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REGULAR PAPER

Social computing in currency exchange

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Abstract
Human communication has evolved over the last decades thanks to rapid technological advances. It has provided us with new ways of communicating with one another and made many aspects of social interaction easier. Social computing is an important area in computer science concerned with the use of computational systems for social purposes. This paper focuses on the use of social computing to simplify the process of currency exchange at airports where services have to be provided to people of all nationalities. This is a complex social scenario in which the buyer and seller must reach an agreement without speaking the same language, and in these cases, the probability of not understanding all the aspects of the transaction is high. The proposed system improves interaction between users and ensures a fast and secure operation. A multi-agent system is the base of the developed software; MAS is an important and commonly used tool in social computing. A case study was conducted with the proposed system at Sydney airport, with a Spanish currency exchange company (Global Exchange) which provides service to travelers from all continents. The Net Promoter Score metric was used to evaluate the developed system, and a score of 29.81 was obtained, indicating that customers were highly satisfied with the performance of the system. Moreover, thanks to the system, there was an increase of 34% in currency exchange operations, and the time it takes to provide service to a customer reduced by 73.67% on average.

Keywords Currency exchange · Social computing · Software · Multi-agent systems

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1 Introduction

Technology has transformed the way in which we interact with each other. Social networks have become an important element of daily interaction, enabling both personal and professional relationships [3]. However, our communication goes much beyond social networks. Social computing is continually revolutionizing the way in which humans communicate [20].

Social computing is the use of technology for interaction and collaboration between users. In this case, specifically, a computer acts as a tool in the currency exchange process between the teller in an exchange office and a client. The use of technology in communication can bring multiple advantages; however, in this proposal, its main benefit is to facilitate communication between people, given the characteristics of the environment. Currency exchange is a service that is offered at all airports to people of different nationalities, and this service may be difficult if the seller and the buyer cannot communicate in the same language. As communication regards money, it is especially important that both parties can clearly understand each other and that the exchange process is carried out in a transparent way. This will help improve customer satisfaction with the provided service. Thus, the business sector can benefit from this paradigm significantly, and one aspect that can be improved is currency exchange.

One of the aspects that makes social relations more difficult is the language in which people must interact. When this is different, it is difficult to understand all aspects of a communication in detail. This situation occurs every day in airports, where the transit of people of multiple nationalities (and therefore speakers of multiple languages) far exceeds the percentage of any other environment [11,21,31]. In addition, when communication is established to carry out an economic operation, good understanding between both parties is a key aspect. Specifically, one of the activities most frequently carried out between people who speak different languages at airports is an economic operation, the currency exchange [22]. During this currency exchange process, there can be a lot of inconveniences such as lack of understanding, possible misunderstandings or the lack of confidence and security that can arise in operations of an economic nature, and even other factors can affect the emotional form of making such communication such as waiting time.

It is necessary, therefore, to develop a system that is capable of taking full advantage of the benefits that social computing can offer [13]. Such a system should simplify the communication process between the user and the teller by providing a user-friendly interface for the transaction. Since the system will make all the aspects of the transaction transparent, the teller will know exactly what he or she should do and the client will understand all aspects of the procedure, contributing to their satisfaction with the service. Clients can be attended simultaneously through computers, and this will allow the company to attend more clients and to reduce the workload of their employees.

Therefore, the main objective is to use technology to provide customer service in the native language of the client. Moreover, this proposal seeks to achieve other commercial advantages: (i) reduce customers' waiting, (ii) reduce the time it takes to provide service to each client, (iii) increase the company's profit, (iv) improve the company's image, and (v) encourage customers to exchange a greater sum of money in each transaction through personalized offers.

The main contribution of this paper is the development of a system which fulfills the objectives described above. A multi-agent system (MAS) was used in our proposal as it is an important paradigm in social computing [30]. More specifically, a set of agents coordinate and interact with each other in such a way as to guarantee that the environment (in this case, the currency purchase operation) is governed by a set of rules that implies that it is carried

out in the appropriate way. The system has been deployed in a real environment (the Sydney airport in Australia) and has been evaluated on the basis of different parameters, such as waiting time for each client or their satisfaction, compared to the traditional care method, where the company's change consultant interacts directly with the client without using any type of technological device for communication. A previously developed basic version of this system was published in [23], which presents the first proof of concept of the system interface.

The rest of the article is structured as follows: The background Sect. 2 analyzes the state of the art in currency exchange systems, and Sect. 3 describes the technology and the development of the proposed system. Then, the experiment and the results are outlined in Sect. 4. Finally, conclusions are drawn on the users' satisfaction with the proposed system, and future work is discussed in Sect. 5.

2 Background

This section outlines the currency exchange companies that operate at present and the way in which they have adapted different technologies to provide their services. We stress, however, that none of the companies listed here have used the system proposed in this article. Moreover, this section outlines the legal requirements that currency exchange companies must meet to ensure secure operations, and finally, state-of-the-art social computing systems are reviewed.

2.1 Existing currency exchange systems

Currency exchange companies are financial institutions whose main function is to buy and sell foreign exchange from different countries. In the past, currency exchange offices were normally located in banks; however, their popularity increased due to greater international mobility of people and globalization. As a result, today currency exchange offices can also be found in travel agencies, at airports and other transport hubs.

Although there are no specific statistics regarding the companies that use online as opposed to offline transaction, it is certain that the majority of currency exchange offices opt for offline transactions where all the procedures are carried out by a teller. The procedure followed to exchange money in these entities is fairly simple if the teller and the client can communicate in the same language. The client simply comes to one of these entities to buy a currency which has an exchange rate, and pays a fee for the completion of this exchange process.

Airports are a central place to currency exchange, where clients can usually find a range of companies to choose from. However, upon arrival to another country, many travelers are not aware of the advantages that different companies can offer such as an anti-theft insurance or currency repurchase at the same price. Thus, their choice usually depends on the exchange rates offered by these companies, which tend to be quite even as well as the number of customers queuing up to change their currency. Thus, making the service faster can help a company outperform competition, as it will allow to reduce queues and attract more clients.

