An E-Commerce Control Unit for Addressing Online Transactions in Developing Countries: Saudi Arabia–Case Study

OMAR SAEED AL-MUSHAYT^{ID1}**, WAJEB GHARIBI**^{ID2}**, AND NASRULLAH ARMI**^{ID3}

[1] Department of MIS, Business College, King Khalid University, Abha 62529, Saudi Arabia
[2] Department of Computer Science and Electrical Engineering, University of Missouri-Kansas City, Kansas City, MO 64110, USA
[3] National Research and Innovation Agency, Jakarta 10340, Indonesia

Corresponding author: Wajeb Gharibi (gharibiw@umkc.edu)

ABSTRACT Online transactions play an increasingly important role in our daily lives. Recently, online shopping has dramatically expanded not only in small and medium enterprises, but also among individual internet users who use social media as online trading platforms. While there are several online-shopping platforms in Saudi Arabia, they are still facing critical obstacles that challenge customers, businessmen, and organizations. This paper presents a smart control unit that could help address current challenges facing e-commerce and suggest recent government legislation dedicated to governing and simplifying online transactions to make them more reliable, faster, secure, and competitive.

INDEX TERMS E-commerce, challenging, perspectives.

I. INTRODUCTION

E-commerce, online transactions, is considered one of the major economic forces driving worldwide growth in general and particularly in Saudi Arabia. The exponential growth of internet use and online purchases globally, combined with the relatively low cost of internet marketing, has enabled new online shopping platforms to operate without governmental management. In addition, the lack of legislation that governs online transactions has allowed many fishing websites, vulnerabilities, and untrustworthy platforms that operate, deceit, and cheat many customers. E-Commerce has several types including business-to-consumer (B2C), business-to-business (B2B), government-to-consumer (G2C), government-to-business (G2B), and recently consumer–to-consumer (C2C). G2C and G2B, or e-government, focus on delivering citizen-centric services via the internet such as filing income tax returns, renewing automobile registrations, requesting a passport, and voting on proposed regulations that could affect their lives. For statistical purposes, the U.S. Census Bureau Department of Commerce announced that the retail e-commerce sales for the third quarter of 2021 totaled $204.6 billion.

The associate editor coordinating the review of this manuscript and approving it for publication was Mohamed Elhoseny^{ID}.
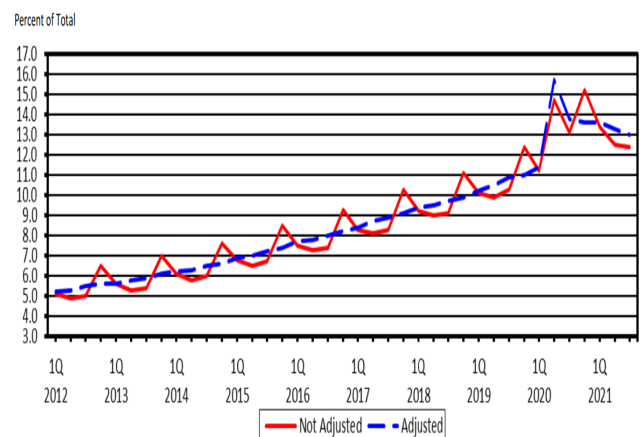

FIGURE 1. The estimated quarterly percentage of U.S. retail e-commerce sales: 1st Quarter 2012 – 3rd Quarter 2021.

Figure 1 shows the increasing percentage of e-commerce quarterly in the last 10 years in the USA [1].

Globally, the size of e-commerce retail sales has been exponentially growing. In 2020, retail e-commerce sales worldwide amounted to 4.28 trillion US dollars and e-retail revenues are projected to grow to 5.4 trillion US dollars in 2022 [2]. Similarly, Saudi Arabia is making affordable rapid

progress toward its 2030 vision with its growing e-commerce market in the recent years driven by e-commerce sales of electronics, appliances, apparel, and cosmetics which has been increased about 30 percent on an annual average and are expected to reach more than 60 and maybe exceeded $13 billion by 2025, see Figure 2 [3].
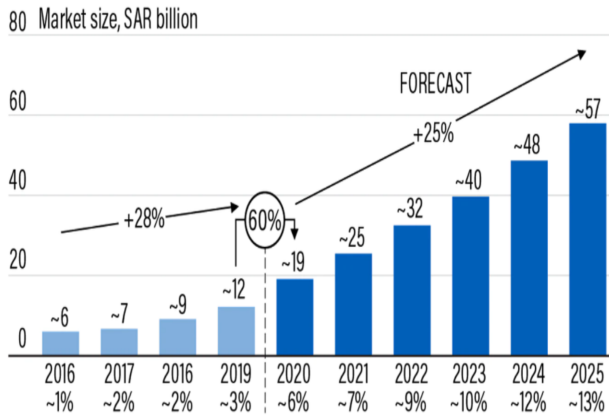

FIGURE 2. E-commerce market size in Saudi Arabia from 2016 to 2025.

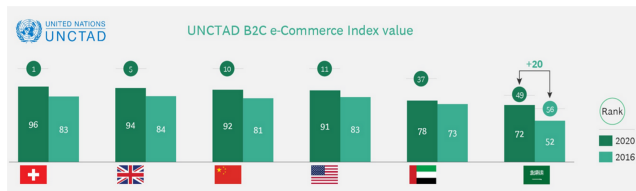Moreover, Saudi Arabia has made great progress in UNCTAD's B2B e-commerce index. See Figure 3 [4].

