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ORIGINAL ARTICLE

An architectural framework for developing a recommendation system to enhance vendors' capability in C2C social commerce

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Abstract
The rapid growth of social networking usage has initiated a new business model called C2C s-commerce which has opened a novel opportunity for SNS users to conduct commercial activities among members. Novice vendors (low-maturity merchants) perform business using a trial-and-error method. Through learning by doing, capability enhancement in online business arrangements to become a mature vendor is difficult and takes time. Having a recommendation system can effectively and systematically support inexperienced vendors to conduct online business and enable vendors to become high-maturity merchants. This study proposes architecture of a C2C s-commerce recommendation system presented in conjunction with its input, process, and output. The architecture was devised to infer from information collected from case study interviews, observation, and secondary research methods. Artificial intelligence technologies and big data were considered to design the proposed framework in order to generate efficient recommendations for capability enhancement in online business arrangements.

Keywords Recommendation system · C2C s-commerce · Machine learning · Maturity model · Artificial intelligence

1 Introduction

The widespread use of social networking sites (SNSs), such as Facebook, Line, and Instagram, in developing countries has been leading to the emergence of a new business model called consumer-to-consumer social commerce (C2C s-commerce). Through social networking platforms, social and commercial functionalities of the sites have given people (both individuals and small retailers) access to new marketing channels. For example, product advertisements have been posted on the wall of a Facebook personal profile, page, and group as well as Instagram (Sukrat et al. 2016; Chen et al. 2016c). Two-way communication between vendors and buyers for placing an order, negotiation and interaction can occur by leveraging communication features of social networking sites such as Line chat and Facebook Messenger (Sukrat et al. 2016). This business model has been growing rapidly in developing countries such as Thailand.

In order to succeed in an s-commerce context, one of the factors that plays a critical role in increasing the consumer's purchase intention is trust. From previous studies, the results show that SNS users intend to purchase through SNSs when they have trust in people (sellers and other users), content (user-generated content), and platforms (Choi and Lee 2017; Lu et al. 2016a; Chen and Shen 2015; Wang et al. 2016). Kim and Park (2013) also found that Korean SNS users intend to purchase in business-to-consumer (B2C) s-commerce context when they have trust in this environment. The key factors affecting consumers' trust are the firm's reputation and size, information quality, transaction safety, communication, and word-of-mouth (WOM) referrals (Kim and Park 2013). It means that consumers have more trust and intent to purchase with the higher-maturity firms than the lower ones. Gefen et al. (2003) believed that when consumers trust electronic vendors, they would purchase products and services from the vendors. Interestingly, Hajli et al. (2017) also claimed that consumers may seek other channels to make a purchase with vendors they trust when they do not trust a

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platform. Before making purchase decisions, buyers can build their trust with vendors in s-commerce platforms through sellers' traits of benevolence, competence, and integrity. Additionally, trust leads to purchase intention (Lu et al. 2016a). Trust is built from knowledge about the capabilities of the company called knowledge-based trust (Alzahrani et al. 2017). Similarly, the findings from previous business research found that there are several factors affecting successful buyer–seller relationships, for example other organizations' perception of firms' capabilities (reputation), partners' satisfaction with firm performance, and trust (Powers and Reagan 2007). Thus, in order to increase consumer trust in vendors and engagement in the purchasing process, vendors have to present high-level maturity in their business arrangements to prospective consumers.

There is complexity within consumer-to-consumer trading in s-commerce (Sukrat et al. 2016). Commercial activities and transactions have been conducted among SNS users themselves. Vendors may be an individual or even a small retailer with no experience in online commerce or do not have a systematic process to perform online business. Moreover, it takes more time when the enhancement of vendors' capability has evolved from learning by doing. Consequently, having systems or applications for maturity assessment in business capability may increase a consumer's confidence when making a transaction with vendors in C2C s-commerce. Additionally, having a recommendation system (RS) that can guide vendors to conduct business through SNSs in a C2C model may help vendors to become trustworthy vendors although they are conducting business in the early stages of maturity. When trust is built from buyers' perception toward the vendors' capability, this perception leads to consumers' intention to buy in s-commerce context.

The major aim of the study is to propose an architectural framework for developing a recommendation system. The research questions are (1) how does a recommendation system for C2C s-commerce work? and (2) what is the appropriate architecture for developing a C2C s-commerce recommendation system? Proposed architecture has been divided into four layers: data preprocessing, data store, important components of system process, and system output. Leveraging RS based on our proposed architecture might be useful for individuals or small online retailers who might be vendors and/or buyers on social networking platforms such as Facebook, Line, and Instagram. The RS can help buyers to build trust in a vendor and make better decisions through an assessment of the vendor toward achieving a mature business implementation in C2C e-commerce. In terms of vendors, recommendations on business implementation may enhance their capability and increase their maturity to perform commercial activities. The study provides AI techniques for anyone with AI background to easily develop the recommendation system from the proposed architectural framework. This will also challenge other researchers to propose better AI techniques.