Studies like the one presented by Ferris et al. in [10] demonstrate that user satisfaction increases considerably when technology is used to provide information of interest. This work in particular provided information on the waiting time that users should expect to wait at a bus stop; however, it can be used in the same way to the estimate the time a client will wait to change their currency in the office of one company as opposed to its competition. In [1], Allon et al. analyze the impact of waiting time on the fast food market rate. This

Table 1 Services offered by existing currency exchange companies

	Services to users		Services to business
	Reserve	Home delivery	International transactions
American Express			X
Travelex	X	X	X
Global Exchange	X	X	X
Ebury			X
Kantox			X
Exact Change	X	X	X
Money Exchange		X	

study shows that decreasing the average waiting time by several seconds allows a company to attract more customers. The success of self-ordering kiosks has already been demonstrated in similar works, and the study presented in [15] looks at the parameters that contribute to their success.

In recent times, different business models have been created in an effort to take advantage of the possibilities offered by technology. Within this new model, the following exchange companies stand out: American Express [6], Travelex [14], Global Exchange [9], Ebury [16], Kantox [17], ExactChange [18], Money Exchange [19].

Analyzing the platforms and technologies that the main companies currently use, we can observe how most of them focus on certain common operations: (i) the purchase and reservation of currency; (ii) the sending of currency at home; (iii) international transactions. Table 1 shows a summary of the main services offered by these companies.

2.2 Social computing

The Internet also introduced a social element that allows the users to collaborate, share interests, publish personal insights and use the computers in a social way. Some authors approach social computing as the computational facilitation for social studies and human social dynamics as well as the design and use of new technologies that consider social context. In 1994, Schuler defined social computing as the methodology "describing any type of computing application in which software serves as an intermediary or a focus for a social relation" [26]. So social computing is basically the use of computers for social purposes [5]. In social computing, the Internet supports the infrastructures within which social interactions and problem-solving activities will be performed according to the deeply interactive rules and patterns that regulate societies. Key aspects include end-user experience in interacting with a social machine and user perception [30].

For Robertson et al. [24], the power of social computing resides in the programmable combination of contributions from both humans and computers. On the one hand, within organized social computation workflows, humans bring their competences, knowledge and skills, together with their networks of social relationships and their understanding of social structures. On the other hand, new technologies can search for and deliver relevant information. Humans can then use this information within their contexts to achieve their goals and, eventually, to improve the overall environment in which they live. Social computing has evolved during recent years to provide more realistic ways to improve social behaviors and relationships using computer science.

Current solutions have focused on theoretical underpinnings, technological infrastructure and applications [24]. These range from simple forms of social interaction to the coordination of large-scale collaborative efforts, and it is necessary to provide new solutions for: various forms of socially distributed problem-solving; various aspects of social relationship management and various aspects of social cognition or social sense-making (for example, people's perception of an economic or social transaction, social networks or currency exchange)

In the business sector, the use of the Internet has brought innovation in the form of social networks [4] which facilitate contact between users and businesses [28]. This makes it possible to provide advertising and online sales services in a more direct way, due to the large amount of personal information provided by users. Existing social networks focus primarily on facilitating social networking mechanisms, but do not attempt to respond to complex problems. Troubleshooting with a high level of complexity requires the design of new computing platforms and the use of innovative technologies that allow for the inclusion of organizational aspects and distributed problem-solving mechanisms [12,30].

Up until now, we have focused on social computing as a methodology that is closely linked to social networks; however, it goes much further than that. Social computing is the basis of the latest trends in software system research and development. Research works that focus on the social interaction of the elements in a system have proliferated [7]. This is the case of the most current lines of research on MAS related to automatic negotiation, argumentation, trust, reputation, etc. Also, the management of virtual organizations [25] (which make it possible to implement a social network in any hierarchical structure), social learning [2] or agreement technologies (which have evolved from being an area of general study of philosophy, sociology and human sciences), has being a key term used by many countries in different lines of research on MAS.

Social networks like Facebook and Twitter have acquired great importance in the field of social computing. Although initially they were not conceived as such, they have come to be the first versions of social machines, and this is because apart of their main function as social networks they can also help solve social problems. Thus, in the field of conventional computing, we can find: (i) social machines oriented at the creation of climatological models (which require large computational resources and management of large volumes of data, but in which the social aspect is not very significant) [8]; (ii) social machines for air traffic control (in which high levels of computing and data management are required and in which the social aspect has only recently been recognized as important) [29]; (iii) social machines based on crowdsourcing (like GalaxyZoo, with social, computational and low data management levels) [8]; (iv) social machines based on collaborative content creation (like Wikipedia, which has a considerable level of social interaction but where information management and computational complexities are low) and machines that focus on (v) social relationships (like Facebook which has a high degree of social complexity).

The design of social machines with these characteristics requires research on the use of distributed artificial intelligence, which allows to model both social behaviors and the interaction and organizational structures found in human societies. In this respect, MAS is particularly suitable for the creation and management of artificial societies.

Social computing can greatly contribute to the efficacy of the system in providing personalized offers to users, as it allows to extrapolate the offers accepted by users with certain characteristics to a group of similar users. These systems can either be homogeneous or hybrid [27]. In the present project, the knowledge acquired from individual clients can be used to benefit sets of clients with similar characteristics. This allows us to offer personalized service in relation to both aspects; offers and the sum of money to be exchanged. The system will detect the needs of every single client even if the client does not specify them.

