An RFID-Based Validation System for Halal Food

Mohd Nasir[1], Azah Norman[1], Shukor Fauzi[2], and Masliyana Azmi[1]

[1]Faculty of Computer Science and Information Technology, University of Malaya, Malaysia

[2]Faculty of Information Technology and Quantitative Sciences, Universiti Teknologi Mara, Malaysia

Abstract: *In recent years, Muslims have depended on the Halal logo, displayed on food packaging, to indicate that the products are prepared according to Halal precepts. As laid out in the Quran, Halal designates that which is lawful and permitted. However, due to the rapid development of advanced technology and the stringent procedures legislated by the Department of Islamic Development in Malaysia, manufacturers may sometimes resort to fabricating a fake logo to attract Muslim consumers. This study is focused on validating Halal status for food products by using radio frequency identification technology to enhance existing methods in Malaysia. A preliminary survey was carried out to evaluate the industry's readiness to implement radio frequency identification technology in Malaysia. A process model and prototype were developed to enhance existing systems. Through this new approach, the authentic Halal logo that is issued by JAKIM can easily be validated, because every stamp that will be embedded into food packages is identified with its own unique identification number. An radio frequency identification reader will be placed in retail venues for consumers to validate their food's Halal status. User evaluation has been conducted to measure satisfaction in terms of usability, efficiency, security, affordability and profitability. Based on the evaluation, all respondents are satisfied with the performance of this new technology and fully support implementing this system globally, as the Malaysian government is now moving towards becoming the world's Halal hub.*

Keywords: *Radio frequency identification, automatic identification, food industry, acceptance, and Malaysia.*

1. Introduction

Consuming Halal products is of great concern to all Muslims. It is written in the Holy Quran that all Muslims are obliged to prepare and consume Halal products [18]. Halal is an Arabic or Quranic word meaning lawful, permitted, or permissible. The opposite of Halal is Haram, which means "unlawful" or "prohibited". Halal and Haram cover aspects of slaughtering, storing, preparation and sanitation for both food and non-food products [24]. In order to help Muslim consumers in Malaysia to validate the Halal status of their purchases, the Department of Islamic Development (JAKIM) has introduced a standard Halal logo. The Department of Islamic DevelopMent (JAKIM) is an Islamic organization based in Malaysia that manages and grants Halal status for manufactured products and food premises.

Securing Halal certification is not an easy process. The authorities must conduct a thorough background check of manufacturers requesting Halal certification. This long process forces local manufacturer to be creative in packaging food products and simply imitating the Halal logo is more economical and adds to a manufacturer's competitive advantage. Halal logo imitations have led to consumer confusion. To avoid uncertainty, some consumers will call the authorities to ask about the validity of a Halal logo. In the worst case scenario, consumers will opt not to purchase a product.

As technology has evolved, the number of mobile applications has increased. JAKIM has introduced a new method for validating Halal status via Short Messaging Service (SMS), termed "SMS Halal JAKIM". Using this system, consumers may send the barcode number to JAKIM to check the status via SMS, and receive a reply via SMS as to the status of that particular product. JAKIM also has introduced a web portal that provides Muslim consumers with Halal information [12, 19, 20, 21]. Through this portal, consumers may validate the Halal status of specific products and also highlight complaints and offer feedback to the proper authority. Additionally, this portal offers a service for manufacturers and retailers to apply for Halal status online. Our study aims to help Muslim consumers confirm the Halal status of food products using Radio Frequency IDentification (RFID) technology. The current approach requires consumers to know the SMS number and to have time to wait for a reply. This has been our main motivation in researching and improving current approaches: to address the drawbacks associated with the current method.

This study is also an extension of previous research by Norman *et al.* [19, 20, 21]. Our paper is organized as follows: section two offers an overview of related work on existing Halal validation systems. Section Three reviews the technical details of an RFID Halal

Validation System. Section Four discusses the proposed approach and prototype developed for this project. Section Five demonstrates the analysis of the users' evaluation results. Future research avenues are discussed in the final section.

2. Related Work

Automated identification procedures have impacted many service industries in areas such as logistics, manufacturing and supply chain management [14, 15, 25]. Automatic identification technologies exist to provide information about people, animals and products. Automatic identification using barcode labels has triggered a revolution in identification systems in the past few years. However, a study by [6] suggested that the barcode has many limitations. Unlike barcodes, RFID is far more efficient and practical and has been widely used in various areas, such as aviation [4, 22, 28], animal detection [1], fabric and clothing, libraries [5, 14], healthcare [7, 12, 26] and food safety [25]. A simple RFID system consists of three main elements: the RFID tag (or transponder), the RFID reader (or interrogator) and associated middleware. An RFID tag consists of an antenna and integrated circuit with memory that is used to store and process information and also to modulate and demodulate radio frequency signals; the antenna is used to receive and transmit signals [6, 17].

