knowledge into a computable format, which can solve more complex *Shariah* issues, where there is currently a very limited number of individuals who are well versed in both *Shariah* and information technology. This challenge leads to a lack of available market solutions (a large gap in supply) that can be utilized for complex Shariah-related decision-making, especially for the *fiqh* ruling process.

Further research is required to develop commercially viable *Shariah* Robo Advisors for Islamic financial institutions (IFIs). A more coordinated collaboration among academics and IBF industry players with respective *Shariah* and technology backgrounds is crucial to unleash the potential of DSS usage and overcome the associated challenges.

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