Mobile application for the purpose of marketing, product distribution and location-based logistics for elderly farmers

Sumitra Nuanmeesri
Suan Sunandha Rajabhat University, Bangkok, Thailand

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Abstract

This research has developed a one-stop service supply chain mobile application for the purpose of marketing, product distribution and location-based logistics for elderly farmers and consumers in accordance with the Thailand 4.0 economic model. This is an investigation into the agricultural product distribution supply chain which focuses on marketing, distribution and logistics using the Dijkstra's and Ant Colony Algorithms to respectively explore the major and minor product transport routes. The accuracy rate was determined to be 97%. The application is congruent with the product distribution, supply chain, in a value-based economy. The effectiveness of the mobile application was indicated to be at the highest level of results of learning outcomes, user comprehension and user experience of users. That is, the developed mobile application could be effectively used as a tool to support elderly farmers to distribute their agricultural products in the one-stop service supply chain which emphasizes marketing, distribution and location-based logistics for elderly farmers and consumers with respect to Thailand 4.0.

Keywords Mobile application, Elderly, Supply chain, Location-based logistics, Distribution, Dijkstra's algorithm, Ant Colony Algorithm

Paper type Original Article

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1. Introduction

Thailand, like many countries, is an aging society, with an increase in elderly people (60 years old or above) from 6.8% in 1994 to 14.9% in 2014. In 1994, elderly people accounted for 6.8% of the total population; 45.1% of them were males and 54.9% of them were females. By 2002, 2007 and 2011, the figures rose to 9.4%, 10.7% and 12.2%, respectively. To be considered an aging society, 10% or more of the population have to be aged 60 years old and above, along with a decrease in the child and working demographic [17,22]. Scholars predicted that by 2025 there will be 14.4 million elderly people living in Thailand, making up 27% of the total population by 2050. Meanwhile, the average life expectancy of females is expected to be higher than males by 4–5 years. The elderly are considered to be valuable because of their knowledge and experience. These members of society may still contribute by continuing to work in agriculture, which is associated with positive mental and physical health benefits. The ability to continue to earn an income rather than relying on a pension or provident fund could continue to make them proud of themselves, and similarly, continuing to do business assists in minimizing the risk of loneliness, and depression, among the elders.

Seeing that agriculture and animal husbandry have been continuously practiced as primary occupations in Thailand. Thai agricultural products are diversely and authentically offered in different regions. These occupations are important as they are the foundation of the country, with exports of agricultural products such as rice, rubber, fruit and other products being important. Traditionally, farmers transfer their agricultural knowledge and practices from generation to generation. However, now elderly farmers are experiencing a difficulty in finding successors. These elders cannot conveniently distribute or transport their products by themselves and are more susceptible to being exploited. In case of mass production without the notification of marketplaces or a fair-trade price, agricultural goods are at risk of being damaged or spoiling, while waiting for buyers. For some elderly farmers, they may have problems with finding a marketplace or customers. These farmers may eventually go bankrupt, or need to close down their agricultural business, leading to the discontinuing of the supply chain or an unbalanced relationship between suppliers and consumers.

In this digital era, the government has supported the application of technologies and new innovations. Integration of technology to the market can be supported by the development of mobile applications for elderly farmers, enabling them to promote their products, improve selling channels, and in securing a fair price. This can improve the livelihood of the farmers, make them proud of themselves, and help them expand their distribution channels by themselves so that they are not a burden on society. Furthermore, such an application can assist society in preserving agricultural careers, as these elderly farmers are experts in their field. That they may lack marketing knowledge, they may be supported by technology, which adds value to their products.

This research thus aims to develop a one-stop service supply chain mobile application focusing on marketing, product distribution and location-based logistics for elderly farmers and consumers in accordance with Thailand 4.0 and contributing to a value-based economy. This will benefit the farmers by giving a platform to promote their products in which they can identify the quantity, price, on-sale dates and locations of the product marketplaces. If there is a prospective buyer in the system, the application will build the connection and show the list of buyers who are interested in purchasing a product directly. To find a route for distributing products is a complicated dilemma since the transportation routes resemble graphs. This study applies the Dijkstra's and the Ant Colony Algorithms (Section 2), to present the major and minor routes for the distributors (respectively), who would like to make better decisions with regard to goods delivery. If there is a consumer or a buyer who is interested in a farmer's released product, the application will show the list of items alongside the routes, as well as the distance between the farmer and buyer, allowing buyers to directly contact the farmer, purchase, and pick up the product (Section 3). This technology will help the elderly farmers to profit from agriculture (Section 4).