FIGURE 3. Saudi E-commerce index value.

Particularly, e-commerce in Saudi Arabia in accordance with the 2030 Vision is considered among the leading commerce arenas due to the exponential increasing number of internet users in Saudi Arabia, which reached 22.42 million in 2016 according to the Saudi Communication and Information Technology Commission (CITC). The report of the CITC from 2016 stated that the penetration of the internet usage in the Kingdom increased significantly in the last few years and the estimated number of the internet users will reach 26.49 million in 2022 where the average percentage of the actively involved users in e-commerce is 59.07% and the retail hit US $9,405 million [4].

The 2017 Global Retail Development IndexTM ranked Saudi Arabia at the 11th position in retail sales globally, whereas it ranked it at 28th position in 2015 for its e-commerce potential based on several variables including its current market and its potential growth. In 2021 Saudi Arabia ranked in position 12 globally (Table 1) [5].

Small Medium Enterprises (SMEs) can be defined in several ways different from one country to another. In general, the number of people employed, size of capital, sales, assets,

TABLE 1. The 2021 global retail development index.

2021 rank	Country	Population (million)	GDP PPP per capita (US$)	National retail sales (US$ billion)	Market attractiveness	Country risk	Market saturation	Time pressure	Final 2021 score	Rank vs. 2019
1	China	1,402	17,192	4,072	100.0	88.4	13.1	100.0	72.8	0
2	India	1,400	6,461	1,163	59.1	50.7	63.7	82.7	64.4	0
3	Malaysia	33	27,402	112	74.5	74.0	27.2	43.9	54.1	0
4	Indonesia	272	12,222	407	51.3	30.7	57.6	60.7	53.0	+1
5	Bangladesh	170	5,307	171	15.7	2.4	96.0	88.4	53.0	New
6	Morocco	36	7,620	46	31.5	92.6	66.5	51.8	52.2	+6
7	Egypt	101	12,790	200	34.3	20.5	71.5	73.8	52.0	+19
8	Ghana	31	5,693	24	13.5	70.2	96.5	52.7	51.9	−4
9	Vietnam	96	10,869	125	27.8	42.2	56.0	98.4	51.8	+2
10	Dominican Republic	11	18,608	25	44.5	70.2	62.2	39.7	51.4	+4
11	Serbia	7	19,146	21	61.0	55.2	27.7	62.8	50.8	+16
12	Saudi Arabia	35	46,811	119	75.8	98.6	16.9	26.9	50.6	−5

and other factors can all play a role in defining the size of the enterprise, which can be classified into micro, small, and medium enterprise. In Saudi Arabia, a company with a number of employees of 10-49 is considered a small enterprise and it is considered a medium enterprise if it has 50-99 employees. This paper is dedicated to studying the SMEs based on the Saudi standards, where we will address and overcome the current challenges to enhance the level of e-commerce of these enterprises. We aim to empower the Saudi economy and improve the online shopping culture. Our paper consists of seven sections and references. We study the related works in the second section. Section three briefly introduces the challenges that face online shopping in Saudi Arabia. A smart e-commerce control unit is stated in section 5. Section 6 is about Federated Learning for enhancing the user's experience and finally, we conclude our paper in section 7.
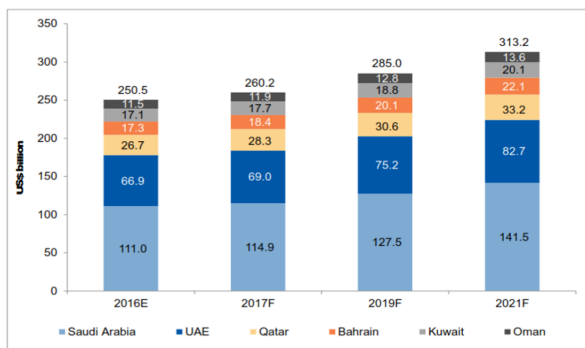
II. LITERATURE REVIEW

The annual report issued by the Saudi Communications and Information Technology Commission (CITC) showed that the number of Internet users has increased 400% over the previous 5 years reaching 19.6 million users [4]–[6]. Internet usage in the Kingdom has increased significantly in the last few years and increased from 13% in 2005 to about 63.7% at the end of 2014. It is expected that the demand for Internet services will continue to increase significantly over the next few years and it is expected to reach 26.49 million in 2022. The total capacity for international Internet connectivity in 2014 was about 1,321 Gbits/s compared to 318 Gbits/s in 2010 and it has risen to 114% (3185 Gigabytes/sec) in 2016 that is due to the increased demand use of the Internet. It is estimated that the ICT contribution to the national GDP was 8.7% in 2014, 151% in 2016 people were using telecom services, 75% were accessing broadband services using the networks of mobile telecom, and 74.9% were using the internet. Moreover, 32.3% of the households used fixed telecom networks, and 46.8% were using telecom networks. The related studies show that there is a direct correlation between the availability of broadband services and the rate of growth in the Growth Domestic Product (GDP). Studies [5]–[8] confirmed that SMEs represent one of the cornerstones of the global economy, providing numerous job