2 Related work

2.1 C2C s-commerce

C2C s-commerce is one s-commerce business model that utilizes the social and commercial functionalities of SNSs for online interactions and purchase arrangements among consumers (Sukrat et al. 2016). The purchasing process can be implemented through various social networking platforms such as Facebook, Line, and Instagram depending on the channel selection of vendors.

For a simple example, a vendor may use a single platform such as their Facebook personal profile for product selling. After posting product information and process description on their Facebook wall, buyers may comment under the post for negotiation and to place an order. Some buyers may use Facebook Messenger for private communication. Some Facebook users may post product pictures and other details via Facebook groups to sell both new and used goods to others within a specific group (Sukrat et al. 2016; Chen et al. 2016c). Using a variety of social networking platforms, vendors may post their advertisement on Facebook (i.e., personal profile, page, and group) and Instagram. Then, buyers can communicate to order product and engage in other activities with vendors through Line chat (Sukrat et al. 2016). It can be seen that C2C s-commerce is highly dynamic in terms of transaction processes and other retail activities. Each customer may have specific rules and transaction processes, which are bilaterally agreed by both parties. Conversely, in traditional e-commerce, which has common rules and transaction processes for all customers, only a few choices are available, but the choices are applied for all. This is why it is difficult to follow traditional recommendation system available for e-commerce.

2.2 Maturity model

Maturity is an evolutionary progress in the achievement of the capabilities of people, organization, process, or even technology in a particular discipline (Mettler 2011). In order to measure maturity, a maturity model has been developed by identifying an anticipated, desired, or evolutionary any path of those capabilities into each level of the maturity model from having few capabilities to the highest stage of maturity (Becker et al. 2009). Having a maturity model can support its target audiences to assess their current situation based on criteria and characteristics of each level. Additionally, these criteria and characteristics need to be fulfilled if

the target audiences would like to reach a high level of maturity in the domain under consideration (Becker et al. 2009).

Offering the right recommendations to the right vendors is an important issue for recommendation system success. Therefore, understanding and identifying their current stage of maturity through a maturity model would be applied when classifying a vendor based on their maturity in business implementation before making a recommendation to the vendors. From the literature review, most of maturity models in the context of online business and social media technologies are developed for the exposition of organization adoption and usage (McKay et al. 2000; Rao et al. 2003; Duane and O'Reilly 2012; Jussila et al. 2011). However, the study of Sukrat and Papasratorn (2018) proposed a maturity model of C2C s-commerce that included five maturity levels and four major maturity dimensions. The study also explained the characteristics of each maturity level in each related dimension. Therefore, this study applied the C2C s-commerce maturity model of Sukrat and Papasratorn (2018) in order to understand the evolution of vendors' capabilities in C2C s-commerce environment.

2.3 Recommendation systems

Recommendation systems are applications which are developed for providing personalized recommendations, content, and services to buyers by using information filtering techniques (Beladev et al. 2016). The recommendations are generated from data regarding buyers' behavior and their preference on items, for example music and TV program recommendation systems (Mao et al. 2016; Oh et al. 2014). Consumers gain more benefits from these applications by offering information that matches their preferences. The system can improve buyers' decision effort and decision quality (Xiao and Benbasat 2007). Buyers can reduce their search time to get a needed item because the systems can identify the items that suit their needs or preferences in an effective way (Li et al. 2013).

2.3.1 Recommendation systems in e-commerce context and social networking services

In the e-commerce environment, recommendation systems can help buyers reduce product search time and decision time, increase the amount of user input, and improve decision quality (Xiao and Benbasat 2007). The typical input data for computing the recommendations are demographic data (e.g., name, age, gender, salary, and education), rating data (e.g., latent comments and rating scores), buyer behavior pattern (e.g., browsing duration, Web links, and downloaded content), transaction data (e.g., purchasing date and quantity, price, and discounting), and item attribute data (e.g., singer, topic, price, and brand) (Wei et al. 2007). The literature revealed most researchers focus on improving techniques or algorithms for recommendation accuracy and performance effectiveness in order to enhance online consumer satisfaction and engagement in e-commerce Web sites, platform providers as well as social networking applications (Xue et al. 2015; Wei et al. 2017).