2. Related works

2.1 Graph theory in the shortest path problem

In the graph theory, the shortest path problem refers to the problem of finding a path between two vertices (or nodes) in a graph by which the total sum of the edges weights is minimum [23].

The components of graph G = (V, E) in which.

- the set of vertex is indicated by V(G)
- the set of edge is indicated by E(G)

According to Figure 1, the results will be:

V(G) = {A,B,C,D,E}

E(G) = {e1, e2, e3, e4, e5, e6, e7}

There are some specific types of graphs which demonstrate additional information and/or present certain limitations as follows [10,13].

2.1.1 Directed graph. A directed graph is a graph where each arc is one directional. This refers to an arc between two nodes which only indicates the possibility of moving from one node to another but not in the opposite direction. The arcs are generally drawn as arrows to point out the directions. An example of a potential use of a directed graph is to track possible states that a computer could identify; there are numerous ways for a computer in one state to find a path to reach another state, but there is no way to immediately return from the second point to the first, as illustrated in Figure 2(A). One can formally define a directed graph as G = (V, E), consisting of a set V of nodes and set E of edges, which are pairs of V elements put in order.

2.1.2 Weighted graph. A weighted graph is a graph where some 'cost' is associated with each arc. In general, each edge in a weighted graph has a numerical value called 'weight'. Given below is an example of a weighted graph; each small numerical digit will appear directly adjacent to every arc to display its cost. A typical use of a weighted graph is the planning of routes between locations on a map where the 'cost' associated with the arc would be the distance between two locations, as shown in Figure 2(B). Figure 2(C) shows a directed weighted graph. It should be noted that in the aforementioned graphs all the weights are positive, but negatives (and zero) weights are also allowed.

2.1.3 Tree graph. A tree graph is a special graph where every connected node can be reached from every other node in relation to each arc; the number of arcs is fewer than the number of nodes by exactly one point. A tree is regularly drawn with a node so-called 'the root node' at the top of the diagram, and then grows downwards with arcs and nodes getting

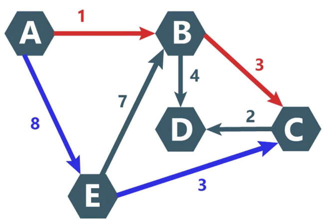

Figure 1.
An example of graph.

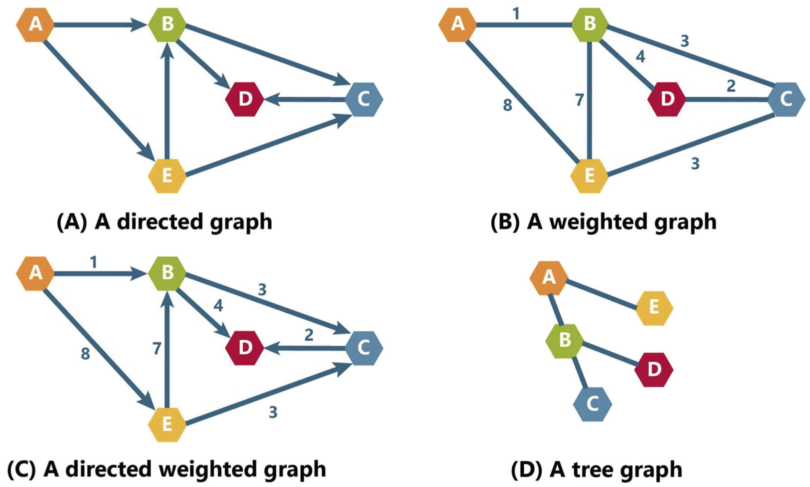

Figure 2.
An example of graphs.

further and further from the root. Correspondingly, nodes can be grouped according to their distances from the root. Every node expanding from the root is referred to as a descendant of the root node to which it is connected and one point next to the root. This kind of node is also called a parent node of its descendant. Every node has one parent node only, but each parent node can have one or more descendants. Nodes without any descendent are frequently addressed 'leaf nodes', as illustrated in Figure 2(D).

By way of example, when considering a blue path from the node A to C (A→E→C) in the directed weighted graph as shown in Figure 3, the path consists of two edges. The total weight of the path derives from the sum of the edges' weights: $8 + 3 = 11$. Simultaneously, according to the existing red path from the node A to C (A→B→C), the total weight of the red path is $3 + 1 = 4$, which is less than the total weight of the blue path. Therefore, the red path from the node A to B to C is the shortest path from the node A to C.