opportunities and making a substantial contribution to national income. According to the report published in 2013 by the Saudi Arabian Monetary Agency (SAMA), the percentage of SMEs is equivalent to 90% of the total number of officially registered companies in the Kingdom [7]. The number of commercial shares increased by 54.7% to reach 12.1 billion in 2017. The total traded shares value reached SAR 229.2 billion [8]. According to paper [9], online shopping is a basic technology in the knowledge economy, it empowers and enhances the economy and sustains its development nationally and internationally. Numerous studies stated that online shopping in the KSA has a strong potential for growth due to the rapidly increasing number of internet users and the maturity of the Information and Communication Technology (ICT) infrastructure [10], [11]. However, despite the considerable ITC infrastructure and the high rate of Internet usage in the KSA, the study [12] showed that only 8% of companies have interactive websites while 54% have non-interactive websites, which merely present the company's current products. Several results were concluded based on different studies conducted to explore the barriers that limit the diffusion of online shopping in the KSA. The researchers of [13] indicated that the high cost of constructing and maintaining online shopping websites has limited the number of available platforms for online shopping, and they suggested the establishment of e-Malls to overcome the cost problems. Moreover, papers [14], [15] realized that the most significant barrier to low online shopping in KSA is the absence of clear government legislation rules despite having the biggest and the fastest-growing ICT market in the Arab world (see Figure 4).

Source: IMF – October 2016, EIU, WTTC, Alpen Capital
Note: E – Estimated, F – Forecasted

FIGURE 4. Country-wise retail sales forecast.

Online shopping in the KSA requires several years to meet the expectations compared to other developed countries [16]. Subsequently, many factors play a major role in limiting the diffusion of online shopping in the KSA such as the cultural barriers and technological infrastructures as discussed in [17]. Likewise, the authors of [14] presented a novel

study and addressed 13 barriers that limit the adoption of online shopping among Saudi SMEs including the unwanted consumer habits, the lack of governmental regulations, and online payment options that led to five suggested solutions to overcome these challenges including the development of online payment options, enhancing ICT infrastructure, and the developing of government regulations. Similarly, the authors in [18]–[26] identified the 13 most affecting factors that prevent the spreading of online shopping in the KSA are due to the fear of cybercrimes, and the absence of legal online portals, and the technical implementation, integration, and related applications issues. We proposed an automating e-government services with artificial intelligence is proposed in [27].

Moreover, the e-commerce retail in the Gulf Cooperation Council (GCC) market has been expanding due to the increasing number of internet users and social media websites, easy and secure payment access to the gateways, the advancement in the delivery system, and the availability of different product offers with competitive prices. Recently, the retailers are looking to grow their online business due to the wide geographical expanding coverage and the high rental costs. The GCC e-commerce sales are expected to exceed US $42 billion where KSA comes in second place with 14% of the online total retail market after UAE which has the largest online sales 53%. Souq, Namshi, and Wadi are the main online shopping portals in the KSA and GCC markets. Saudi Arabia's retail market is projected to exhibit the Compound Annual Growth Rate (CAGR) of around 6% during the forecast period of 2021-2026. The market confirmed growth of more than $119 billion in 2019, on the account of the increasing personal disposable income, change in consumption pattern from staple food to healthier food, and shifting focus from dependency on fuel to other sectors. In terms of product category, Saudi Arabia's retail market has been categorized into food & beverages, apparel & footwear, appliances, jewelry, pharmacy, and others. Food & beverages category is accounted for nearly one-third market share in 2020 and the segment is anticipated to maintain its market dominance during the forecast period as well. Saudi Arabia's retail market has been segmented into central, west, east, south, and north regions. Among these regions, the central region is the largest demand generating region in the country's retail market, due to the strong presence of key market players in the region. Riyadh, the capital of Saudi Arabia, which is presented in the central region, has seen a significant transformation in other cities or regions. Riyadh has become the central hub for the new technologies and latest creations [1]–[10]. Saudi Arabia's retail market is fragmented in nature due to the presence of several companies. Approval and commercialization of various products and expanding geographical reach are the major strategies adopted by industry participants to enhance their market share. Some of the major players operating in Saudi Arabia's retail market are Panda Retail Co. (Savola Group), Lulu Group International (EMKE

Group), Abdullah Al Othaim Markets Co., Fawaz Abdulaziz AlHokair Co., Majid Al Futtaim Retail LLC, among others [14], [18], [19].

The papers [28]–[31] are the references of implementing Federated Learning in our e-commerce control unit which we explain in details in section 6.

Our paper makes use of all previous studies and produces a smart control unit for enhancing and solving most of the faced difficulties and barriers of e-commerce in Saudi Arabia.

III. E-COMMERCE CHALLENGES IN SAUDI ARABIA

There are several challenges that face e-commerce in Saudi Arabia as following:

A. INCREASING COMPETITION AMONG RETAILERS

The expansion of malls and organizations of retail regional e-commerce in Saudi Arabia increases the competition in the GCC retail market, especially in the UAE where much international food and non-food brands began to be competitive and dominated as the major player in the country such as LuLu group, Carrefour, BMA, Spinneys. The traditional retailers began to adopt e-commerce in the area due to the increasing number of stores in the area and this also turn again the competition between retailers. This competition induces retailers to scale up the quality of their goods, reduce the prices, and expand their offers which led to improving the shopping environment. In Saudi Arabia, the traditional retailers are dominant in the market store because they are preferred by the local consumers so the modern retailers began to increase their presence in the kingdom and start struggling against traditional retailers by attracting the consumers. The government in Saudi Arabia has begun promoting competition by allowing 100% foreign ownership in retail and wholesale e-business. Consequently, the increasing e-commerce portals in the area for different diverse products with different qualities has increased the competition between the retailers and led to what is named price wars.