Due to a rapid increase in the use of social networking services, current studies attempt to develop recommendation systems for the enhancement of SNSs' services. Researchers exploit social media information (e.g., posts, comments, tagging information, common friend information, and like records), user behavior information, and user profile to provide recommendations to target users in various patterns such as virtual group recommendation (Guo et al. 2016a; Bok et al. 2016; Reshma and Pillai 2016), upcoming events recommendation (Sun and Chen 2013), informative friend recommendation (Chen et al. 2016a), and social media item recommendation (Sun et al. 2015; Lu et al. 2016b). A variety of techniques were combined and applied for creating a recommendation, such as filtering techniques (e.g., collaborative filtering) and sentiment analysis.

To sum up, most existing research studies focus on proposing recommendation systems for increasing performance of e-commerce Web sites and SNSs. The developed systems can facilitate consumers and SNS users when buying on Web sites and using SNSs. Interestingly, from the literature review, there is no article presenting recommendation systems for helping vendors to conduct commercial activities in the C2C market through SNSs. Additionally, the proposed recommendation system aims at maturity model with focus on one (or a few) man operated entities, while traditional maturity models usually apply to commerce entities with systematic management system (involving a number of people).

2.3.2 Approaches for the development of recommendation systems

The popular techniques for recommendation systems in e-commerce focus on filtering and providing items or products to consumers based on their interests and preferences. Various filtering techniques have been utilized to achieve the recommendation task in this environment such as content-based filtering, collaborative filtering, and hybrid filtering (Beladev et al. 2016; Chen 2010; Isinkaye et al. 2015). Content-based filtering techniques use the content of the objects that the buyer chose in the past to analyze the similarity between the items and commodities relationship and then generate recommendations. This technique needs to have an in-depth description of item attributes. Collaborative filtering technique makes recommendation based on information collected from other buyers. Buyers' interests and preferences are matched with other buyers who have

Table 1 The demographic information of research participants

Vendor	Experience (Year)	Sales channel	Product type
V1	< 1	Facebook personal profile	Cosmetic products
V2	< 1	Facebook page	Handmade products
V3	1–2	Facebook personal profile	Beauty products, sport shoes, bedding sets, handbags
V4	1–2	Facebook page and trade group	Clothes and books for kids
V5	2–3	Facebook personal profile	Beauty products
V6	3–4	Facebook personal profile and trade group	Clothes for kids
V7	> 6	Facebook personal profile and trade group, Instagram, Twitter	Clothes, fashion shoes, and imported products

similar preferences in order to offer an item that may be of interest. Necessarily, this technique has to have adequate information to prevent a cold-start problem that can reduce the performance of the recommendation system (Wei et al. 2017; Elahi et al. 2016). Hybrid filtering technique uses the combination of recommendation techniques to build hybrid recommendation systems for providing more accurate and effective recommendations and eliminating disadvantages (de Campos et al. 2010; Burke 2007). Additionally, some researchers applied machine learning approaches (such as deep learning) to improve the quality of recommendations, user experience, and trust of recommendation systems (Guo et al. 2016b; Wei et al. 2017).

3 Architectural design methodology

Xiao and Benbasat (2007) stated that there are three components to design a recommendation system: (1) input (where user behavior and preferences are acquired, explicitly or implicitly); (2) process (where recommendations are made); and (3) output (where recommendations are offered to the user). Similarly, Wei et al. (2007) also claimed that a recommendation system consists of three stages: (1) eliciting preferences from users' input data; (2) using appropriate techniques to generate a recommendation; and (3) presenting the recommendations to users. In order to propose an architecture of the C2C s-commerce recommendation systems, we applied two research methods (in-depth interview and observation method) for the identification of input, output, and functional specification (process) of the proposed systems.

3.1 Understanding business activities and transaction process to identify system inputs

To understand how C2C s-commerce vendors perform business activities that would be used to identify an input of the system, in-depth interviews and observation methods were applied to this phase. This study initially collected data from seven vendors as a pilot study to explore a vendor's commercial activities and transaction process. The interviewees were asked to explain how they conduct their businesses and what activities they do. Table 1 shows the demographic information of vendors who were participants of this study.

Through observation, more details on business activities and transaction process that were not found from the interviews were gathered. The detail of observable examples is shown in Table 2. Based on information from the interviews and previous studies, we found that vendors in C2C s-commerce use Facebook (personal profile, page, and group) and Instagram as a sales channel. There are two major categories of products that Thai consumers prefer to buy through SNSs: clothing and footwear, and health and beauty (Booasang 2017). From interview data and the study of Chen et al. (2016c), C2C vendors usually sell products for kids and second-hand products via Facebook group. Therefore, we used 300 observable examples from Thai SNS users who announce products for sale via Facebook (personal profile

Table 2 Number of observable examples

Sales channel	Product type	Amount
Facebook personal profile	Clothing and footwear products	50
	Health and beauty products	50
Facebook page	Clothing and footwear products	50
	Health and beauty products	50
Facebook group	Products for kids	25
	Second-hand products	25
	Clothing and footwear products	25
	Health and beauty products	25
Instagram	Clothing and footwear products	50
	Health and beauty products	50

and page) and Instagram. We also observed 100 examples of Facebook group to articulate the commercial activities of C2C s-commerce. Table 3 presents examples of business activities performed by C2C vendors through social networking platforms.