According to the IDC's forecast, Malaysia's RFID market is expected to reach one million units by 2010, with a compound annual growth rate of 45.84%. A study by [10] showed that RFID has been used in several areas of Malaysia for transportation, identity verification and validation, payment and ticketing. In 1998, Kuala Lumpur International Airport deployed the Malaysian ePassport auto-gate system that requires Malaysian travellers to place their passport in the auto-gate slot, which verifies fingerprints with a biometric scanner. This system is intended to identify any criminal suspects who try to enter Malaysia. In December 2006, the Malaysian Road Transport Department initiated the usage of RFID registration plates that contain information about the owner and the vehicle, in an attempt to reduce the number of automobile thefts in the country. Using this technology, the police will immediately know if the car has been stolen.

Several issues faced by Muslim consumers in Malaysia were highlighted in a previous study conducted by [19, 20, 21]. It is important for authorities and manufacturers to provide correct information, since consumers depend primarily on product packaging, including the Halal logo, ingredients and manufacturers in order to validate Halal status. However, researchers found that 66% of all consumers had questions about Halal logos displayed on food packaging, as many are bogus. Ninety-two percent of surveyed consumers

urged the authorities to provide an alternative validating system that uses real time methods. According to this study, only 26% of the respondents opted for RFID, but SMS and barcodes were seen as desirable by 48% and 22% of respondents, respectively. As concluded in that study, this response may have been due to the maturity of barcodes, SMS and MMS - and the lack of penetration of new technology such as RFID. Sixty-eight percent of the respondents also strongly agreed that validating Halal status using RFID should be implemented, as this would help to reduce the number of counterfeits and help Muslim consumers to easily validate genuine Halal status, as well as helping Malaysia to become the world's Halal hub. Given the results of this study, we decided to develop a prototype.

Five attributes were identified as qualifying benchmarks: namely usability, efficiency, security, affordability and commercial viability. It is difficult to compare established and mature identification technologies especially barcodes to emerging ones like RFID. One has had extensive testing in a commercial environment and the other has had limited commercial exposure in Malaysia. Table 1 compares the existing systems based on the above attributes.

Table 1. Comparison of existing systems based on identified attributes.

	Barcode	Portal	SMS	MMS	RFID
Usability	★★★★	★★★	★★★	★★	★★★★★
Efficiency	★★★★	★★★★	★★★	★★	★★★★★
Affordability	★★★★	★★★★	★★★	★★	★★★★★
Security	★★★	★★★★	★★★	★★★	★★★★★
Profitability	★★★★★	★★★★	★★★	★★★	★★★★★
Total	21	19	15	12	25

2.1. Usability

Research done by [14, 20] proved that ease of use is a significant factor in the success of barcode technology

and RFID. Automated technologies have brought companies like Procter & Gamble double digit productivity gains, as the data collected can easily be distributed throughout an enterprise with the use of advanced management systems. Since the concept of the barcode is similar to RFID, neither identification method requires users to go through many steps to validate the status of an article. In fact, status can be validated in a few seconds. As for SMS and MMS, the component steps may be as quick as for RFID and barcodes, but it takes time for the system to receive the request, to process it and to deliver the results, especially during peak hours when the networks are congested.

2.2. Efficiency

Based on the above evaluation, RFID has been found to be the most efficient technology to validate Halal status on products, as it is uniquely capable of reading multiple tags at one time [14]. This can reduce processing time for consumers, as well as reducing human errors, since products are not scanned by hand [14]. Another factor that contributes to RFID efficiency is that an RFID reader can read tags without requiring a clear line of sight. As stated by [14], in order to retrieve information printed on barcode labels, the labels must be clearly visible to the reader and in good condition, as the labels are fragile. A similar study conducted by [23] showed that barcodes are easily damaged by abrasion and harsh environments and must not be exposed to extreme temperatures. Barcode reader must be clean in order to achieve effective scan rates; harsh environments such as fog, dirt and rain can be key factors in barcode failures. Other technologies also have limitations; to validate product status using MMS, users must have a mobile phone that is equipped with a camera of at least one megapixel resolution [11]. Additionally, the image of the barcode must be captured properly in order to be recognized and processed by the reader. Distorted pictures cannot be processed and users have to recapture the barcode image and repeat the MMS process. As for SMS, given a situation where users are in a rush to decide whether to buy a product, a 13-digit number has to be entered to validate Halal status. This scenario may involve typographical errors, as the numbers are too long and sometimes too small. Separately, another key factor in RFID efficiency is that it can read tags using a wide radio frequency range. Thus, RFID tags can be easily read from a shopping trolley full of products.