B. INCREASING MALL CENTERS AND MARKET SATURATION

In the previous years, the number of retail centers, malls, and project stores has been increased due to the increasing number of tourists and expatriates which led to the saturation in the marketplace where the prices began to decrease up to more than 50% in the last years.

C. INCREASING FAKE GOODS AND PRODUCTS

For the last ten years, the counterfeiting has begun to take a place actively in the GCC area, especially in Saudi Arabia and the Emirates, where the number of the fake goods increased gradually, for example, in 2016 the Dubai Department of Economic Development (DED) confiscated more than US$ 500 million of fake goods including mobile phones, accessories, cosmetics, and many other goods. Moreover, Saudi Arabia closed around 10,000 social media accounts specialized in selling fake goods. That means the counterfeiting began to spread not only in the retailers in malls and shops but in e-commerce, so Saudi Arabia began to take strict steps to curb the spread of fake products online and issued new related rules. For example, UAE introduced a new anti-fraud law to stop counterfeiting and other commercial fraud. They introduced low levies and strong penalties on traders who produce fake products with fines up to US $285,000 with 2 years in jail. So, the e-commerce market needs more legislation and governmental crackdown to curb, limit and stop the counterfeiting business.

D. LACK OF LOGISTIC SERVICES

It is very important to mention that logistic services play a critical role in e-commerce especially in the retail value chain. Unfortunately, the logistic services are not developed enough in Saudi Arabia, due to the most transactions operations and purchases take place in small retail stores. The absence of the right network distribution of the goods and inadequate cold storage and warehousing facilities yields customer dissatisfaction with operational inefficiencies. This also affects the online retailers and their reputation. So, the government in Saudi Arabia should develop and strengthen the transportation networks to meet retailers' requirements, and customers' expectations and to fit the growing trade in the region.

IV. E-COMMERCE TRENDS

A. GROWING NEED FOR OMNICHANNEL MODEL

The Omnichannel is the way of integrating seamless sales channels such as computers, phones, iPads, and tablets to provide a better shopping experience for customers. Recently, the idea of Omnichannel has been abuzz in retail due to the proliferation of new digital devices and technologies. The Omnichannel benefits the customers in many different ways such as allowing customers to check previous customers' ratings and experiences, and this helps in making a good purchase decision. The new generation is driving a high shopping experience by having better expectations and demanding tailor-made shopping experiences. Although there are still many people in the Middle East who prefer the conventional mode of shopping, still there is a large expansion in e-commerce and the internet connection where the mobile subscribers in the GCC area are more than 40 million and there are nearly as many internet users. The Omnichannel model has been increasing in the region due to the increasing number of retailers. For example, Majid Al Futtaim has announced his plan to integrate his online and offline business to build an online portal by 2017. Due to the growth in e-commerce in the GCC area and the high offline shopping competition, more retailers are likely to offer an integration between online and offline shopping in order to remain competitive.

B. SUB-FRANCHISING OF BRANDS

The GCC has the major franchise markets in the area, where the franchise in the Middle East and North Africa exceed

US$ 30 billion mostly fashion brands, food, and beverages. These international brands' stores are located in malls which are almost 80% of the retailer's stores. These foreign brands usually collaborate with big groups of businesses by granting them master franchise agreements to spread their presence across a wider region. There are many examples such as Apparel, BinHendi, and Al Hokair groups that used to expand the foreign brands in different geographies on their own which is known as sub-franchising. The model of sub-franchising allows the master franchise to focus only on the large business groups and the large groups will lead the shopping in wider areas. However, the sub-franchising has been expanding quickly over wide regions. The master franchise of F&B brands, Al Madani, has expanded its sub-franchising to open several outlets and malls in Abu Dhabi and Al Ain. In 2016, for example Tariq Albassami started a master franchise between India and Saudi Arabia to open 10 stores in GCC of Toonz retail.

C. GROWTH OF PRIVATE LABELS

There is a huge increase in the private brands known as store brands locally. The local private brands used to be not preferred and to be considered low-quality brands. Recently, the perceptions have totally changed, and the private brands became a preferred choice among a very large set of customers who are looking for a quality product with economical prices. The Nielsen Global Survey of Private label in 2014, for example, showed that 71% of the perceptions have changed completely toward the private brands, and 61% they actually believe that the private brand's products are competitive and a good alternative to the name brands. In response, there is a huge expansion in the private brands among regional retailers not only in the clothes industry but also in many private brands for food, sweets, and beverages. Many other sectors such as apparel, accessories, and electronics have been increasing and many private labels have been introduced such as Carrefour and LuLu.

D. INCREASING NUMBER OF COMMUNITY MALLS

Due to business expansion and financial investment the GCC deal-making sector has remained active and there are several acquisitions from cross-border companies for the purpose of financial gain. Dubai and Saudi Arabia have witnessed large overseas investors such as Souq.com which was sold to Amazon.com for US$ 650 million.