According to information in Table 3, system inputs that the RS should collect and analyze in order to generate a recommendation for its users were defined and these are presented in Table 4. This information would be queried from SNSs' databases. Additionally, other inputs that should be collected are user profile and information for business performance evaluation. Typically, the user profile would be developed and maintained for the performance of the entire recommendation systems (Li and Kim 2004; Gulla et al. 2014). In this study, user profile plays a critical role in the success of recommendation tasks because the RS exploits the profiles for identifying current maturity level of vendors for preparing recommendations that are fit for vendors' competency.

3.2 Understanding the evolution of vendors' capabilities using the C2C s-commerce maturity model

Typically, a maturity model is used as a benchmark for capability assessment in a particular area (Becker et al. 2009). A maturity model is an important tool for this study as it provides the evolutionary path and coherent criteria for vendors' capability assessment. In C2C s-commerce, vendors can take advantage of the model for the assessment of their current capability and the capability enhancement to reach the higher levels. With regard to

Table 3 Business activities conducted by SNS users (vendors) in C2C s-commerce

Business activities	Interview	Observation
Posting product advertisement including payment and delivery methods through Facebook personal profile, page, and group	x	x
Posting product advertisement and other information through Instagram	x	x
Contacting consumers via Facebook Messenger or Line chat	x	x
Generating VDO clip for product presentation	x	x
Posting product reviews created by vendors	x	x
Posting product reviews received from their customers	x	x
Posting an image of postage receipt to customers after product delivery	x	x
Offering promotions for special events	x	x
Presenting product images and information through comments under such posts that customers post their wanted products through Facebook group	–	x
Selling products via auction method through Facebook page and trade group	–	x
Using Facebook live video for real-time product selling through Facebook page and group	–	x

Table 4 System inputs of C2C s-commerce recommendation system

Input	Source	Description
SNSs' post	SNS	Content about product descriptions, price, payment method, delivery method, contact information, and other information that have been posted on SNSs such as Facebook (personal profile, page, group), Instagram, and other SNSs
		Content about a wanted product posted by buyers through Facebook group
Comment	SNS	A comment under such posts including text and images
Product review	SNS	A product review posted by vendors or buyers
Video stream	SNS	Multimedia content posted by vendors for product presentation and selling
Product image	SNS	A photograph that presents quality products offered for sale posted by vendors
		A photograph that presents wanted products of buyers posted to vendors through Facebook group
Group profile	SNS	Information representing a Facebook group such as name, cover, and description
Page profile	SNS	Information representing a Facebook page such as category, cover, and description
User profile	User	Information representing a vendor (e.g., name, gender, email, and education) and their experience in C2C s-commerce that would be used to verify to what extent vendor's capabilities are relevant to a maturity level
Business transaction	User	Information representing a business transaction performed through SNSs that would be used to evaluate business performance and compared with business plan

the use of a maturity model in RS, the characteristics of each maturity level help understand how RS will assist novice vendors to conduct online business as an experienced vendor. The system will identify the current stage of vendors' proficiency and offer an efficient recommendation. This study applied the C2C s-commerce maturity model presented by Sukrat and Papasratorn (2018). The model consists of five maturity levels (i.e., ad hoc, active repeatable, proactive functional, preemptive managed, and optimized). Each level is described with four major dimensions (i.e., business environment, people, process, and technology). The model used in this study is presented in Table 4.

3.3 Identifying system outputs and processes

The recommendations or outputs of C2C s-commerce recommendation systems help vendors to have a systematic approach for business arrangements in an s-commerce scenario. Understanding the evolution of vendors from novice to experienced vendors through a maturity model can support us to identify system outputs or recommendations that could be used by vendors for business implementation and lead them to be high mature vendors. The RS processes were identified using information from semi-structured interviews and observation as well as the maturity model shown in Table 5. Table 6 presents input, process, and output of the C2C s-commerce recommendation system.

4 Architecture of the C2C s-commerce recommendation system

Architecture of the C2C s-commerce recommendation system relies on machine learning and natural language processing. As shown in Fig. 1, the architecture is multilayered capable of coping with social networking service logs and content as input data and provides directions for conducting commercial activities on SNSs.

