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ORIGINAL ARTICLE

A Systematic Mapping on Android-based Platform for Smart Inventory System

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ABSTRACT – Inventory tracking is one of the most crucial aspects in business strategy. Effective inventory system can help the prevention of stockouts, effective management of different locations, as well as the maintenance of accurate records in a business. Nowadays, digitalization is a critical component of business operations. Digitalization is the process of implementing new digital technology into all aspects of a company's operations, resulting in a significant change in how the business operates. A systematic mapping has been performed on Android-based for smart inventory system by using digitalized technology which is barcoding technology. The mapping are done by conducting systematic mapping process for analyzing related research areas on barcode and inventory system. Two research questions and related keywords are initiated for identifying possible operating system platforms in developing a smart inventory system with barcoding technology for tracking product items.

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INTRODUCTION

The business world is changing its demand and supply for customers' satisfaction. In managing daily operation, the company needs to control its inventory based on customers' demand [1]. An inventory management is a method for increasing stock levels by managing finished goods, work-in-progress, support operations, and to control wastage [2]. Inventory management is also known as a continuous and planned operation that attempts to manage goods and materials according to the needs of the organisation, ensure adequate supply, balance supply and demand, and avoid overstocking [3].

The success of a company's future is determined by the inventory as well as the company's objectives. To ensure the smooth traffic of goods, the supply of goods must be properly managed. Inventory management is fraught withsome problems such as cost of capital, storage, charges, insurance, and losses, while also aspects that lean toward keepinga high inventory, such as the cost of ordering, transportation, the elimination of unnecessary setups, and better use of labour resources [4]. There is a possibility of producing a smart inventory management system to allow suitable decision-making regarding stocks and hence improve efficiency in stock control.

To support the technology-driven smart inventory technology, the authors need to investigate the requirements for operating systems for preparing the smart inventory tracking product. This paper conducts a systematic mapping on an Android-based platform for smart inventory systems. Two research questions related to the study have beenhighlighted to produce a systematic mapping result. The first research question helps the researchers to narrow down topic or issue to be searched for. The first question is, **'What are the differences between Android and IOS operating system?'** and the second research question is **'What are types of barcode technology?'**. The structure of the paper also illustrates related works regarding inventory technology and barcode technology. The following paper structure elaborates methodology, systematic mapping result and conclusion.

RELATED WORK

Inventory Technology

Inventory is important to a company's operational needs since it is one of the essential components required in the conversion of inputs into desired products and services, which contributes to the trade-off of goods and services between the business owner and the customer. Inventory management is a method for increasing stock levels by managing finished goods, work-in-progress, support operations, and raw materials [5]. According to Sharma *et. al*[3], inventory management is a continuous and planned operation that attempts to manage goods and materials according to the needs of the organisation, ensure adequate supply, balance supply and demand, and avoid overstocking.

Inventory systems are a critical technology for all businesses. The success of a company's future is determined by the inventory it has and the achievements of the company's objectives. There are three types of inventory in a products inventory which are raw materials, semi-finished goods, and finished goods [6]. Inventory management is crucial to a business's performance and should be included in its entire strategy [7]. If a business's inventory transaction process is not effectively computerised, both in terms of documenting incoming and outgoing goods and searching for goods data,

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it can result in a lack of effectiveness and efficiency in business performance, especially when it comes to delivering inventory information. As a result, many businesses choose automation over manual inventory management when it comes to running a successful inventory management. The development of an inventory information system will improve a business' productivity by making it easier for businesses to find and monitor inventory data, as well as generate inventory reports at any time[8].

Digitalization for Small and Medium Enterprises (SMEs)

Recently, all business activities tended to follow digital trends that can make information accessible for all activities. The transformation of systems and processes in small and medium-sized enterprises into digital ones has been a key goal of global business in recent years [9]. Generally, digitalization refers to the integration of new digital technology into all aspects of a company's operations, resulting in a significant shift in how the company operates [10] whereas mobile tools and applications, social media, the Internet of Things (IoT), analytics tools and applications, networking and data sharing networks, and collaboration applications all play a key role in digital transformation[11].