To discover the shortest path (a path with the minimum weight) between two nodes in a graph is often a problem in the programming process. The shortest path puzzle is one of the most typical algorithm issues concerning graph theory, which aims to find the shortest direction between the two nodes in a network. The shortest path algorithm is designed to identify a passage between two nodes in a graph by which the sum of the weights of its constituent edges is minimized; this refers to the search for the lowest cost path between the starting point and destination [13]. Not only used in discovering the shortest distance in common geographical problems, it is also applied in other fields, for example, finding the most reliable source in communication networks, solving critical route problems [10], and

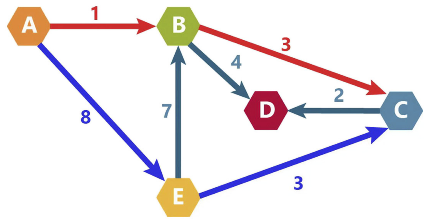

Figure 3.
An example of directed weighted graph.

solving the direction search problems in network routing algorithm, game design and artificial intelligence. Moreover, it is applicable when finding the shortest routes in the following scenarios: the shortest path between two nodes, the shortest distance among all nodes, the K shortest path, the real-time shortest path and the shortest direction of the designated path. In this case, the shortest route algorithms can be classified into single-source shortest path algorithms and multi-source shortest path algorithms. A single-source shortest path algorithm provides the shortest route from an assumed vertex to any other vertex. One of the most classic single-source shortest path algorithm is Dijkstra's Algorithm, commonly used in road networks. In order to interpret graphs, nodes, and branches in graph theory, it is necessary to solve the shortest path puzzle.

2.2 Dijkstra's Algorithm

Dijkstra's Algorithm is an algorithm used for identifying the shortest routes between nodes in a graph, which may portray, in this case, road networks. It was conceptualized by Edsger W. Dijkstra, a computer scientist, in 1956 and then publicized in 1959 [5]. The algorithm has been utilized in different ways depending on the application. For instance, the original variant developed by Dijkstra was employed to pinpoint the shortest path between two nodes. Nonetheless, a single node is set as the source node by a more common variant to identify the shortest paths from the source to all other nodes in the graph, creating a shortest-route tree. Given a graph G = (V, E) with positive edge weights, Dijkstra's Algorithm has been applied to tasks such as finding directions and transportation routes, without negative edge weights, by running O(—V—) time operation [6,18].

The identification of the shortest routes has been determined by the use of a modified Dijkstra's Algorithm, and presented in the form of a Matrix with previous nodes, that follow the shortest-path tree [12]. The algorithm can reduce the repetitive procedures and find the shortest routes effectively. The application of Dijkstra's Algorithm considers the different weights and determines the priorities for the specific identification of starting points and destinations. The starting points and the destinations are set as the center of their own circles. The priority is specifically fixed in the circle, when the next point is connected with a starting point, the process is repeated until it reaches the zone of a destination. By using the principles of the modified Dijkstra's Algorithm, it can be seen that the data processing time has been optimized when compared to the normal Dijkstra's Algorithm [3]. The normal Dijkstra's Algorithm has been applied to calculate the shortest paths for network expansions, but it tends to take more time when nodes increase in each network. The modification of the Dijkstra's Algorithm is based on the Heap Sort Algorithm, a special kind of complete binary trees, as operating in a priority queue. This research has developed a modified Dijkstra's Algorithm by using a complete binary tree, and node information, stored in the 3-element compression structure and this has lead to an improved data processing procedure and consequently reduce the processes to O (n log n). In this study, a graph with 54 nodes is utilized to test the validity of the procedure; this will likely verify that this method offers more stability and effectiveness than other methods [11].

2.3 Ant Colony Algorithm

The Ant Colony Algorithm is a probabilistic technique using the metaheuristic optimization method for finding the best result within the time limit. This technique was inspired by the food hunting behavior of ants. By nature, ants try to find the shortest path from the anthill to their food by following the way marked with pheromones released from each ant. The ants following the previous ones will reinforce the pheromones to improve the food trail and locate their resources. Pheromones, hence, are an important source of information for ants to go back and forth between the anthill and the food source. Ants use pheromones to identify the shorter routes, and then decide which path they will follow. If they do not discover any pheromone trail, their choice is entirely random. As time passes by, ants will choose the shorter routes detected by the pheromones [1]. As ants locate their resources by laying down their pheromones, other ants can follow the path with the highest density of pheromones as shown in Figure 4.

The structure of the Ant System Algorithm is divided into two stages as follows.