2.3. Security

Falsifications of logos and certificates are the biggest issues faced by the Halal industry and Muslim consumers in Malaysia. For that reason, other identification methods, such as web portals and SMS

applications, have been introduced by the authorities to overcome this problem. Additionally, there is ongoing research [11] into MMS as a possible alternative. While these services and applications enhance the mobile computing experience, they also introduce serious security concerns. The number of illicit applications that have been distributed to users is already high; the poor usability of current web security technology invites exploitation as well. This unlawful activity is also known as phishing, where criminally fraudulent individuals aim to acquire sensitive information. Unlike barcodes, RFID offers better security, as each item is registered before distribution with Unique IDentification (UID) number by respective RFID manufacturers, and the UIDs are maintained by the manufacturers to ensure authenticity in each product that is embedded with an RFID tag. This also reduces the possibility of counterfeiting [14].

2.4. Affordability

RFID may offer the best security of all the identification methods available. However, most implementers would prefer other identification technologies, as the price of RFID is quite high. As the two core components used to produce barcodes are ink and paper, they will remain relatively inexpensive. SMS and MMS, on the other hand, require users to have a mobile phone to validate product status. In addition, users will be charged for requesting needed information. However, according to [9], a projection for the next ten years shows that the average tag price, including passive and active tags of all shapes and sizes, is expected to reach 8 cents each. With this new projection, the price of RFID will be cheaper and more affordable for retailers. Thus, the cost of assisting and educating their consumer base would be low, while increasing business productivity.

2.5. Commercial Viability

RFID has been shown to bring huge profits to companies that deploy the technology. According to [14], RFID has helped retailers to reduce inventory, because products will be monitored using computer systems and tag readers. Also, as quoted by [14] mentions that asset utilization is improved because limited product inventory is stored, increasing the revenue of the company. Unlike barcodes, reprogrammable tags are a huge advantage for retailers as there is less paper waste involved even though product information might change regularly. In contrast, SMS and MMS require users to spend some amount of money to validate product status.

3. Research Methodology

Our research methodology involved preliminary review, analysis, design, prototyping, evaluation and testing. This research took eighteen months, starting in August 2007 and finishing in February 2009.

During the preliminary review phase, existing systems and approaches in Halal validating systems were reviewed. In addition, electronic documents from several electronic databases such as ISI, SCOPUS and ACM were also studied to gain an in-depth understanding of Halal concepts, as well as of automatic identification technologies such as barcode technology, biometrics, smart cards and RFID.

During the analysis phase, a comparative analysis among existing systems and approaches was performed to identify respective strengths and weaknesses. Based on the analysis and reviews, data collection was performed to identify problems faced by users and the solutions provided by authorities in validating Halal status for food products in Malaysia. In addition, opinions on RFID technology for Halal tracking were also reviewed at this stage: 250 questionnaires were distributed to respondents in supermarkets in the Klang Valley area.

A process model as shown in Figure 1 was developed in the next phase. Based on the preliminary data collection results, a prototype was developed using Visual Basic, Visual Studio.Net 2005 and Microsoft SQL Server 2005. Physically, the system consists of the RFID tag reader, an information system and a RFID passive tag to represent the Halal identification tag. Among the modules that were developed for the system are the tag writer module and the tag reader module that connects to a database containing information about the Halal certification of food products. This prototype covered several key aspects such as efficiency, security, usability, affordability and practicality. The prototype used a database identical to the Islamic authority's database (i.e., JAKIM). System tests were conducted after implementation to ensure that the prototype had met the requirements from the preliminary stage. The testing was based on products listed by JAKIM.

The prototype was evaluated by 173 respondents in supermarkets in the Klang Valley area. All respondents were briefed and guided by the researchers during this session. The respondents were also given opportunities to explore the system themselves before answering the survey questions. The evaluation was performed to identify users' satisfaction with the prototype, as well as to ensure that the prototype had met all necessary requirements.