A business may undertake digital transformation for a variety of reasons. The most likely reason is that they have a survival issue. The ability of a business to quickly react to supply chain interruptions, time to market challenges, and rapidly changing customer expectations is very important especially during a pandemic. A business's productivity, profitability, and sales revenues are all affected by digitalization. The basic goal of digital transformation is to reinvent small and medium enterprises (SMEs) using digital technology, gaining competitive advantages by increasing productivity, lowering costs, and assisting in innovation. Digitalization and the effective use of information and communication technology are essential factors of successful innovation, competitiveness, and growth, and they provide SME's a few opportunities to increase their business position. SME's can also benefit from digital transformation by being able to innovate and grow. SME's must constantly innovate and raise their level of digitalization.This will initially increase costs, but they will progressively reduce and contribute to higher profits [9].

METHODOLOGY

This section elaborates systematic mapping process [12] for Android-based platform that is used in smart inventory system. The related papers are gathered based on some criteria of keywords during the search process. In acquiring data and assessing the quality of the reviews, the searching process is initiated by identifying two research questions (RQ) which consists of:-

RQ 1: What are the differences between Android and IOS operating systems?
RQ 2: What are types of barcode technology?

The first research question, RQ 1, helps the authors to narrow down topic or issue that needs to be searched for. The second research question is also taken from the original study. This research questions are initiated according to keywords namely ‘Android’, ‘IOS’, ‘difference’, ‘comparison’, ‘inventory’ ‘barcoding technology’, ‘barcode’ and ‘inventory’. The search process involved IEEE online database and the search took place between 2014 to 2022.

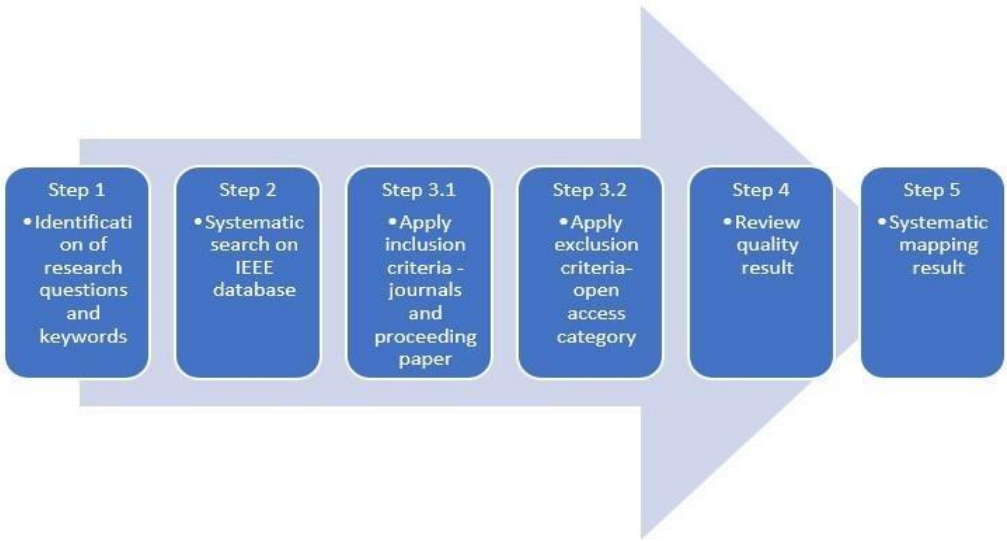

Figure 1. Systematic Mapping Process

The inclusion criteria imposed for the systematic mapping is the journals are open access journals in IEEE online database while the exclusion criteria are conferences, early access, standards, magazines courses books category. Next

section elaborates systematic mapping result for smart inventory system by using Android-based platform.