2.3.1 Path identification process in Ant System. To establish or find a path, ants randomly choose a city or a starting node and then select the next node by a probabilistic state transition rule, so-called 'random proportional rule'. For instance, if the probability is in city i, ants will choose to move to the next city j as illustrated by Eq. (1) [21].

$$\rho_{i,j} = \frac{\left(\tau^{\alpha}_{i,j}\right)\left(\eta^{\beta}_{i,j}\right)}{\sum\left(\tau^{\alpha}_{i,j}\right)\left(\eta^{\beta}_{i,j}\right)} \tag{1}$$

where

$\tau_{i,j}$: amount of pheromone on edge i,j

α: parameter to control the influence of $\tau_{i,j}$

$\eta_{i,j}$: desirability of edge i,j (typically $1/d_{i,j}$)

β: parameter to control the influence of $\eta_{i,j}$

2.3.2 Pheromone update. Once every single ant has traveled to all cities or nodes, it is possible to measure the distances that each ant travels by appointing each ant to update the pheromone on its trail. The amount of pheromone is updated according to the equation [21].

$$\tau_{i,j} = (1-\rho)\tau_{i,j} + \Delta\tau_{i,j} \tag{2}$$

where

$\tau_{i,j}$: amount of pheromone on a given edge i,j

ρ: rate of pheromone evaporation

$\Delta\tau_{i,j}$: amount of pheromone deposited, typically given by

$$\tau_{i,j} \leftarrow (1-\rho)\tau_{i,j} + \sum_{k=1}^{m} \Delta\tau^{k}_{i,j} \tag{3}$$

where

ρ: evaporation rate

m: number of ants

$\Delta\tau^{k}_{i,j}$: pheromone quantity laid on the edge (i,j) by the k^{th} ant, typically given by

$$\Delta\tau^{k}_{i,j} = \begin{cases} \dfrac{1}{L_k} & \text{if ant k travels on edge } i,j \\ 0 & \text{otherwise} \end{cases} \tag{4}$$

where L_k is the tour length of the k^{th} ant

This study has applied the Ant System Algorithm to propose the application of Ant Colony Optimization (ACO) and improve the quality of the solutions by swapping and

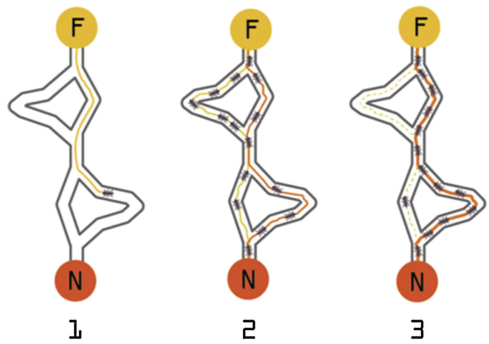

Figure 4.
The simulation of ants' food tracking.

moving 2-opt and 3-opt algorithms to solve the problems in locating different product distribution centers and managing the transportation and delivery routes. This will provide the most optimal transportation distance for each car. To find a solution for big problems, the use of a Very Large-Scale Neighborhood (VLSN) search was performed alongside with the Ant System Algorithm [4]. The Improved Ant Colony System (IACS) was developed for solving route management problems by applying multi-phase rewrite rules, the pheromone update rule, the 2-opt local search algorithm, and the exchange method. The findings show that the modified ant colony system gives better solutions than the normal Ant System method. Route management problem falls into the NP-hard problem category, in which one of the solutions for this problem is the metaheuristic technique and the application of ACO. After computing the results, it was revealed that service-level price change can affect overall spending. If the level of service is high, the overall spending will also be high [2]. The combination of ACO and Emergency Material Scheduling (EMS) establishes an effective emergency rescue system, by which its functions involve material management, city information management, vehicle management, emergency call center and rescue operation. The multi-objective optimization programming is occasionally difficult to operate due to multi-objective constraints. In such cases, it is important to solve the problem with optimal multi-vehicle scheduling. The Pareto optimal solution is the optimization by Data Envelopment Analysis (DEA), providing the best scheme of time balance [7]. In addition, ACO is also viewed as a basic algorithm used together with other algorithms. Hybrid Genetic ACO is often applied to solve the EMS model problem where Genetic Algorithm (GA) is employed for searching the primary solution universally and rapidly. Subsequently, the result is interpreted as the fundamental pheromone distribution of the ACO. The positive feedback mechanism and parallelism of ACO are used for operating the optimization efficiently [9]. The Multi-objective EMS model for multi-reserve depots and multi-supply depots is designed by using a hybrid intelligent algorithm based on non-dominated sorting genetic algorithm II (NSGA-II) and ACO to solve the problem. For the problem-solving, two-dimensional binary chromosome coding, corresponding crossover frequencies and mutation operations are applied, and an improved coding strategy is proposed to determine the possible conflict of the EMS between multiple supply depots [25]. The ultimate goal of the EMS model based on emergency relief characteristics is to discover the shortest delivery time by considering both the road conditions and the material shortage in demand depots. The improved fish-swarm ant colony optimization (FSACO) is also designed for optimization purposes [27], alongside the Hybrid algorithm based on artificial immunity and ant colony optimization algorithm. With this hybrid algorithm, the Pareto optimization model can be used for calculating the congestion degree, while the population is determined by the ant colony optimization algorithm. By applying the rapid global convergence, randomness of the improved immune algorithm, the distributed search ability and positive feedback ability of the ACO algorithm, a better solution set is achieved speedily [26]. ACO is a probabilistic algorithm adopted for identifying the optimal route; the features of this algorithm include positive information feedback, distributed computing and heuristic search. It is basically a heuristic global optimization approach under the evolutionary algorithm processing. Furthermore, this algorithm can be used for solving route management problems with time limitations, regardless of the level of service. The solutions given by this algorithm are usually more practical than other algorithms.