4.1 Development approach

To develop a C2C s-commerce recommendation system, a variety of AI techniques have been exploited in order to extract content within SNSs' databases and compute information into a recommendation. Table 7 presents important techniques used for our proposed recommendation system.

Through defining the main processes in Table 6 and RS development techniques in Table 7, each process was described with subsections regarding an adaptation of AI approaches for developing an application to meet the system requirements as shown in Table 8.

4.2 Recommendation system organization

Figure 1 describes an architecture of the proposed RS in terms of its main components. The model has three main layers which were adapted from the recommendation process of Isinkaye et al. (2015)'s study (i.e., information collection phase, learning phase, and prediction/recommendation phase). Data preparation and data layers of the model present the phase of information collection. The recommendation engine layer shows all components used to make a recommendation in the learning phase in which related algorithms are applied to execute information collected in the information collection phase. Last, the recommendations are offered to vendors in the recommendation phase.

4.2.1 Data preparation layer

Before the data mining process, social data from SNSs' data warehouse would be preprocessed in order to reduce data redundancy, noise, heterogeneity, and imbalanced data through data processing tasks such as data cleaning, normalization, transformation, missing values imputation, integration, and noise identification (García et al. 2016). Additionally, feature extraction and selection as well as data discretization would be processed in order to reduce data complexity for the machine learning approach (Zhou et al. 2017; Medhat et al. 2014). An important task of this layer is the process of extracting structured information from SNSs' data warehouse and collecting into databases for further data processing. For generating a recommendation, the RS has to select the relevant postings related to product advertisement and prepare structured information for categorizing all product postings by product type, determining the structure of product announcement posting, and supporting sentiment analysis and vendor behavior analysis.

4.2.2 Data layer

Important issues when designing the data layer are: (1) data access layer must meet the application requirements; (2) execute efficiently and securely; and (3) be easy to maintain (Microsoft 2009). Regarding the development of RS for business operations, the data layer should contain information regarding business environment (e.g., product offering, vision and mission, regulatory requirements, workforce profile, and assets), relationships (e.g., organizational structure, customers and stakeholders, and supplier and partners), and strategic situation (e.g., competitive environment, strategic context, and performance improvement system) (NIST 2015). Therefore, our architecture has four data sources:

Table 5 The maturity model for C2C s-commerce. Adapted from Sukrat and Papasratorn (2018)

Maturity level	Business strategy	People	Process	Technology
Level 1: ad hoc	No or very few defined business goals and objectives	A vendor has no or little experience to perform commercial activities through social networking platforms	No formal business process exists	A single SNS or service of SNSs is used for conducting commercial activity among users by trial-and-error method
Level 2: active repeatable	Business goals and objectives are defined but still unclear	A vendor has the capability to perform some core functions of business operation	Business processes are beginning to be carried out with well-ordered, repeatable approaches	A single SNS or service of SNS is still used in an efficient and effective way
Level 3: proactive functional	Business goals and objectives are formally defined as well as a business plan and strategy	A vendor has full capability to perform all core functions of business operation	All processes of business operation are characterized by effective, well-ordered, repeatable approaches	Multiple SNSs or services of SNSs are applied for expanding business and increasing sales
Level 4: preemptive managed	Business goals and quantitative objectives are fully defined for a measurement of sales performance	A vendor has the capability and commercial experience to perform all core functions and some support functions of business operation	Business processes are measured and evaluated to specified customer requirements in order to understand the process performance	The use of technology is for analytics and monitoring internal information in order to improve sales performance
Level 5: optimized	Based on the principles of plan–do–check–act, business goals and plan focus on continuous improvement through measures, monitoring, reviews, and reporting	A vendor has full capability and commercial experience to perform all core and support functions of business operation	Effective and efficient business process is established to reach current and future business needs	The use of technology is for analytics and monitoring external environment in order to continuously improve sales performance

Table 6 Input, process, and output of the C2C s-commerce recommendation system

Objective	Process	Input	Output
Understand current level of a vendor	Defining vendor's maturity level by classifying their capabilities from maturity model	User profile	Current maturity level
Help a vendor to reach maturity level 3	Recommending commercial activities for business operations in C2C s-commerce	SNSs' posts Product image VDO stream Comment Product review Group profile Page profile	An example of product posting (text, images, video, and emoticons) Appropriate time to post Appropriate channels to post
	Recommending promotional marketing strategies	SNSs' posts Product image VDO stream Comment Product review	List of promotional marketing such as contests, coupons, and giving away products that other vendors with similar products typically use for their business
Help a vendor to reach maturity level 4 or even level 5	Computing business transactions in order to find income statement and compare with business plan	Business transaction	Sales reports Financial reports Business performance reports