SYSTEMATIC MAPPING RESULTS

Number of Articles with Keywords and Inclusion and Exclusion Criteria

Table 1 depicts the number of articles found based on RQ 1 and RQ 2 and also after inclusion and exclusion criteria has been applied into the searching process. The searching process is done in IEEE online database only for systematic mapping purposes.

Table 1. Number of articles based on RQ 1, RQ 2, keywords, inclusion and exclusion criteria

Research Question	Keywords	Total articles found	Inclusion criteria – open access journals in IEEE Exclusion criteria- conferences, early access, standards, magazines courses books category
RQ 1: What are the differences between Android and IOS operating system?	'IOS' AND 'Android' AND 'difference' OR 'comparison' AND 'inventory'	761	9
RQ 2: What are types of barcode technology?	'barcode technology' OR 'barcode' AND 'inventory'	794	17

Mobile Operating Systems: Android

The Android, which means "robot" in English, is a mobile operating system based on a modified Linux kernel. In November 2007, the Android operating system was published by the Open Handset Alliance, which was led by Google. It enables developers to build managed Java code that controls the device with Google-developed Java libraries [13]. Android is primarily operating for mobile devices. Android has the largest installed base among mobile operating systems in 2015. Furthermore, Android provides a custom-built virtual machine called Dalvik, which is programmed by a Linux kernel and has APIs written in C [14]. From 2008 to the present, Android has undergone numerous upgrades that have continuously improved the operating system by introducing new features and correcting errors in previous versions. In alphabetical order, each new edition is named after a dessert. For example, 1.5 cupcakes, 1.6 donuts, Eclair 2.0, Froyo 2.2, Gingerbread 2.3, Honeycomb 3.0, Ice Cream Sandwich 4.0, Jelly Bean 4.1, KitKat 4.4, Lollipop 5.0, Marshmallow 6.0, Nougat 7.0 and the latest Oreo 8.0 version.

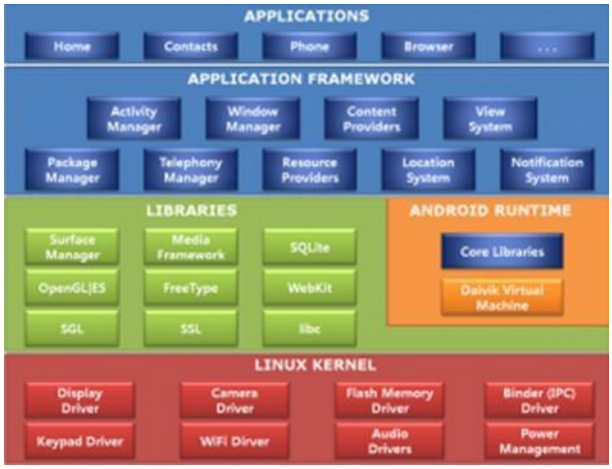

Figure 2. Android Architecture [15]

Mobile Operating Systems: IOS

Apple Inc. developed and sold the iOS mobile operating system [16]. Apple Inc. released iOS in June 2007, and it is onlycompatible with Apple hardware. IOS is a UNIX-based operating system designed for Apple's iPhone, iPod touch, and iPad smartphone and tablet devices. Cocoa-touch, media, core services, and core OS are the four layers of IOS. This structure architecture demonstrates that level of complexity, with higher-level layers being more abstracted and a stronger connection between the lower and hardware layers [17].

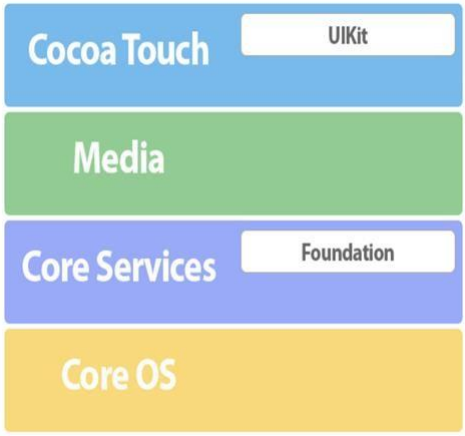

Figure 3. iOS Architecture [18]

Comparison between Android and IOS

During the technical feasibility, the authors have produced a comparison between Android and IOS. The comparison is done to ensure whether the most suitable operating system is selected for developing mobile-based smart inventory system. Table 2 depicts issues on software architecture, application development and developer support on Android and IOS.