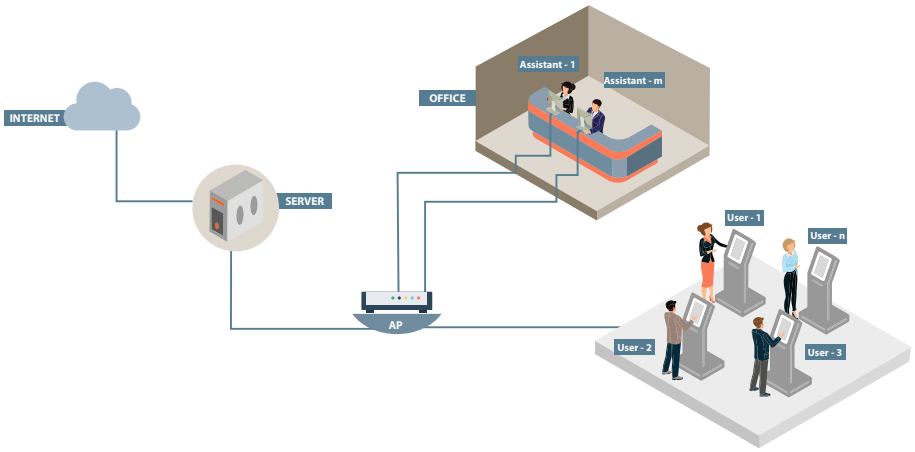

Fig. 1 Proposed case study

3 Proposed system

This section focuses on the technical details related to the system proposed in this work. It describes the different technical aspects that make up the proposed system.

3.1 Architecture deployment environment

Although some companies have used the Internet to provide services to users that enable them to buy currency or book money online, none have provided solutions to customers at airports who tend to be in a hurry and need a fast service. For this reason, it is necessary to develop a self-ordering kiosk system (Fig. 1) that simplifies the process of currency exchange in airport offices. Thus, the system proposed in this work is an advancement over traditional currency exchange offices, which can have a very positive impact on customer satisfaction.

This project has been designed in collaboration with an international currency exchange company, called Global Exchange. Global Exchange has a new affiliate in Sydney Airport, Australia, with around 150 employees of which 80% are bilingual and 40% speak a third language. However, this is not enough to be able to communicate with each client using his/her native language. The main aim of this project is to provide a system that will help eliminate all possible language barriers in providing currency exchange service, reducing errors in communication and the time of service.

3.2 Platform services

To develop the proposed system, the needs of the market have been analyzed and the new possibilities that technology gives us to provide for these needs have been considered. Thanks to the objective of offering a service in the native language of each client, the system should allow to exchange currency at airports in an easy and quick way. Another objective of the system is to provide a safe and error-free operation process in human-to-human interaction, thanks to the advantages of human–machine interaction in social computing. In addition, this should reduce the time that a teller needs to attend each customer, which considerably

reduces the time that clients have to wait for the service, and this increases their satisfaction with the service. Rapid service and clear communication are important as clients often have little time to exchange the currency before their flight leaves.

All the developed functionalities will be integrated in a tablet which will be located in each of the offices in the airport. To this end, the following functional objectives must be met:

(i) Interconnection with central systems: it is important that all information introduced in the device remains up to date and unified with the company's central information systems, and this will ensure that transactions are recorded properly and that the exchange rate is appropriate. Since most airports are not allowed to deploy a Wi-Fi access point, the interconnection must be via cable.
(ii) Interconnection with money laundering and terrorism prevention systems: the system will be integrated with existing blacklisting services.
(iii) Multi-language: as mentioned above, one of the main problems in providing currency exchange service to people of all nationalities is the difficulty in communication. When one of the two parties does not have a good command of the language in which the conversation takes place, it is likely that errors or misunderstandings occur. To resolve this problem, the system will offer a wide variety of languages so that users can be attended n their native language or in the one they know best.
(iv) Presentation of offers: the rate at which the service is provided often depends on the amount of money that a client wants to exchange. Generally, the more money the customer exchanges, the lower the exchange rate. Thus, the client is offered different exchange fees which depend on the amount of money that they will exchange. This allows them to decide carefully which is the option that best adapts to their needs, without feeling pressured by the teller.
(v) User verification: to verify a client, a confirmation request must be sent to the client's e-mail. In the traditional currency exchange method, the client spells out their e-mail address to the teller, and this increases the probability of typing errors, implying difficulties in user verification. In the proposed system, the user introduces their e-mail address by themselves in order to avoid typing mistakes.
(vi) Payment management in the device: the user can choose to pay with their credit card and will only have to give the receipt to the teller at the counter, whose task will be to verify that the personal information has been entered correctly and will subsequently give the client the corresponding amount of money in the currency they had requested. This makes the whole procedure much faster. If the customer wants to pay with cash, the teller will issue the receipt. In this case, the process of buying and selling is also much more simple as all the information is introduced in the tablet and there is no need for the client to communicate anything to the teller.
(vii) Feedback: the system will be fed back with the information obtained from the transactions. In this way, it will learn about different user profiles, providing offers that are of interest to users.

The company will pursue the following objectives:

(i) Reduced time of service: the use of social computing in the process of currency exchange implies a reduction in the time that tellers spend at attending the clients. This is because a large part of the process is carried out by client through the device.
(ii) Reduced waiting time: as a result of the above objective, clients will not have to wait for long to be attended. In addition, several clients will be able to make their currency exchange requests simultaneously, on the tablets provided in the office. The cost of

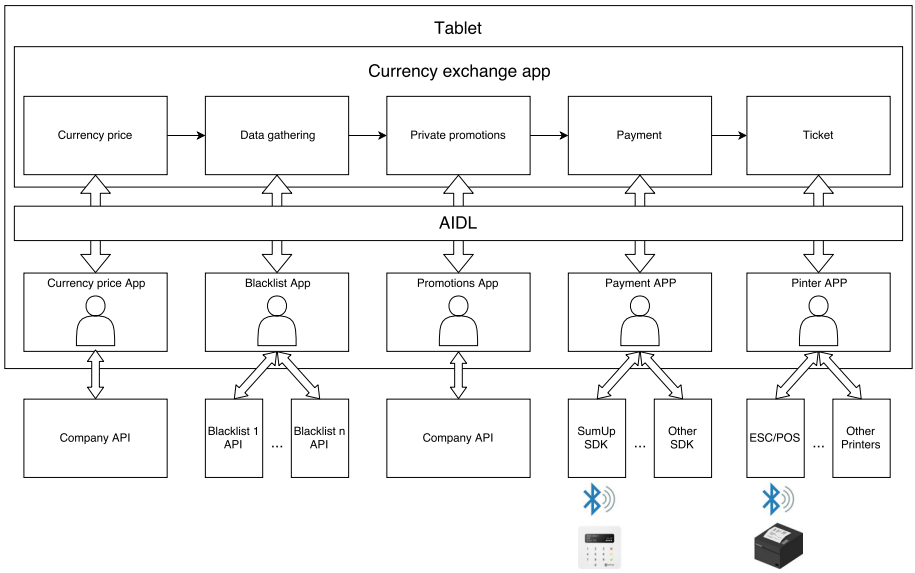

Fig. 2 Software diagram

supplying the office with additional tablets is not high and can reduce the waiting time considerably. This also reduces the company's needs for more staff members.