4. Overview of Proposed Framework

As illustrated in Figure 1, this application requires that users have packages that are embedded with RFID tags and an RFID reader to read information from the tags.

The entities involved are Islamic authorities, food manufacturers, retailers and consumers. As this project involves a huge number of products, passive tags are used to store product information, as these are cheaper than active tags. For security purposes, each tag is registered with a unique identification number by its respective RFID manufacturer. These unique identification numbers will be mapped to corresponding product information in the JAKIM Halal database. Registered tags will be distributed to the food manufacturers once products are certified for Halal status. Tags store nothing other than their unique ID's. Food manufacturers will embed the tags in the packages before they send their products to retail stores. RFID readers will be placed in the store. When the users place any products with embedded tags within frequency range, the reader will read the tags. Middleware acts as a connecting layer to manage and process the flow of data coming from one or more tag reader devices and send it to the application layer. In addition, the system performs filtering, aggregation, and checking of data, to reduce the volume of information prior to sending it to the retailer's enterprise applications, or the supply chain management system. The system will look up the requested identification number in the database. Alternatively, authorities could perform regular checks using a PDA (Personal Digital Assistant) that has the RFID reader application installed.
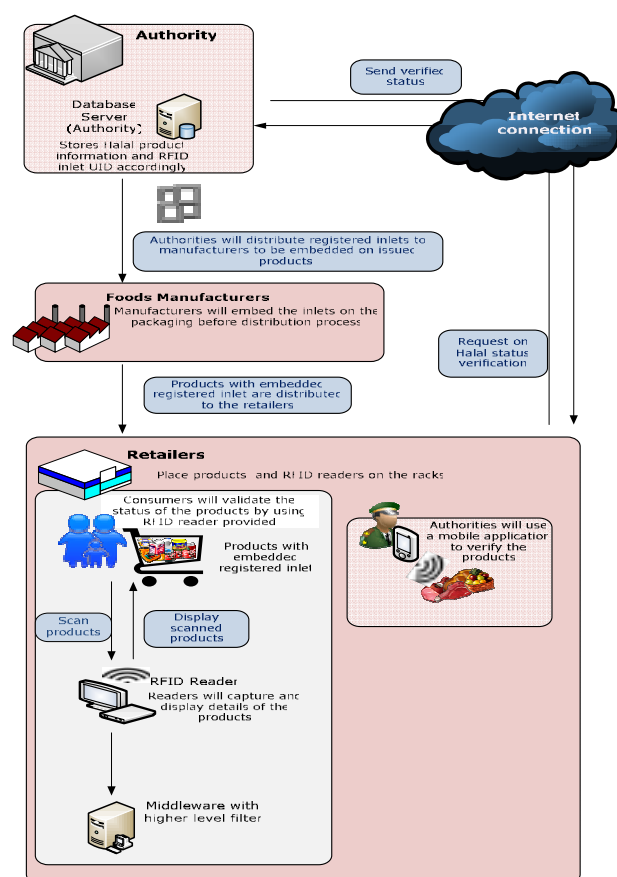

Figure 1. Process model of a Halal validating system.

5. Findings

Table 2 presents the users' evaluation results with respect to the system attributes namely usability, efficiency, security, affordability and commercial viability. The following sub-section will discuss in details about the result gained.

5.1. Usability

Scores for this attribute proved that this application is usable. About 92% of the respondents agreed that this application provides sufficient information to consumers and 97% agreed that this system helps consumers making decisions during the purchasing process. The results also showed that finding the required information was easy and convenient, even though some respondents were new to RFID.

Existing approaches such as web portal and SMS barcode may provide the same information, but it is impractical for retail stores or in urgent situations. The mean scores above also indicate that all implementers, such as authorities, retailers and manufactures, strongly agreed that this application will help them to transmit the latest information to their consumers. Implementers also reported that, by using the UID in this application, consumers can retrieve the latest information effortlessly, since details for each product will be synchronized and updated regularly. However, there are several important points that need to be considered, such as whether this application would be more beneficial if information on imported products were also included. Respondents argued that RFID technology should be embedded inside mobile phones for mobile applications, so that the application could be used more widely, instead of limiting it to retail stores alone.

5.2. Efficiency

Since many complaints have been received from consumers regarding the performance of existing methods provided by JAKIM, efficiency became one of the main criteria that we evaluated. During the evaluation period, users were given a chance to compare response times for both existing and RFID systems. RFID was found to be the quickest information delivery modality. It took only seconds to retrieve the information required using RFID and, on average, about fifteen minutes for SMS. This proved that RFID provides information more quickly than other existing approaches. According to the respondents, existing systems such as barcode and SMS, sometimes fail to return any information to consumers, thus causing frustration and hesitancy. Ninety-nine percent of the respondents strongly agreed that our application should be a new alternative in validating Halal status for all consumers.