Table 2. Types of issues on Android and IOS

Issues	IOS	Android
Software architecture		
Development language	Objective-C	Java
Packaging	A distribution provisioning file is included in the Apple application package (IPA).	Android package (APK) file
Database and persistent storage support	Support for local SQL databases and local file access	Support for local SQL databases and file access
Application development		
Debugger availability	Very Good	Excellent
Deployment speed (packaging, installing, testing)	Fast	Relatively fast
Size of the deployment application by default	Medium	Large
Developer support		
Support and community for developers	Very large	Very large
Penetration of market	Very large	Very large
Availability of an integrated development environment (IDE)	Excellent support through Apple Xcode and Jetbrains Appcode	Excellent support by all major IDE's
Tools cost of development	Free for emulator Small fee is charged for device and App Store	Free Small fee is charged for Android Play

Comparison between Android and IOS

This paper reports the first attempt to enhance the exploration capability of SKF by applying COOBL technique. In addition, jumping rate is also integrated in the proposed method. Once the jumping rate condition is met, the opposite solution.

Barcode Technology

In different domains of application, barcode technology is employed to automate operations. The goal of it is to employ a scanner to scan the import and export of goods with barcodes to achieve maximum efficiency, effectiveness, and profit. The technology consists of a barcode and a barcode reader which is also known as the scanner.A barcode is a printed machine-readable data symbol that provides information about an item to aid in its identification and tracking. Modern inventory management software is more streamlined, less difficult, has a web interface, and allows to control inventory using smartphone [19].

Barcode systems require a particular barcode reader, which is more complicated and expensive than a standard barcode reader. A barcode reader is an electrical device that reads barcodes written on products or other labels to identify them. Itis a tool for extracting optical data from barcodes [20]. In recent years, any smartphone can be used to read barcodes. In most cases, a smart phone can only read ID barcodes and QR codes. The ID barcode read rates for both complete and damaged barcodes were 100%. At 30 and 50 photos per minute, 92.5 percent and 85 percent of QR codes were readable. As a result, the smartphone can be used as a barcode reader. In the case of QR codes, the reading rate is low. However, there are other benefits to using a smart phone as a barcode scanner, including cost, versatility, and ease of use and reinstallation [21]. Table 3 illustrates 1D and 2D barcode definitions from various articles.

Table 3. 1D and 2D barcode definitions from various articles

One-Dimensional (1D) Barcode	References
A series of lines is used to represent 1D barcode normally product packaging	[22]
A 1D barcode can only store alphanumeric data. If more data needs to be saved; the barcode's length should be increased	[23]
The computer scans the binary codes once the information is extracted into binary form, and the decoded information or data is presented on thecomputer screen	[24]
The QR code is one of the most famous and well-known 2D barcodes. They are commonly used in apps, creative ads, and to deliver links and others	[22]
Type of 1D barcode are Code 39m Code 128, Interleaved2 to 5, Universal Product Code (UPC) and International Article Number (EAN)	[24]
Two-Dimensional (2D) Barcode	
QR codes also have a high level of fault tolerance, allowing users to decode data even if a portion of the code is damaged.	[25]
Types of 2D barcode are PDF417 Data Matrix QuickResponse (QR) Codes	[24]

CONCLUSION

This paper reports a review for investigating Android-based platform for developing smart inventory system.The systematic extraction result reveals that digitalization in inventory system is important to contribute to efficient product tracking. Hence, 1D barcode and 2D barcode technology can help to resolve the issue of item tracking and it will be able to produce real-time updates for the organization.

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