3. Methodology

The research methods adopted in the development process for the mobile application for the purpose of marketing, product distribution and location-based logistics for elderly farmers, include the following steps:

3.1 Data collection

Distribution information for the agricultural products was studied to understand the supply chain as produced by elderly farmers based on the feedback of volunteer groups who communicated via social media for a period of 90 days. They were divided into three groups, which comprised 20 agricultural producers/suppliers, 20 prospective distributors, and 20 prospective buyers. Each volunteer contacted the team by telephone and full information about the survey was provided and all queries were answered. This was performed with regard to the marketing, and selling of products, the buying process of the buyers, and the product delivery process.

3.2 Exploring the shortest routes

Exploring the shortest routes to distribute products, was done by the developed mobile application which is connected to the Google Map API to portray the map of transportation routes, from the starting point to the destinations. This research applied Dijkstra's Algorithm to support the mobile application in determining the shortest paths. Goods transportation in Thailand is usually a high cost due to traffic congestion and speed restrictions in urban areas, this study thus modified the Dijkstra's Algorithm to identify the shortest paths as rapidly possible with reasonable capital as illustrated by Eq. (5).

$$D[s,t] = min\left(\sum_{i=1}^{j}\left(\frac{d_{i,j}}{sp_{i,j}}(1+OR)\right)\right)(\text{typically } \ 0 \le OR \le 1, \ \ i \in n, \ \ j \in n) \tag{5}$$

where

$D[s,t]$: shortest distance from node s to t

s: original source (or current node)

t: target or destination node

n: set of all nodes from node s to t

i: node in the path between node s to t

j: the next node from node i (adjacent of node i)

$d_{i,j}$: distance from node i to j

$sp_{i,j}$: maximum speed or speed limit from node i to j

OR: occupancy ratio (traffic congestion levels), typically given by:

0.0–0.2 is no traffic delays

0.3–0.7 is medium amount of traffic

0.8–1.0 is high traffic delays

The occupancy ratio was calculated by CCTV cameras which are installed on various streets or roads. These cameras collect the video streams for counting the number of vehicles and then translate this data into the traffic congestion level in metropolitan areas.

The researchers used the fourth equation and applied the Ant Colony Algorithm to recommend minor routes for distributing products. The system stores the routes that have been used for transporting products from the start to the finish/end point, and then records the route suggestions from the distributors who have provided their routes, for calculating the shortest path from the data in the database. The information is then presented on the mobile application and can be seen by other product distributors accordingly, as shown in Figure 5.

By applying Dijkstra's and the Ant Colony Algorithms, 50 vehicle samples which included motorcycles and cars that voluntarily took the accuracy test, were used in the exploration of main and minor routes. The result showed that it was 97% accurate. Accurate efficiency was evaluated using their accuracy show in equation [20,24].

$$Accuracy = \frac{(TP + TN)}{(TP + FP + FN + TN)} \tag{6}$$

where

TP: path that reaches the destination is fast, with a given path that allows reaching the destination quickly

TN: path that reaches the destination is slow, in a given path that allows reaching the destination slowly

FP: path that reaches the destination is fast, in a given path allowing to reach the destination slowly

FN: path that reaches the destination is slow, in a given path that tends to reach the destination quickly

Figure 6 shows the confusion matrix with 1,000 samples, the values of TP, TN, FP and FN are 645, 325, 22 and 8.