V. APPROACH: A SMART E-COMMERCE CONTROL UNIT

To this end, we thoroughly studied and investigated the Saudi E-commerce challenges and we present our novel strategy to overcome these challenges by developing an end-to-end e-commerce platform. Specifically, we present an online platform (See Figure 5) that aims at governing, monitoring, and facilitating the e-commerce lifecycle from the end-users (shoppers) to the online retailers through all intermediate financial and delivery services. The overarching goals of the platform are to protect both the end-users and the online

retailers and to facilitate their two-way interactions. The objectives of the platform include, but are not limited to, the following:

 (a) Secure and authenticate all e-commerce transactions
 (b) Provide authentication services to identify genuine online stores and sellers
 (c) Provide e-commerce services for online sellers, such as registering their business and securing their online payment options.
 (d) Provide e-commerce services for shoppers, including a list of registered and trusted sellers, online payment options, and online complaint services for fake and damaged goods.
 (e) Provide e-commerce policies and rules
 (f) Control and bar trading weapons and illegal drugs and other prohibited items in Saudi Arabia
 (g) Provide secured channels for transmitting transactions
 (h) Identify and block illegal and fake transactions
 (i) Track and block terrorist attacks that could reach online stores to trade materials used in creating weapons and other destructive tools.

   In addition to providing an end-to-end secure and trusted platform for e-commerce, the platform will help improve the e-commerce experience and services through user feedback and data mining services. Moreover, such as platform can complement the Kingdom's cyber security programs and 2030's Vision. Figure 5 illustrates our proposed E-commerce Platform. The left-most unit represents the end-user (shopper). The right-most unit represents the online shopping platforms and sellers. Our proposed platform is represented in the middle under the name of the Saudi E-commerce Control Unit (SECU). The first and most important part of the platform is the e-commerce policies and regulations unit. This unit is responsible to study, explore, and release the most recent policies and regulations regarding e-commerce in Saudi Arabia. This unit is most likely to be governed by the Ministry of Commerce. The next essential component includes the following three units:

 (a) Retailers' registration unit: It is responsible to register and keep track of the current online retailers in the KSA. It makes sure that the retailers conform to the policies and regulations set by the authorities.
 (b) User's registration system: This system should be connected to the government database of the citizens, which includes accounts for each citizen in the country as part of the e-government initiative of Saudi Arabia. This ensures that the online shoppers are real customers and help authenticate their transactions. This also helps online retailers to better trust their customers and provide tailored products and delivery services more efficiently.
 (c) Authentication system unit: It is the controller between the online retailers and shoppers. It facilitates two-way communication and authentication between customers and service providers.
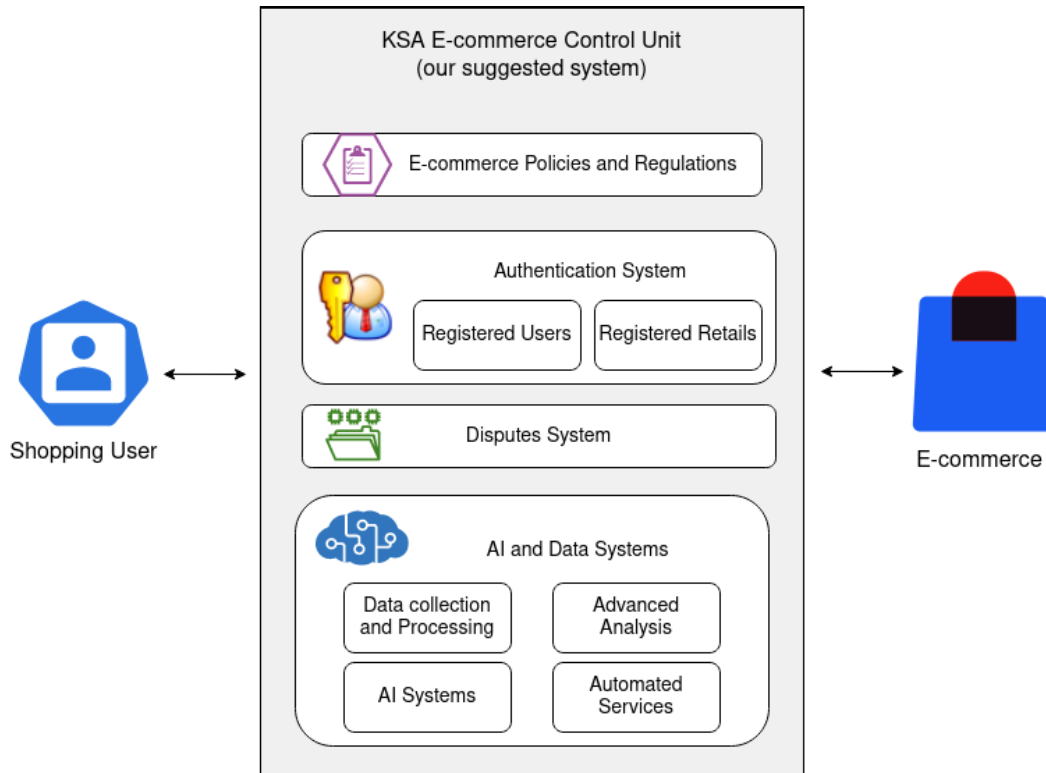
FIGURE 5. Our proposed system of Saudi E-commerce control unit.

Another important unit of the proposed solution is the dispute system. This unit is responsible to handle the complaints from both sides, mostly the online shoppers and the online shopping platforms. This unit allows the shoppers to place their reviews and complaints on a specific service, product, or shopping platform. These complaints will be handled by the control unit based on the given policies and regulations. Having an independent dispute system can facilitate and help solve e-commerce issues with minimal bias. In addition to the aforementioned units, the Saudi e-commerce control unit will be equipped with a smart AI data system unit which consists of four units: Data collection and processing, advanced analysis, automated services, and AI systems. These data mining and explorations techniques. Data-driven analytics and predictions can greatly assist in improving the overall system and its services. Moreover, it can provide several services to both the end-users and the online shopping platforms. For example, it can list and compare the prices of a specific item from multiple shopping platforms. Moreover, it can provide the online retailers with the users' behaviors and predictions to modify, enhance, and update the units with their services accordingly.