(iii) More operations: by reducing the time required to attend each client and by providing digital simultaneous service, it will be possible to offer the service to more clients. Reduced queues are likely to attract more clients, given that the majority of them are in a hurry to get to their flight on time.

(iv) Error-free data: social computing greatly enhances the process of communication between people who do not speak the same language. In this case, the user is responsible for providing their information electronically, reducing the possibility of errors occurring due to poor understanding of a language.

(v) Offers suited to users interests: social computing and agent technology are integrated in the system. This makes it possible for the system to detect and learn from behavior patterns, creating profiles of the clients and matching the offers they are interested in. These learning capabilities allow the system to provide users with offers that are suited to their interests, and such offers will persuade users to increase the amount of money that users exchange.

3.3 Social computing agent-based architecture for currency exchange

Part of the designed software, more specifically the one that customers interact with, runs on a tablet with an Android operating system. This device was chosen because it provides greater flexibility in connecting peripheral devices. In this case, the device must be connected (i) physically to an access point via Ethernet cable connected to an adapter and the USB of the Android device; and (ii) through Bluetooth to the devices in charge of the transaction (band, chip and contactless card reader) and a receipt printer. The software was designed

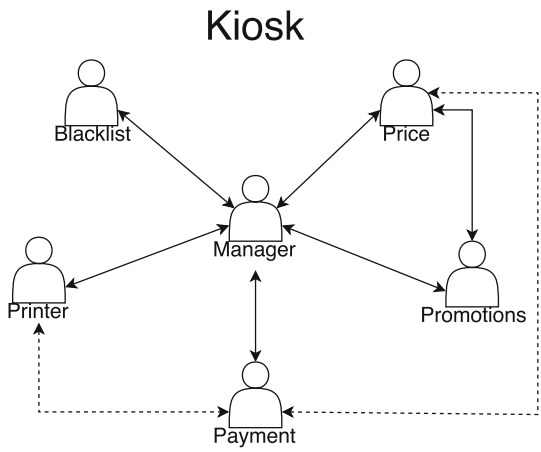

Fig. 3 Agents communication diagram

in modules (see diagram in Fig. 2), and this type of systems are dynamic and can add new solutions at any of the modules without interfering with the operation of the rest.

This user interaction software is connected to the agent-based architecture, which has been developed using the JADE framework and has been modeled using the GAIA methodology. Each role is defined in GAIA by four attributes: responsibilities, permissions, activities and protocols. Responsibilities, in turn, can be divided into two categories: life properties and security properties. Responsibilities determine functionality and are perhaps the key attributes associated with a role. The permissions identify the resources that the role has available to carry out their responsibilities. The roles fulfilled by the agents can be seen in Fig. 3, the roles of these agents are reactive based on the BDI model, and the agents react to the actions of the users. The "Price agent" is proactive as it is in charge of adjusting the currency exchange price. All the communication processes are carried out through the FIPA-ACL protocol that JADE included.

The "Currency exchange app" is administered by the Manager Agent, who is in charge of the system flow, error control and displaying all the information in the language that the user indicates at the beginning of the process. To ensure that the immediate implementation of solutions is secure, a main app was created to execute the agent in charge of controlling the flow of the transaction: calculation and presentation of the price of currency, obtaining user data, providing private promotions based on the customer's data so that they fit the profile, payment management (which allows payment by card at the moment or cash at the counter) and printing of the transaction receipt.

Each functional block is structured in agents, which are embedded in different applications, so that a functional change in one part of the system does not affect the rest of the modules that operate within the system. Figure 3 shows the connectivity between the different agents, and Fig. 4 shows a sequence diagram of an error-free operation (to simplify its understanding).

Thus, each module has an associated app where an agent is executed to ensure that the associated standards its functionality is complied with at all times depending on the state of the environment: the entire operation. These modules have a completely independent application that encapsulates all its functionality and communicates with the application through Android Interface Definition Language (AIDL).

Thanks to the use of the AIDL language, each agent that runs as a standalone application can communicate using communication between Android applications. By means of AIDL,