From the confusion matrix of the route suggestions can calculate the value of accuracy as follows.

$$\begin{aligned} Accuracy &= \frac{(645 + 325)}{(645 + 22 + 8 + 325)} \\ &= 0.97 \times 100 \\ &= 97\% \end{aligned}$$

3.3 Design of the mobile application

The design of the mobile application is based on the documentary research and transportation route analysis which consists of:

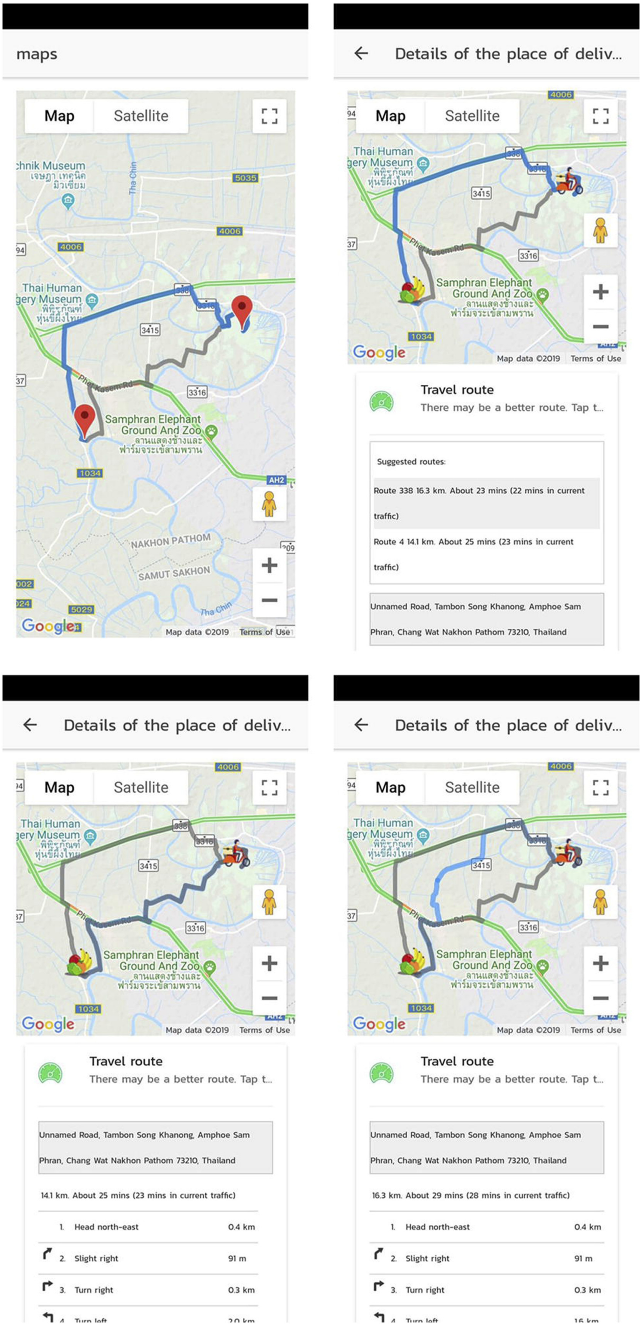

Figure 5.
The map of major and minor route suggestions for distributing products.

1) Elderly farmers who promote, distribute and deliver their products.
2) Online buyers who, via the mobile application, will search and purchase products for delivery.
3) Distributors or transport contractors who will transport the products of elderly farmers to consumers.

In this section, the information collected from the data collection process was analysed using requirement analysis processing in order to determine the features in the mobile application. The consistency of the contents was analyzed by 5 experts in the field of information technology and logistics. Accordingly, the information was taken from the experts to determine the Index of Item-Objective Congruence (IOC) value by using the formula as presented in the Eq. (7) [14]:

$$IOC = \frac{\Sigma R}{N} \tag{7}$$

where

ΣR: sum of scores as rated by the experts

R: score provided by the experts

N: number of experts

The features in the mobile application were assessed by five experts specializing in the field of information technology and accounting. The IOC was applied to the evaluation to determine scores. If the criteria measured by the IOC value of each indicator was higher than 0.5 (the highest IOC value is 1) because the number of experts answering the questionnaire met the following objective: the number of experts who answered that it was not a the questionnaire met the objective was more half of all the experts [8,19], it could be implied that the features met the objectives and possessed the contents suitable for the operation, showing that the features worked effectively. For instance, if the IOC value of each indicator was 0.8, it means the features met the objective and were suitable for use in the mobile application development. The experts were able to provide a rating by using the assessment criteria as in Table 1.