Table 2. Users' evaluation results based on system attributes.

Attributes	Mean Scores	Std. Deviation
Usability		
a. Helps implementers easily provide consumers with the latest information	5.00	0.000
b. Provides sufficient information to consumers	4.60	0.400
c. Status can be validated using a few simple steps	4.79	0.209
Efficiency		
a. Consumers do not have to wait very long for the information	4.98	0.012
Security		
a. Helps to identify fake Halal logos	4.63	0.370
b. Helps the authorities to gain consumers' trust	4.77	0.225
Affordability		
a. Implementers should bear all the cost of implementation in order to educate consumers about their products	4.13	0.896
b. Consumers should not have to spend anything to validate product status	3.10	2.900
Commercial viability		
a. This system should be implemented widely in Malaysia	4.88	0.124
b. This system could boost business productivity and generate more revenue for implementers	4.01	0.985
c. This system could help Malaysia to become the world's Halal hub	5.00	0.000

5.3. Security

In a survey conducted by [5], it is reported that the advancement of technology has contributed to the production of fake *Halal* logos. The survey also reported that this issue leaves the impression that the Islamic authorities are corrupt and willing to grant *Halal* status to unqualified manufacturers. Based on our evaluation, 92% of the respondents believed that RFID could help to reduce the number of fake Halal logos. By using static and invisible UID's, RFID is impossible to duplicate or reproduce, unlike barcodes or any other existing methods. Ninety-five percent of officials strongly agreed that this system might help them to gain the trust of consumers and other authorities from all over the world.

5.4. Affordability

The result above shows that only 72% of our respondents agreed that consumers should not have to spend anything to validate Halal status. Respondents sometimes find existing methods frustrating, as they have to spend money to validate product status. Additionally, by using this application, respondents noted that consumers do not have to have an internet connection to validate product status. On the other hand, a further 18% of respondents said that it is unfair for the implementers to bear all the costs of implementation. Indeed, implementers remain reluctant, due to the high price of RFID readers and

tags, as well as the changes that would have to be made for them to deploy this technology.

5.5. Commercial Viability

Establishing Malaysia as a global Halal hub has been the aim of the government for many years. All respondents strongly believed that this system could contribute to the development of Malaysia as the world's Halal hub.

6. Discussion

In the Malaysian Halal industry, RFID technology is considered immature since barcodes are often used as automatic identifiers despite the existence of web portals and mobile phone applications. "Sistem Maklumat Halal," or the Halal Information System, is a directory managed by JAKIM that provides information on Halal products. Consumers may retrieve significant information, such as which products have been granted Halal status, the manufacturers, Halal status validity and the authorities who manage inquiries. However, in order to use this application, consumers must have an internet connection to access the information, thus making this process impractical. No retail stores in Malaysia provide computers with Internet connections for their customers to use to validate products. This scenario could lead to unsold products in the market.

The emergence of mobile applications such as SMS has helped JAKIM to overcome some challenges. "SMS Halal JAKIM" is an application that helps Muslim consumers in Malaysia to validate Halal status on food products by sending text messages to JAKIM. Consumers have to type in 13-digit barcode numbers in order to validate product status. However, texting long numbers to the JAKIM server is time consuming and tiring [6]. Typographical errors may occur, as the numbers are long. One simple mistake can produce poor results. In addition, this SMS application also requires users to have a mobile phone and enough of a credit balance on the phone to send a text message.

A study by [6] offers a new solution for validating product status using MMS (Multimedia Messaging Service). Through this system, consumers do not have to type in 13-digit barcodes; instead, they use mobile phone cameras to capture the image of the barcode. This captured image is then sent to JAKIM for validation. The barcode image must be captured using, at minimum, a one-megapixel camera, as lower resolutions will produce images that cannot be recognized by the JAKIM server. Regrettably, this system will cost consumers more money, as the cost of sending MMS images is higher than sending SMS. According to mobile service providers in Malaysia, such as [3, 13], consumers are often charged 4 cents per SMS and USD0.07 (MYR0.30) to USD0.14 (MYR0.70) cents per MMS. However, consumers are charged USD0.10 (MYR0.35) cents per SMS to use SMS Halal JAKIM to validate Halal status. Therefore, it is predicted that the price for Halal JAKIM MMS would be USD 0.20 per message.