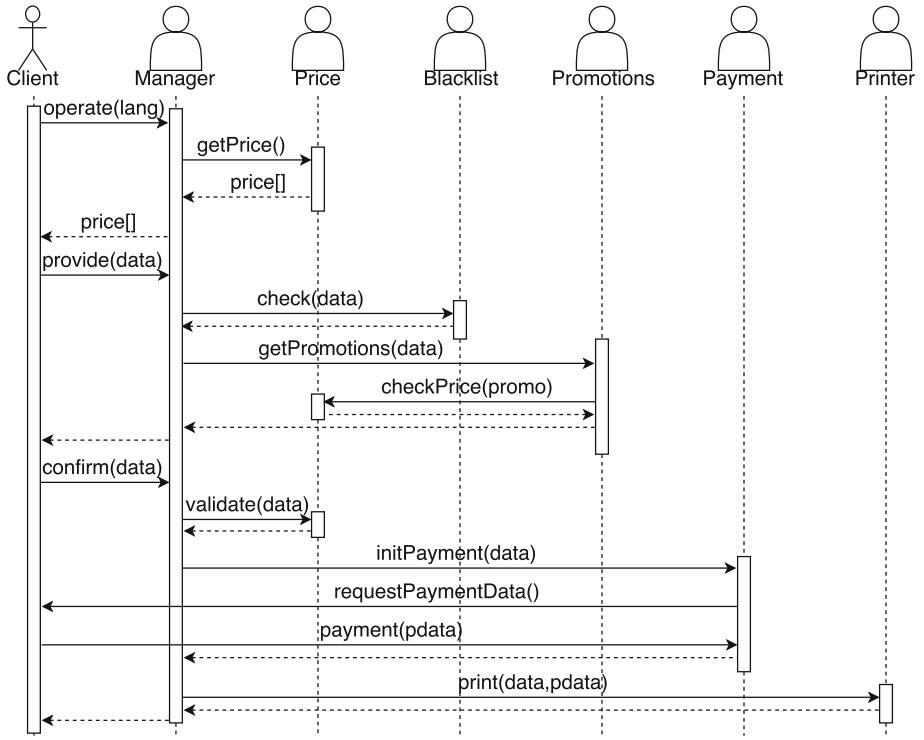

Fig. 4 Agents sequence diagram

methods are established which can be called remotely by other agents. "stub" is used to make these remote calls transparent to the programmer. The mechanism involved in the functioning of AIDL is illustrated in Fig. 5

In this way, the main application relinquishes control of functionality to the secondary application, which will perform its operations and return the result and control to the main application. Thus, there is an interface that provides independence even when working with other SDKs (Software Development Kits), such as the payment gateway system or with specific protocols, such as the ticket printing device. In this way, if a better system appears in the future, it can be integrated transparently. Each of the system's independent modules is presented in greater detail below.

– *Currency exchange fee* this module presents the user with the fees the company will charge for exchanging currency, and these fees vary depending on the currency and the private algorithm of the company. These prices are calculated specifically for each office and include factors such as the profit margin and the minimum value at which each currency is traded. In addition, the user has the option of choosing different fees, depending on the quantity they want to exchange, and in this way, the user can choose the offer that they find most convenient. The agent who is in charge of the fee system must guarantee the client that the following rules will be met: (i) The fee does not change once the client has selected it and completes the transaction. (If this is not possible, the transaction is stopped by the system and fee information is recalculated.) (ii) The stated monetary value can be provided based on the minimum value at which the office operates. If this is not the case,

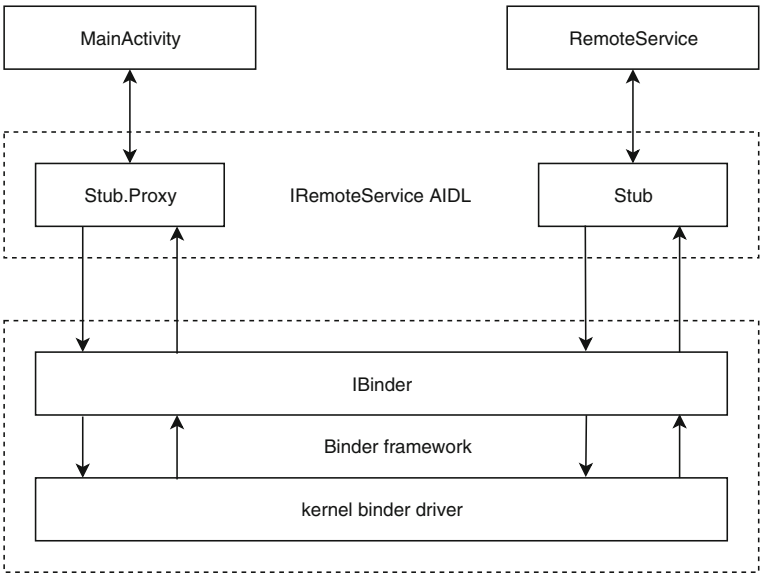

Fig. 5 AIDL diagram

the lower and upper rounding should be suggested so that the office can operate so that the user chooses whichever rounding he or she wishes; (iii) the office has sufficient cash to satisfy the amount requested by the user.

– *Blacklist* this module connects to different blacklisting services in multiple countries, and they contain information on potential tax evaders, criminals etc. These blacklists were examined to ensure that they comply with the law in terms of the company's own operations: It is guaranteed that the maximum amount of change is not exceeded and that no two operations take place in distant locations in a short period of time. In this case, the agent responsible for ensuring the viability of the operation must check that the following rules are met: (i) The data provided by the user are not included in any of the databases. If so, the transaction is permitted, but the teller is warned and is to act as required depending on the type of list; (ii) the user does not cross the maximum exchangeable currency under the laws of their home country and the country in which the transaction is performed; (iii) the user did not perform any transactions with the company in the past that would violate the law; (iv) the user did not make any operations with the company in two distant places; and their presence in the two offices in such a short period of time would have been improbable.
– *Promotions* private promotions are offered to foster loyalty among customers who have used the company's services at any of the its offices. Depending on the circumstances, private promotions can be presented even if the client is new. In this case, the agent must ensure that the following rules are met: (i) the promotions presented are not exclusive of any other factor related to the transaction, such as the selection of an offer on the exchange rate. In the event that a promotion is exclusive, it is not shown to the user; (ii) the customer complies with the conditions of the promotion in terms of usage, etc. If the customer does not comply with the conditions, the promotion is not shown to the user.
– *Payment* this system module connects to the payment gateway which, for now is an external system (does not belong to the company). In order not to remain permanently