Figure 7 shows a diagram of features in the operation, data input and outputs depicting the whole procedure of each user of the mobile application.

3.4 Development of the mobile application

The mobile application was developed for use by suppliers (elderly farmers), consumers and product distributors. The map system is connected to Google Map API. The mobile

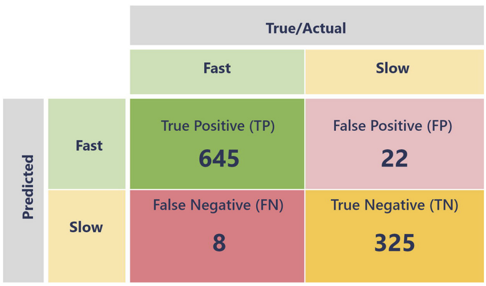

Figure 6.
The confusion matrix of the route suggestions.

application was developed based on the ionic framework which allowed the application to work with iOS and Android operational systems. The architecture consists of HTML, TypeScript and Google Map API. The process involves the information hyperlinks on web server which is the host service for clients. JavaScript Object Notation (JSON) is applied to share the data, while the data is stored in MySQL database showing the architecture used in the development of the mobile application as shown in Figure 8. Examples of the mobile application in operation are depicted Figures 9–11.

3.5 Evaluation of the mobile application

The mobile application was evaluated by 60 respondents. The sample consisted of 20 agricultural producers or suppliers, 20 prospective distributors, and 20 prospective buyers; they voluntarily registered for the training which was offered in the form of a group demonstration. So, researchers had no information with regard to farmer identification and their performance. This was the basis upon which ethics approval was obtained for the study.

Rating criteria	Meaning
1	There is content consistency, showing suitability for inclusion as a feature in the application.
0	Uncertainty in content consistency and inappropriateness for use as a feature in the mobile application.
−1	No content consistency and cannot work as a feature in the mobile application.

Table 1. Rating criteria for content consistency and identifying features in the mobile application development.

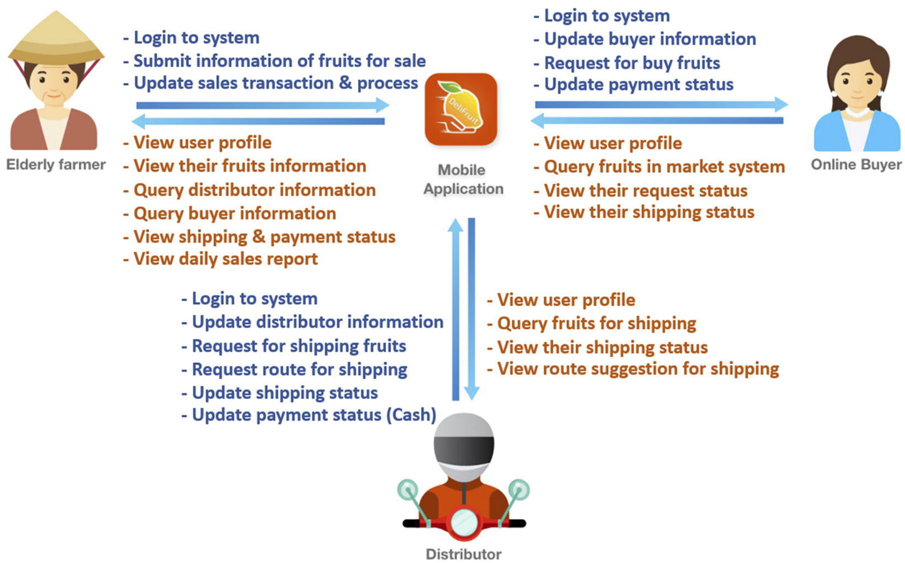

Figure 7. Diagram of features in the operation of the mobile application.

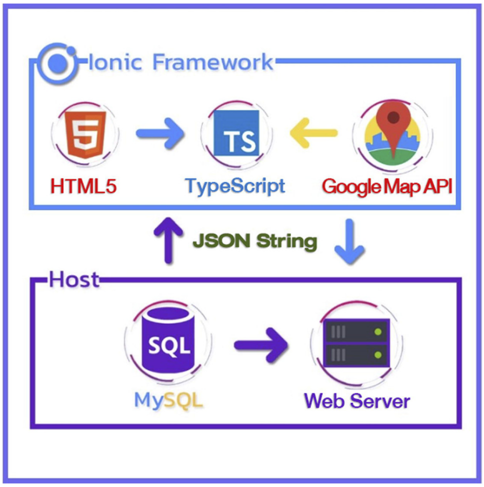

Figure 8.
The architecture used in the development of the mobile application.