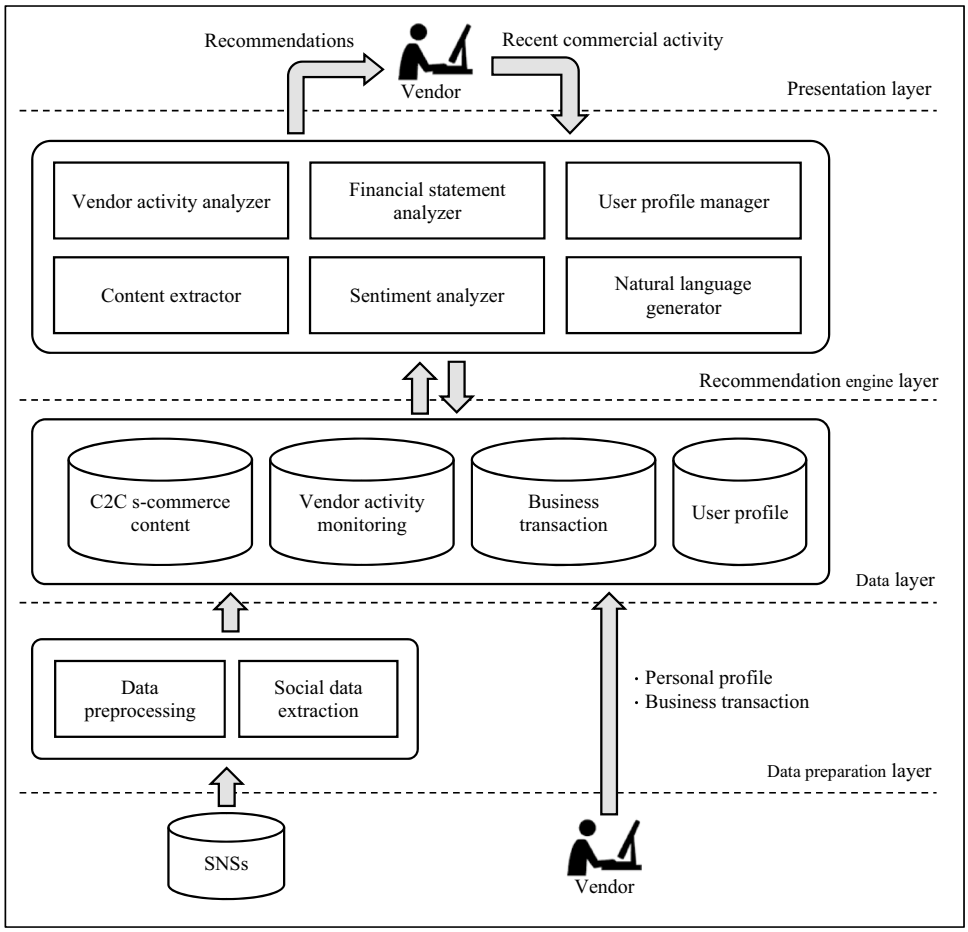

Fig. 1 An architecture of the proposed C2C s-commerce recommendation system

C2C s-commerce content; vendor activity monitoring; business transaction; and user profile. Table 9 presents the description of each data source.

Table 7 AI techniques for the development of C2C s-commerce recommendation system

Technique	Description
Text analysis	An approach for the extraction of textual data such as product announcement information, comments, and reviews in order to understand product announcement characteristics and buyers' opinions of such posts. An example of text analysis techniques is information extraction technique, text summarization techniques, and sentiment analysis (Gandomi and Haider 2015)
Image analysis	An approach for the distinction of an image from its texture, color, and shapes (Zheng et al. 2016; Chen et al. 2016b). For this study, image analysis would be applied for matching the product images with consumers' needed products as well as analyzing images for preparing an example of product announcement
Video analysis	An approach for video content analysis by processing both real-time and pre-recorded video information (Gandomi and Haider 2015). This technique would be used for understanding how vendors present and announce their products through video stream on YouTube or Facebook live video
Supervised machine learning	An approach for mapping new inputs to outputs based on learning from training data. Supervised learning algorithms include Bayesian networks, support vector machines, decision trees, and neural networks (Zhou et al. 2017). Using this approach, current maturity level of vendors can be defined in order to provide appropriate recommendations based on their business capabilities
Unsupervised machine learning	An approach for the discovery of hidden patterns in the input data by learning without labeled responses (Zhou et al. 2017). Self-organizing maps, K-means clustering, and hierarchical clustering are important algorithms of this approach. This approach exploits SNSs' content to find commercial activity patterns such as time periods for product posting
Social network analytics	An approach for the extraction of information from the structure of social networks such as community detection and social influence analysis (Gandomi and Haider 2015)
Natural language generation	An approach for the production of natural language as output by turning structured input data into easily understandable texts using linguistic knowledge and NLS application to automatically generate these texts (Ramos-Soto et al. 2016; Tintarev et al. 2016)