To overcome these problems, a Halal RF Validator is being developed with the intention of helping Muslims validate the Halal status of food products in the most convenient way possible. Through this system, Halal status may be determined in a few seconds and without cost. Most importantly, with the use of unique identification numbers, this application could help to reduce the number of imitation Halal logos. UID's could also synchronize with changes made on the authority's server, thus providing consumers with the latest data.

7. Conclusions and Future Work

In Malaysia's Halal industry, web portals and mobile applications are often the best options for delivering information to consumers to validate Halal status. Regular checks are also carried out by the authorities to ensure that the products are safe. However, the development of illicit applications and techniques by unscrupulous people, such as faking logos and certifications, phishing, etc., has led to confusion and hesitation on the part of consumers. These activities have affected the economy of the Halal industry and the level of respect accorded to the authorities. For this reason, RFID has been suggested to be the best validation system in the Halal industry. Implementation of RFID technology in Malaysia is still too costly. With the ability to safeguard the most vulnerable data, RFID has become the most secure technology for this industry. In addition, its ability to store more data than barcodes and to read multiple tags at once has made it the most usable system in the Halal industry. Thus, we believe RFID should help to increase revenues for the Halal industries in Malaysia.

There are numerous opportunities for research on RFID-based system in addition to the investigations presented in this study. Since the cost of implementation is the main barrier at present, this study may also serve as motivation for RFID researchers and other developers to develop RFID technology that offers a better operating range at a lower price, such that RFID could be more broadly implemented. As for the Halal industry, this research may serve as a benchmark for assisting consumers in validating Halal certificates that are displayed in retail premises. Imported products may also use this application to help consumers validate Halal status and confirm their origin. Other than that, there is a great opportunity for mobile phone manufacturer such as Nokia, Sony Ericsson, Samsung and etc to embed an RFID reader in their manufactured mobile phones, so that the Halal status on food products can easily be validated by using this system. The mobile phones

with SMS or GPRS capability will send the captured unique identification numbers to the JAKIM to check the status, and receive a reply via SMS or GPRS as to the status of that particular product.

In conclusion, this study was beneficial for all entities involved. Our study may help the authorities to win back the trust of Halal practitioners and consumers. Muslim consumers may find our work useful. Most importantly, this study could be valuable for Malaysia as it works to become the world's Halal hub.

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Mohd Nasir received his Bachelor of computer science (Hons.) specializing in software engineering and Masters of computer science from University of Malaya in 2003 and 2005, respectively. He is currently serving as a lecturer in the Department of Software Engineering, Faculty of Computer Science and Information Technology, University of Malaya. His area of specialization includes software process, software process improvement, radio frequency identification, object-oriented design and development, accessibility & computing. He is also a member of IEEE computer society and association for computing machinery, technical council of software engineering, technical committee on internet and technical committee on electronic commerce. As an active researcher, he has run several research projects and produced significant research output. He has published more than 50 scientific publications and won several medal at national and international exhibition.

Azah Norman is a lecturer in the Faculty of Computer Science and Information Technology, University of Malaya, Malaysia. Her research focuses on information system security and e-commerce. Before joining the academic world, she has worked as a consultant in a Malaysian premier security company which is the subsidiaries to the Malaysia leading company that directs and oversees Malaysia's national information & communication technology initiative for more than three years. She has won several research medals for her research in Halal RFID verification and she is currently pursuing her PhD in information systems security management.

Shukor Fauzi is a lecturer from Faculty of Information Technology & Quantitative Sciences, Universiti Teknologi MARA Perlis Campus. He obtained his Master of computer science (real time software engineering) from Universiti Teknologi Malaysia. He also is a BSc (Hons) information systems engineering and Diploma in computer science. Before he joins the academic world, he was a systems engineer at one of the global financial solution company. In that company, he has been assigned to CMMI/ISO Process Department. His research interest are in software quality which focus on software process improvement, software process assessment, software engineering, software configuration management, software project management and also software testing. He has published several papers in International and National conference. In professional activity, he has involved in technical committee software engineering for standard and industrial research institute of Malaysia. Besides, he also is a member of software process improvement network MSC Malaysia and a member of Malaysia Software Engineering Interest Group.

Masliyana Azmi is a researcher in the Faculty of Computer Science and Information Technology, Malaya, Malaysia. She obtained her Bachelor of information technology from University of Malaya in 2007. She has won several research medals for her research in Halal RFID verification.