VI. FEDERATED LEARNING FOR ENHANCING USERS' EXPERIENCE

The suggested control unit can also provide users with a secured shopping experience by providing recommendations for different online stores and items. With the implementation of AI models such as Matrix Factorization, we could recommend items for users based on their previous shopping experience. But the question is how to retain this model without having access to users' shopping experience in the retail stores? The answer is by applying Federated Learning.

A. FEDERATED LEARNING

Nowadays, privacy is the major concern for almost all of the different sectors of business. However, the effectiveness of AI and building reliable models depends on having good data to train the model on. In some scenarios where there is a lack of data, or it is almost impossible to reach the data (such as patients' sensitive data in healthcare sectors) it becomes a challenge to train a model with high accuracy. Luckily, McMahan *et al.* [28] provided a secure approach to train models on the data-owner sites without having direct access to the data which is known as Federated Learning. Federated Learning is the paradigm to train a global model by aggregating many models that have been trained on the data owners' locations. The process starts when the server (in our case it is the e-commerce control unit) creates a model (null model) and sends it to the data owners (retail stores). At each data owner site, the model will be trained a specific number of epochs and then will be sent back to the server. The server will then aggregate all of the data owners' models to generate a more generalized model (global mode).
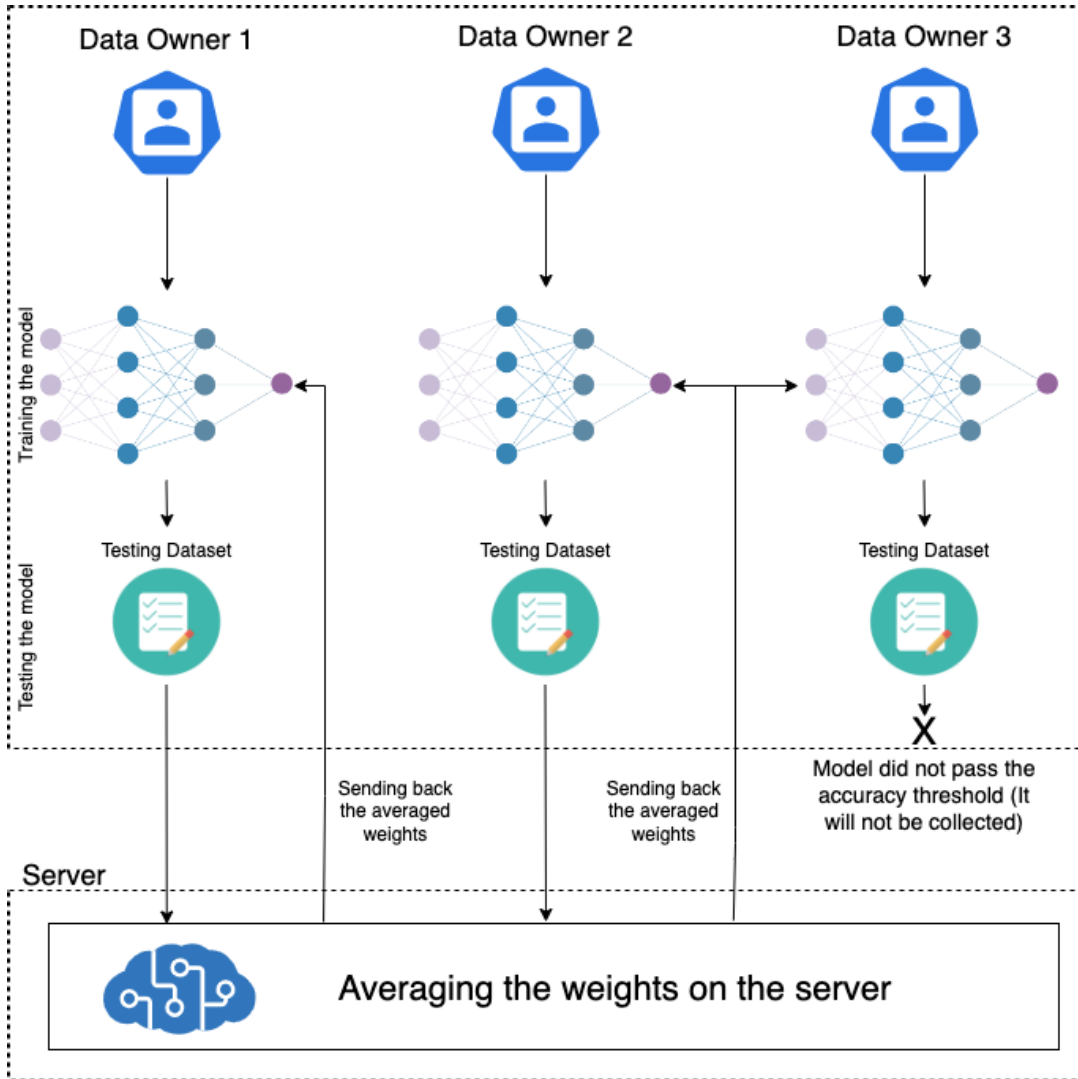
FIGURE 6. Models with high accuracy will be sent to the server for aggregation and will be part of the next global model.

This technique allows the server to train a global model without having direct access to the data. We take this implementation a step further by adding a small test dataset at each data owner location to test the trained model before sending it to the server-side. Models with high accuracy will be sent to the server for aggregation and will be part of the next global model, Figure 6.