Table 8 Functional specification and proposed techniques

Functional specification	Technique
Defining vendor's maturity level by classifying their capabilities from maturity model	
Analyzing user profile information	Supervised machine learning
Recommending an example of product advertisement posting	
Selecting product postings having a similar type to the products that a vendor sells	Text categorization
Selecting product postings that make customers feel satisfied or liked in order to be an input for information extraction	Sentiment analysis
Analyzing product advertisement posting on Facebook (Personal profile, page, and group) and Instagram in order to understand product posting pattern	Information extraction Image analysis Video analysis
Analyzing page and group profile in order to define page/group objective, rules, and regulations	Information extraction
Analyzing page/group quality based on buyer satisfaction	Sentiment analysis Social network analytics
Analyze consumer's needed product images that are similar to vendors' products	Image recognition
Analyze textual content that customers post through groups in order to find their desired products	Information extraction
Analyze vendors' commercial activities patterns (e.g., posting time, type of posts, and marketing channel)	Unsupervised machine learning
Generating an example of advertisement posting on Facebook (personal profile, page, and group) and Instagram	Natural language generation
Recommending promotional marketing strategies	
Analyzing product advertisement posting in order to uncover market strategies that vendors use for their business	Information extraction Image analysis Video analysis

Table 9 Data source of C2C s-commerce recommendation system

Data source	Description
C2C s-commerce content	The structured information executed from product posting, comments, reviews, group and page profile, product image, and multimedia stored in SNSs' content repositories (e.g., Facebook, Instagram, and Line) using the proper API
Vendor activity monitoring	Vendor activity information (e.g., posts and comments) monitored and collected from social networking logs in order to understand how online vendors perform business on SNSs which can reflect vendor common behavior to operate the business for success
Business transaction	Income and expenditure as well as a day-by-day record of receipts and payments manually entered into the system by vendors/users. For business performance evaluation and recommendation improvement, vendors need to keep sufficient records of business transactions to enable the assessable profits to be readily ascertained. The results from business transaction analysis would be used to adjust the recommendation by the comparison between business plan and actual production
User profile	Personal profile (e.g., name, address, and gender) and business profile (e.g., product type, target customer, business plan, and objectives) collected at the first time of user registration. User profile would be updated continuously when vendors perform any commercial activities. This information can reflect vendors' recent capabilities that would be used to identify current maturity level of the vendors

Table 10 Components of C2C s-commerce recommendation system

Component	Description	AI Technique
Content extractor	The content extraction component executes both online and offline information for further data processing. For offline information processing, this component will find patterns of product postings in order to make recommendations which harmonize with product types, offering high-quality trade groups for vendors to join and sell products. Regarding online information, the system also monitors new postings about buyers' needed products on trade groups and matches the posted content with vendors' product. The recommendations can increase opportunities for selling products	Text analysis Image analysis Video analysis
Vendor activity analyzer	The vendor activity analyzer executes information to explore vendors' selling behaviors through user log analysis and content analysis. This component provides information about commercial activity, appropriate channel and time period to vendors to perform their business. System outputs help vendors understand how existing vendors conduct commercial activity, what time they post product announcements, how they treat their customers, and how they promote their business and build customers' trust of vendors	Unsupervised machine learning
Sentiment analyzer	The sentiment analyzer is a component for the extraction of an opinion of buyers toward products on SNSs as well as an attitude about Facebook pages and Facebook groups through posts, comments, and reviews. Having positive opinions, product postings would be utilized in order to be an input for providing an example of product posting and offering high-quality groups or pages for vendors to join	Sentiment analysis Social network analytics
Natural language generator	Because C2C s-commerce RS provides an example of product advertisement posted on SNSs to vendors, the natural language generator is an important component for automatically create natural language following the patterns of product posting which are discovered from historical data	Natural language generation
User profile manager	The main process of this component is to identify a vendors' current maturity level at the beginning of system use and update all commercial activities of the vendors in order to evaluate vendor's maturity level for the adjustment of the recommendations. Once the vendor maturity level has been obtained, the vendor profile database is automatically updated. Then, the recommendation engine will use this additional information during the computation of recommendations	Supervised machine learning
Financial statement analyzer	The financial statement analyzer processes all business transactions in order to understand the current status of business financial health and enable more effective decision making. Financial data (such as the balance sheet or profit and loss statement) stored in the business transaction database would be reviewed and evaluated through financial statement analysis to become more useful to the system by comparing the results with the business plan in order to provide a recommendation that suits the current business situation	Online Analytical Processing Data mining Data visualization

4.2.3 Recommendation engine layer

The C2C s-commerce RS is an application which was developed for helping vendors systematically implement online transactions through SNSs among members. The system leverages artificial intelligence techniques such as text mining and machine learning approaches to generate a recommendation to vendors for maturity improvement. The recommendation engine of this recommendation system is divided into six components. A more detailed description for each component is explained in Table 10.