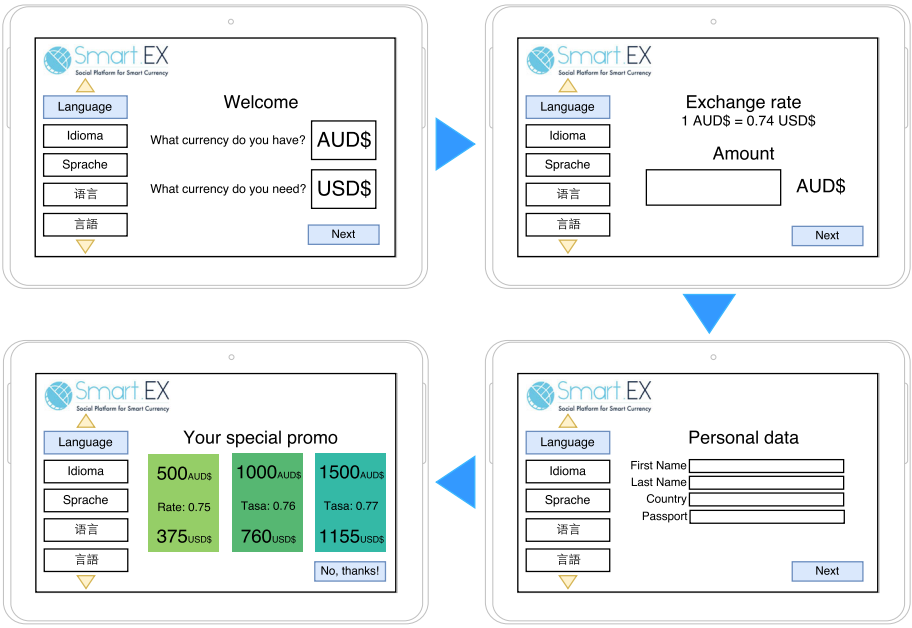

Fig. 6 Software system schema

linked to a system and be able to change payment gateways in the future, this application allows the use different SDKs and even change gateways depending on each country. SumUp was used in this first prototype, from SumUp Payments Ltd. It allows for payments by card with chip, band and contactless. In this case, the agent must ensure the following rules are met: (i) The exchange rate has not changed since the confirmation of the purchase. In the event that the price has changed, the exchange rate, the amount to be paid, the rules of the agents associated with the above steps are updated, and a confirmation message is displayed to the user; (ii) if the user chooses to pay by card, a successful transaction must be confirmed with a message. If the system returns an error message, the customer will be asked to pay a total of three times and if not successful, the customer will be asked to pay at the counter.

– *Printer* there are different hardware devices and protocols that allow the printing of receipts through USB, Bluetooth or Wi-Fi connections. For this first system, we have chosen the Bluetooth option to reduce the physical connection. The ESC/POS protocol was chosen, a variation of the Epson Standard Code for Printers (ESC/P), created by the Epson company for communication with its printers and which is the most used standard for communication with receipt printing devices. It can print images, including the company's logo and a QR code that identifies the transaction unambiguously, providing all the information about the operation performed by the user. The associated agent must check that the following rules are met: (i) The printer is connected to the tablet, and the device is initially connected through Bluetooth; (ii) the system returns the return code successfully; otherwise, the transaction identifier is displayed on screen, which the user must write down and show to the teller.

The advantage of using a multi-agent system is that each agent or layer of agents can be replaced by another to achieve the desired objectives. This allows each module to operate

independently, allowing the system to work with different hardware components or service provider systems in a transparent way for the whole system. Figure 6 shows a diagram of how the software works on the tablet.

4 Case study

To validate whether the proposed system provides more benefits than the traditional method of currency exchange, it was necessary to conduct a case study in which its performance would be compared with different control groups. This subsection describes the implementation of the proposed system in detail.

4.1 Experimental setup

The experiment was divided into two phases and took place between August and November 2017. In the first phase, the tellers participating in the case study did their work as usual, using the traditional face-to-face currency exchange method. In the second phase of the experiment, the proposed system was implemented and the tellers used it to provide service to the clients at the airport.

The first phase of the experiment was conducted in August and September, and in this phase, all the objective parameters to be improved through the use of the system have been checked and measured. The start time of each currency exchange operation was done through the monitoring system used by the security cameras. At the end of this stage, a process was carried out to compile the values (some of them manually) of the objective factors: persons for each age range, nationality, operation time, amount of transactions, amount per transaction, acceptance of suggested offers and errors in the obtained user data. The system was implemented in the second phase, in the months of October and November. Operation time was measured from the time the customer started interacting with the tablet, and nationality and age range information were obtained from the passport. The system also shows an analysis of the amount per transaction and number of transactions performed per day, week and month (and for different time slots within a day) as well as the percentage of acceptance of suggested offers and errors in the obtained user data.

The assessment was conducted at T1 Sydney Kingsford Smith International Airport, Sydney, Australia. Sydney Kingsford Smith International Airport receives forty million passengers annually, of which fourteen million are international. Global Exchange was conceded all 21 currency exchange offices at Sydney airport's international terminal, each office has 12 self-service kiosks and six tellers exchanging currency at the counter, and if the currency exchange has been performed at the self-service kiosk, the teller only verifies if personal information has been entered correctly and exchanges the currency.

Over the course of the case study, 5,692 people aged between 25 and 55 used the service to exchange the currency from their country of origin to AUD or vice versa. Table 2 classifies the case study participants by their nationality and age range.

4.2 Results

The different factors measured in the case study were evaluated in order to obtain the results. The performance of the implemented system was assessed by looking at the extent to which it helped improve these variables. The first part of this section analyzes customer satisfaction

Table 2 Case study participants classified by their nationality and age range

	25–30	30–35	35–40	40–45	45–50	50–55	Total
Argentinian (ARS)	65	85	87	90	82	84	493
Brazil (BRL)	76	103	102	140	96	78	595
China (RMB)	53	68	172	135	82	27	537
Colombia (COP)	25	34	30	44	52	49	234
Germany (EUR)	37	26	47	85	111	34	340
India (INR)	54	82	67	79	98	56	436
Japan (JPY)	45	132	139	106	72	3	497
Korea (KRW)	38	108	130	149	56	21	502
Mexico (MXN)	64	75	110	80	67	44	440
New Zealand (NZD)	68	99	145	167	102	131	712
Qatar (QAR)	0	12	2	21	7	0	42
Spain (EUR)	2	35	35	66	57	0	195
United Kingdom (GBP)	17	16	71	96	34	18	252
United States (USD)	35	34	86	133	65	64	417
Total	579	909	1223	1391	981	609	5692

with the proposed currency exchange system. Then, the parameters collected in the case study are compared: the time it took to attend a client using the traditional method and the time of operation with the proposed system; the amount of transactions and amount of money exchanged before and after the implementation of the proposed system. Differences in obtaining data from customers have also been studied.