We implement Matrix Factorization with Homomorphic Encryption technique for recommender systems [29], [30] and to maintain the privacy of the models, we utilize the FedMF model in our unit control. To understand the implementation, let's assume that we have m number of items and n number of users where each user rated a number of items (a subset of m). Given $[n] := \{1, 2, \ldots, n\}$ which is the set of users and $[m] := \{1, 2, \ldots, m\}$ which is the set of items. We denote $\mathcal{M} \in [n] \times [m]$ for the rating pairs of (user-item) where M is the total number of items, so $M = |\mathcal{M}|$.

For each rating r, we denote the user i that rated item j with r_{ij}. Assuming r_{ij} is given, we expect the recommendation system to predict all the items for all the users by fitting a binary model on the existing ratings. The user matrix is computed as $U \in R^{n \times d}$ and the matrix of items is $V \in R^{m \times d}$ and the output matrix will be used to predict the user's i'th rating for item j which can be described as $\langle u_i, v_j \rangle$.

$$\min_{U,V} \frac{1}{M}(r_{i,j} - \langle u_i, v_j \rangle)^2 + \lambda ||U||_2^2 + \mu ||V||_2^2 \quad (1)$$

$$u_i^t = u_i^{t-1} - \gamma \nabla_{u_i} F(U^{t-1}, V^{t-1}) \quad (2)$$

$$v_i^t = v_i^{t-1} - \gamma \nabla_{v_i} F(U^{t-1}, V^{t-1}) \quad (3)$$

where

$$\nabla_{u_i} F(U, V) = -2 \sum_{j:(i,j)} v_j(r_{i,j} - \langle u_i, v_j \rangle) + 2\lambda u_i \quad (4)$$

TABLE 2. Matrix Factorization model on the MovieLens dataset using Federated Learning.

		Time	Loss	RMSE
3 Users - 10 Items	Round #1	0:00:42	19.4	3.87
	Round #5	0:02:35	19.38	3.87
	Round #10	0:05:08	19.35	3.87
	Round #15	0:07:50	19.31	3.87
	Round #20	0:09:27	19.26	3.86
	Round #25	0:12:59	19.2	3.86
5 Users - 20 Items	Round #1	0:01:48	17.32	4.24
	Round #5	0:07:52	17.28	4.23
	Round #10	0:15:31	17.2	4.23
	Round #15	0:23:41	17.1	4.22
	Round #20	0:28:41	16.98	4.21
	Round #25	0:37:42	16.71	4.2
10 Users - 40 Items	Round #1	0:06:09	16.98	4.21
	Round #5	0:27:52	16.53	3.85
	Round #10	0:57:02	16.35	3.84
	Round #15	1:20:59	16.01	3.81
	Round #20	1:50:39	15.36	3.76
	Round #25	2:19:47	14.18	3.65

$$\nabla_{v_i} F(U, V) = -2 \sum_{i:(i,j)} u_i(r_{i,j} - \langle u_i, v_j \rangle) + 2\lambda v_j \quad (5)$$

Our suggested e-commerce Control Unit does not only provide a secure bridge between customers and e-commerce businesses, but it also provides recommendations for users to enhance their shopping experience. To truly achieve this goal, we trained a Matrix Factorization Recommendation System using customers' data from different retail stores. Table 2 shows the experiment results for running the Matrix Factorization model on the MovieLens dataset [31] for a different number of users and items.

VII. CONCLUSION

The objective of this study is to explore the most important factors that inhibit the adoption of online shopping by SMEs in Saudi Arabia. In particular, we investigated the most challenging factors that face e-commerce and addressed the mentioned challenges that discussed and surveyed in our paper. We recommend that the Saudi government has to play a critical role in regulating and controlling the e-commerce and take its responsibility in developing legislation, rules, and regulations that govern e-commerce for more secure, reliable, and safe online transactions. Moreover, we presented and suggested a smart e-commerce control unit that aims to facilitate and control the overall e-commerce process to provide an end-to-end secure, trusted, and efficient platform for customers and small-medium enterprises in Saudi Arabia.

REFERENCES

[1] [Online]. Available: https://www.census.gov/

[2] [Online]. Available: https://www.statista.com/statistics/379046/worldwide-retail-e-commerce-sales/

[3] [Online]. Available: https://www.zawya.com/mena/en/business/story/Saudi_ecommerce_market_value_to_exceed_13bln_by_2025-SNG_267746740/

[4] [Online]. Available: https://www.bcg.com/en-mideast/publications/2021/e-commerce-market-50-billion-sar-opportunity-in-saudi-arabia

[5] [Online]. Available: https://www.kearney.com/global-retail-development-index

[6] [Online]. Available: https://www.statista.com/statistics/1201920/saudi-arabia-e-commerce-market-size/

[7] [Online]. Available: https://www.techsciresearch.com/report-section.aspx

[8] [Online]. Available: http://www.citc.gov.sa/en/Pages/default.aspx

[9] [Online]. Available: http://www.sama.gov.sa/en-U.S./Pages/default.aspx

[10] [Online]. Available: https://www.atkearney.com/global-retail-development-index/rankings

[11] A. A. Bahaddad, L. Houghton, and S. Drew, "Attracting customer in Saudi Arabia to buy from your business online," *Int. J. Bus. Manage.*, vol. 8, no. 7, pp. 65–81, Mar. 2013.