To prepare data for generating recommendations of sample product posting and trading channel, the system executes data stored in SNSs' content repositories following these processes:

First, the system extracts buyers' opinions and attitude on products from each posting in order to select the postings that make customers feel satisfied or liked at the sentiment analyzer. In this component, the system also analyzes the quality of Facebook page and group based on user satisfaction in order to recommend high-quality pages or groups to join for business implementation. Next, at the content extractor, the system analyzes the product postings that are selected and collected from the sentiment analyzer component in order to find patterns of product postings using information extraction, image analysis, and video analysis. To explore appropriate Facebook page and group to join for trading, the system also applies information extraction to analyze the profile of Facebook page and group in order to understand objectives, rules, and regulations of the pages and groups. These pages and groups will also be recommended to vendors for product selling if they suit the vendors' business. At the same time, the system analyzes social networking logs to understand vendors' commercial activities patterns using unsupervised machine learning at the vendor activity analyzer. This component provides an appropriate time, channels, types of posting, marketing activities, and promotional activities that will be recommended in conjunction with a sample product posting. After collecting business transactions for a period of time, the financial statement analyzer will analyze business transactions to provide reports such as sales, financial, and business performance reports. The component also evaluates the current business performance and compares with a plan in order to provide the right recommendation to vendors.

To generate recommendations to vendors and recommend promotional marketing strategies, the system performs activities following these steps below:

Step 1 At the user profile manager, the system will analyze user profile data using supervised machine learning in order to predict current maturity level of a new user. This information supports the system to provide a recommendation that suits the vendor's products and experience.

Step 2 At the natural language generator, the system will select information from C2C s-commerce content database based on vendors' product types in order to generate a sample product posting as well as posting time and appropriate channels.

Step 3 To increase the sales volume, Facebook pages and groups that are investigated from the sentiment analyzer and are consistent with vendors' products will be recommended to vendors for making a decision to join. After joining any Facebook group, the system will monitor new postings from the joined groups. When group members post their needed products (both text and image), the system will apply image recognition and information extraction for matching its users' selling products with the posted content. If the results match, the system will immediately send a push notification to the vendors using push-based alert. The vendors can post their product content under any buyers' postings using comment feature.

4.2.4 Presentation layer

The aim of the presentation layer is to allow the interaction between the system and the user and to present the recommended activities for business operation to the user. The layer mainly includes graphic user interface for entering user profile data and business transaction into the system, and the results of the recommendation system and reports.

5 Conclusion and discussion

Although there are some previous works that focus on the development of RS for s-commerce (Salvatori and Marcantoni 2016), few research studies pay attention to the RS in vendor's perspective. In this paper, a novel architecture of recommendation approach for C2C s-commerce vendors has been presented and discussed. It has also provided the main components of the RS and described the main approaches of the recommendation system. Several approaches related to text analysis, image recognition, machine learning, and social network analytics have been considered for executing structured and unstructured big data and generating efficient recommendations. Vendors can use the important advantages of the recommendations to enhance their capability in online business arrangements.

In practice, C2C s-commerce recommendation system can support vendors to systematically perform business. The application helps novice vendors evolve from the initial stage of maturity to reach maturity level 3 vendors by providing a systematic process as experienced vendors do. By doing so, vendors can reach the fourth maturity level through business performance measurement conducted by financial statement analysis. Then, the system will adapt the recommendations

based on the results from business performance analysis. This activity leads to the continuous improvement as can be seen in maturity level 5. Additionally, knowing a vendor's maturity level may aid buyers to build trust and confidence in vendors before placing an order and leads to the growth of the digital economy in developing countries.

Future work should include a feasibility study from the framework in order to empirically understand vendor perception toward C2C s-commerce recommendation system adoption. The related acceptance models in IT adoption such as TAM (Davis et al. 1989) and UTAUT (Venkatesh et al. 2003) may be applied in order to understand the degree to which a vendor believes that the use of the RS can improve their business performance. Additionally, we intend to develop this software engineering perspective to real-world implementation by providing user requirements and constraints to facilitate application development. However, this research has some limitations. First, data access permission is a vital concern of this study. Second, there may have been some important commercial activities which have not been addressed in this study. These activities may have a significant influence on the main function of the RS.

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