The performance of the proposed system was assessed by comparing it with the traditional money exchange method, which had been used by the company (decrease in the time of operation/increase in the amount of transactions per day/increase in the amount of currency exchanged/customer loyalty/percentage of acceptance of offers/decrease in error in process of obtaining user data). The conducted case study consists of two phases because we could not compare our system with that of competing companies. This was not possible because it would have been necessary to define the same parameters and the same users, so it would not have been a valid test. Another aspect that prevents such is the confidentiality of this type of transactions, since no competitor would provide personal user information and transaction data (nationality, age, amount of currency exchanged, etc.). Moreover, all currency exchange offices at Sydney airport are owned by Global Exchange.

As we can see in Fig. 7, there has been an improvement in the variables evaluated (Amount per transaction, Customer satisfaction, Obtaining of User Data, Operation Time, Transaction Volume) for customers from Asian countries. Obtaining of User Data and Customer Satisfaction are the variables that achieved the best rating, and Global Exchange also considers these variables the most important since their aim is to satisfy customers and be able to provide them with new offers. A large percentage of these customers will return to the company to perform another exchange operation.

The following subsections discuss more factors that were evaluated as part of the case study.

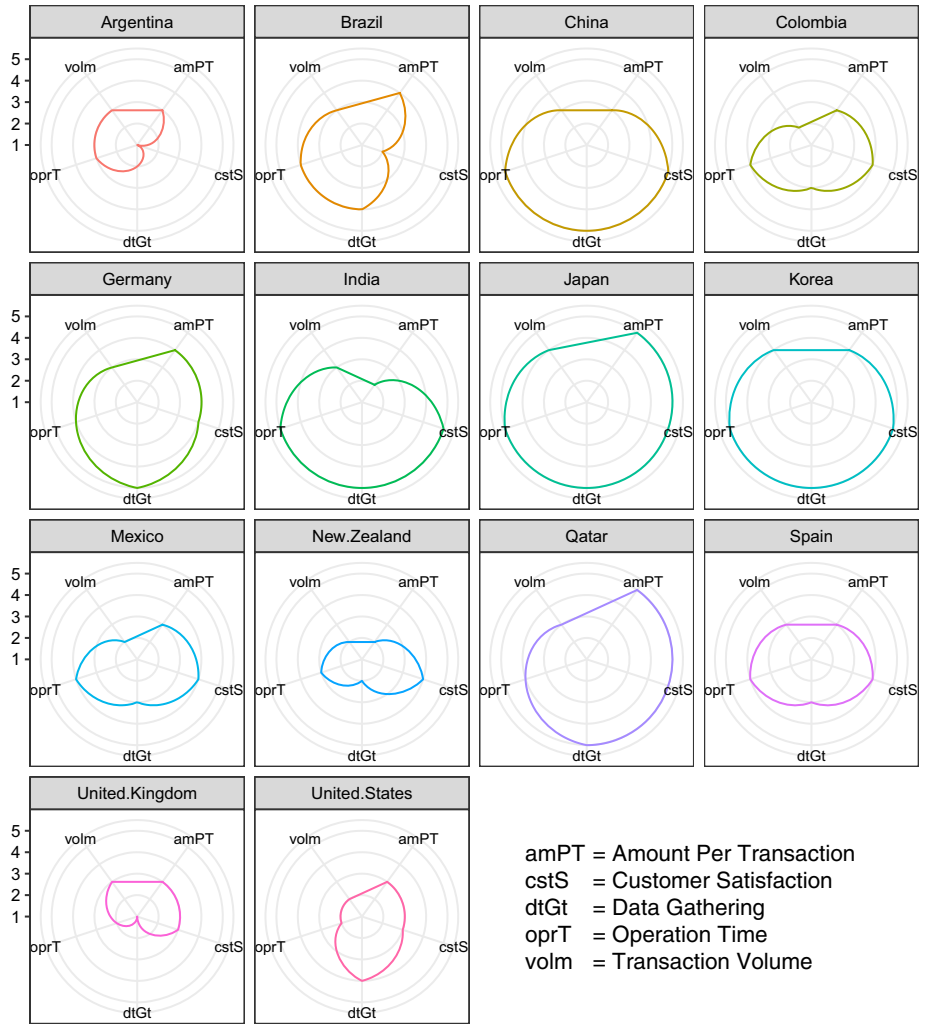

Fig. 7 Comparison of the average values given by customers according to their nationality for the factors analyzed

4.2.1 Customer satisfaction

In order to assess user satisfaction with the system, a feedback system was implemented over the two-month case study period. The feedback system asked the user for two different ratings. One regarding the exchange rate, something that users generally do not find pleasing. The other rating was on the exchange procedure provided by the developed system. Here, we only focused on the ratings that regarded the performance of the implemented system. If a user liked the procedure, then they will not hesitate to recommend its use to others. As one of the objectives is to make the currency exchange process simple and user-friendly, customers can even recommend this system to their acquaintances, and the Net Promoter Score (NPS) metric was used to evaluate user satisfaction with the system.