[12] S. A. Al-Somali, R. Gholami, and B. Clegg, "An investigation into the adoption of electronic commerce among Saudi Arabian SMEs," *J. Electron. Commerce Organizations*, vol. 9, no. 2, pp. 41–65, Apr. 2011.

[13] S. A. Al-Hudhaif and A. Alkubeyyer, "E-commerce adoption factors in Saudi Arabia," *Int. J. Bus. Manage.*, vol. 6, no. 9, p. 122, Sep. 2011.

[14] S. A. Al-Hudhaif, R. Gholami, and B. Clegg, "An investigation into the factors affecting e-commerce adoption decisions by SMEs: A study in Saudi Arabia," in *Strategic e-Commerce Systems and Tools for Competing in the Digital Marketplace*. Hershey, PA, USA: IGI Global, 2015, pp. 206–243.

[15] R. AlGhamdi, J. Nguyen, A. Nguyen, and S. Drew, "Factors influencing e-commerce adoption by retailers in Saudi Arabia: A quantitative analysis," *Int. J. Electron. Commerce Stud.*, vol. 3, no. 1, pp. 83–100, 2012.

[16] F. A. A. Aleid, "An investigation of the factors affecting consumers' adoption of E-commerce: An empirical study of Saudi Arabia," PhD thesis, De Montfort University, Leicester, U.K., 2011.

[17] R. AlGhamdi, S. Drew, and W. Al-Ghaith, "Factors unflinching e-commerce adoption by retailers in Saudi arabia: Qual analysis," 2012, *arXiv:1211.2404.*

[18] I. Ahmad and A. M. Agrawal, "An empirical study of problems in implementation of electronic commerce in kingdom of Saudi Arabia," *Int. J. Bus. Manage.*, vol. 7, no. 15, p. 70, Jul. 2012.

[19] A. Azam, "Investigation of psychological dimensions of trust on e-loyalty: A case of Saudi Arabia consumers," *J. Islamic Marketing*, vol. 6, no. 2, pp. 224–249, Jun. 2015.

[20] T. S. AL-Nahdi, S. A. Habib, and A. A. Albdour, "Factors influencing the intention to purchase real estate in Saudi arabia: Moderating effect of demographic citizenship," *Int. J. Bus. Manage.*, vol. 10, no. 4, p. 35, Mar. 2015.

[21] M. Almousa, "The influence of risk perception in online purchasing behavior: A multi dimensional perspective," *Int. J. Arts Sci.*, vol. 4, no. 12, p. 373, 2011.

[22] M. Almousa, "Barriers to E-commerce adoption: Consumers' perspectives from a developing country," *Ibusiness*, vol. 5, no. 2, pp. 65–71, 2013.

[23] R. AlGhamdi, J. Nguyen, A. Nguyen, and S. Drew, "Factors influencing e-commerce adoption by retailers in Saudi Arabia: A quantitative analysis," *Int. J. Electron. Commerce Stud.*, vol. 3, no. 1, p. 83, 2012.

[24] R. AlGhamdi, A. Nguyen, and V. Jones, "A study of influential factors in the adoption and diffusion of B2C E-Commerce," 2013, *arXiv:1302.0272.*

[25] R. AlGhamdi, A. Nguyen, and V. Jones, "A study of influential factors in the adoption and diffusion of B2C E-Commerce," 2013, *arXiv:1302.0272.*

[26] M. A. Albugami, "E-commerce and economy: A case study of Saudi Arabia," *BVICAM's Int. J. Inf. Technol.*, vol. 7, no. 2, p. 916, 2015.

[27] O. S. Al-Mushayt, "Automating e-government services with artificial intelligence," *IEEE Access*, vol. 7, pp. 146821–146829, 2019.

[28] B. McMahan, E. Moore, D. Ramage, S. Hampson, and B. A. Arcas, "Communication-efficient learning of deep networks from decentralized data," in *Artificial Intelligence and Statistics*. 2017, pp. 1273–1282.

[29] Y. Koren, R. Bell, and C. Volinsky, "Matrix factorization techniques for recommender systems," in *Computer*, vol. 42, no. 8, pp. 30–37, Aug. 2009.

[30] D. Chai, L. Wang, K. Chen, and Q. Yang, "Secure federated matrix factorization," *IEEE Intell. Syst.*, vol. 36, no. 5, pp. 11–20, Aug. 2020.

[31] F. M. Harper and J. A. Konstan, "The movielens datasets: History and context," *ACM Trans. Interact. Intell. Syst.*, vol. 5, no. 4, pp. 1–19, 2015.

WAJEB GHARIBI received the Ph.D. degree from the Institute of Mathematics, National Academy of Sciences of Belarus, in 1990. He is currently a Professor of computer science with the University of Missouri-Kansas City, USA. His research interests include mathematical cybernetics, cybersecurity, machine learning, quantum computing, and optimization.

OMAR SAEED AL-MUSHAYT received the master's degree from the University of Illinois, USA, in 1993, and the Ph.D. degree in MIS from Loughborough University, U.K., in 2000. He is currently a Professor with King Khalid University, Saudi Arabia. He has more than 30 publications in reputed journals and conferences.

NASRULLAH ARMI received the master's degree from the Toyohashi University of Technology, Japan, in 2004, and the Ph.D. degree from the Universiti Teknologi Petronas, Malaysia, in 2013. His research interests include signal processing and wireless communication. He is currently working as a Researcher with the National Research and Innovation Agency, Indonesia.

• • •