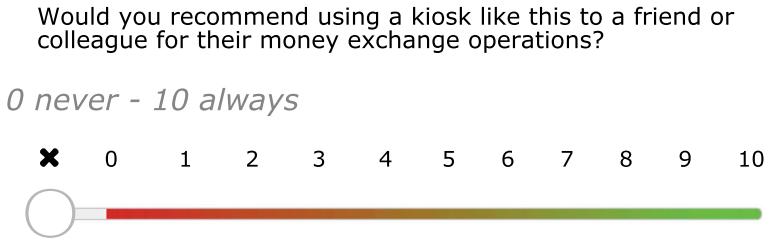

Fig. 8 Feedback form

Table 3 Feedback results

Total clients	Promoters	Passive	Detractors
5692	2201	2979	504

NPS provides a metric that is used to measure customer satisfaction through the question "How likely is it that you would recommend our company/product/service to a friend or colleague?". In our case, the question is "Would you recommend using a kiosk like this to a friend or colleague for their money exchange operations?". In NPS, users who respond with a score of 9 to 10 are the "Promoters." Users who respond with a score of 0 to 6 are labeled "Detractors." Responses of 7 and 8 are labeled "Passives." Then, NPS is calculated by subtracting the percentage of users who are "Detractors" from the percentage of users who are "Promoters" by applying the equation defined in (1).

$$\text{NPS} = \frac{\text{Promoters} \times 100}{\text{Total Respondents}} - \frac{\text{Detractors} \times 100}{\text{Total Respondents}} \tag{1}$$

So NPS can be as low as -100 if all the users are "Detractors" or as high as $+100$ if all users are "Promoters." In general, an NPS that is positive is good enough and an NPS of $+50$ is excellent.

All the 5,692 users filled the form shown in Fig. 8. Of them, 2201 were "Promoters," 2979 were "Passive," and 504 were "Detractors," resulting in a value of NPS $= 29.81$, which is considered an intermediate level among good (NPS > 0) and excellent (NPS ≥ 50) results (Table 3).

4.2.2 Operation time

The average that tellers spend at providing service to each client reduced significantly, from 319 s (without using the system) to 84 s (with the system). This reduction is due to the fact that the teller only performs a half of the procedure: They receive the receipt of the currency purchase process, which specifies the amount of currency that the customer is to receive and the currency with which he is making the purchase. Moreover, the time a client waits from the moment they queue until they are attended reduced from 276 s to just 128 s. A comparison between these times in the two phases is shown in Fig. 9.

4.2.3 More transactions and greater amounts of money

The amount of completed transactions increased by 27%, and this is due to the number of customers who were previously discouraged from exchanging currency when they saw a

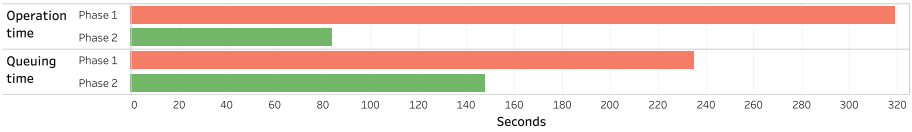

Fig. 9 Operation and queuing time comparison

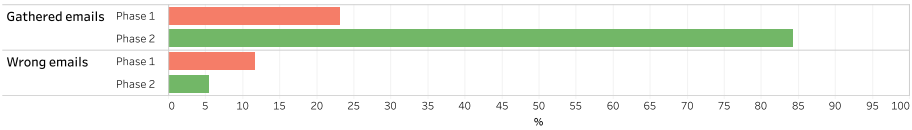

Fig. 10 Gathered e-mails comparison

large number of people queued for the service. Customers from Asian countries knew of the implementation of the system, and this had also contributed to an increase in customers. For privacy reasons, the amount of daily, weekly or monthly transactions cannot be disclosed.

As for the increase in foreign exchange, there was a 34% increase per transaction. This was mainly due to the fact that by showing three options with which to obtain a better exchange rate, people increased the amount of money they exchanged in order to get the offer that benefited them. However, the company cannot reveal the daily, weekly or monthly amount of transactions.

4.2.4 Obtaining user data

The main aspects that were considered in the evaluation of the proposed system were the waiting time period per customer and the extent of customer satisfaction in interacting with the designed system. However, for an international company like Global Exchange, it is very important to have detailed information on its customers (mainly the nationality and age range of the customer), which is provided by the developed system. This will allow the company's marketing team to develop an operational strategy for currency exchange offers with this target audience in mind. This allows marketing campaigns to focus on building loyalty in a specific market niche and to focus on attracting customers with other features that do not change currency through the system.

Another noteworthy figure was the percentage of users who gave up their e-mail addresses; the percentage of users who gave up their e-mail addresses in the first phase was around 23.15%, and the percentage of users who gave up their e-mail addresses in the second phase was 84.3%. Of the mails that were provided in the first phase, 11.7% of the mails were erroneous (a reply was received from the mail server informing about it), while in the second phase, this percentage was reduced to 5.52% (Fig. 10.)

In this case, the number of customers operating is not too significant since the company is the only one operating at the airport as it has the exclusive concession of currency exchange. However, it has been evaluated since there are a number of potential customers who change currency outside the airport (at their travel destination or at exchange offices in the city center), noting an increase in the number of customers.

5 Conclusions and future work

Social computing concepts are all associated with a new area. Currency exchange is a market that has many customers, and no exchange company has ever adopted a technological approach to provide service to users. Social computing makes it possible to take advantage of the information that each user provides to adapt to future user profiles, increasing both their satisfaction and the company's benefit.

The results of the case study demonstrate that the objectives posed in this work have been achieved. The result sought was to develop a system that boosts the company's performance by making its services faster. This could be achieved by pursuing multiple sub-objectives. The use of a multi-language system made it possible to provide service to a wide range of clients coming from different countries. This made it possible to provide good service to people whose native language was not known by the tellers (such as Asian or Oriental languages). Short waiting period for the service also encouraged customers to change their currency in the company's office, before going to their destination. Notable data on system usage have been obtained; the operation time and the queue time. The time it took to exchange currency decreased by 73.67%, which was around 235 s less for an average operation. The waiting time in the queue was reduced by 148 s, resulting in an average of 53.62%. These percentages show why the system obtained such a good NPS value.

Due to the success of the first version of the prototype, future work will focus on the design of a new version which will integrate all the peripheral devices in a single device (printer, card reader) together with the tablet. The aim of this new version will be to attract new customers with a more visible and appealing design. Once the new device with all the integrated components has been developed, it will be deployed in the company's offices at airports around the world. After an evaluation period of four months, the system will be re-evaluated in this case, taking into account airports where there are offices of rival companies, so that there may be a wider scope for attracting customers. This also allows knowing other data and cross-checking them with data from the counters of other airports to know, improve and adapt the products to the customer, improving the user's attention and experience with the system.

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