The questionnaire was evaluated by five experts who specialize in the field of information technology and business. The evaluation used the IOC [15,16] for scoring (Eq. (7)). If the criteria determined by the IOC value of each indicator was higher than 0.5 (the highest IOC value is 1), it means the questionnaire met the objective and possessed content suitable for evaluation purposes. The IOC value of each indicator was 0.8, indicating that the questionnaire met the objective and is suitable for using in evaluation. The experts were able to provide a rating by using the assessment criteria as in Table 2.

From the evaluation used the IOC, the questionnaire for the evaluation of the mobile application which consisted of the following:

3.5.1 Comprehension aspect. There are four topics in this term. First, promotion and distribution of products: the mobile application helps elderly farmers to promote and distribute their agricultural products. Second, enabling connections between buyers and distributors: the mobile application provides a direct communication channel and facilitates connections between buyers, distributors and the elderly farmers. Next, free distribution and transactions: the mobile application allows the users to freely sell, distribute and buy agricultural products at a fair price. Lastly, knowledge of the distribution network: the mobile application improves trading knowledge for distribution informing users of the shortest path to deliver agricultural products.

3.5.2 User experience aspect. There are four topics within this category. First, increases in trading productivity: the mobile application helps customers and elderly farmers to trade and increases the number of trading channels. Secondly, sources of income: the mobile application provides tools as a source of income to elderly people and agricultural product suppliers. Thirdly, encouragement of sales: the mobile application encourages elderly farmers to sell their agricultural products. Lastly, financially support: the mobile application helps elderly farmers to financially support themselves through selling agricultural products.

Before the evaluation of the mobile application, the training was provided to 60 people who made up the research sample and participated voluntarily in the testing of the mobile application as advertised on social networks. In this study, the participants received documents explaining the protocols and research ethics and allowing them to consent to participation. The 2-h training involved a lecture, product demonstration and real practice sessions to try out the mobile application. There was a guest speaker who was a lecturer in the

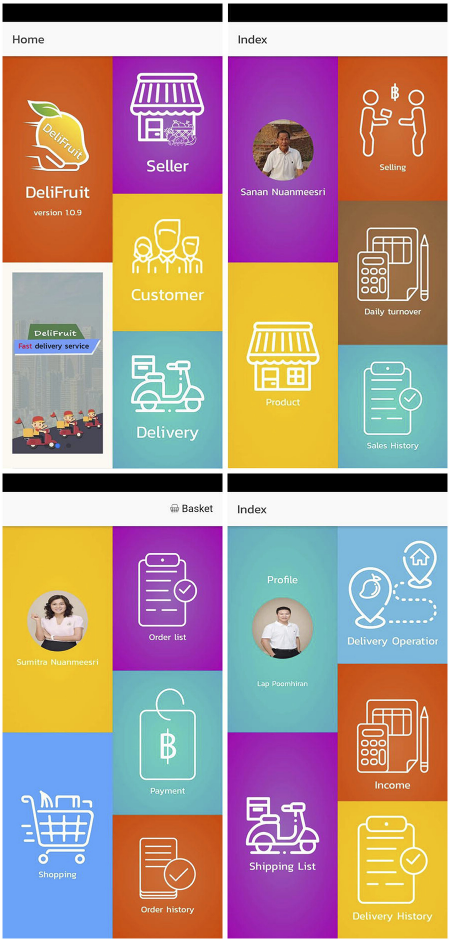

Figure 9.
Main menu for each type of user.

field of information technology and 15 information technology students as assistants. Both the guest speaker and the assistants had tested the developed mobile application and had participated in the projects of academic service related to mobile applications and social media for community previously.

The guest speaker used PowerPoint slides when giving the lecture and demonstrated the installation and the utilization of the mobile application. Each participant received a copy of the lecture materials which illustrated the procedures and offered an explanation of how to the mobile application functions. The participants practiced with the mobile application while the guest speaker advised and supervised. Following the training session, there were 1-h online pre- and post-learning tests created by Google Form. The guest speaker explained and gave advice to the participants before taking the tests with the aid of the projector. The assistants took care of and guided the participants in how to access the pre-test and post-test forms. Nonetheless, the guest speaker and the assistants did not persuade or complete the tests for respondents. The tests consisted of 10 questions each in which the order of questions and answers in the pre-test and post-test were switched around. Finally, once the post-test

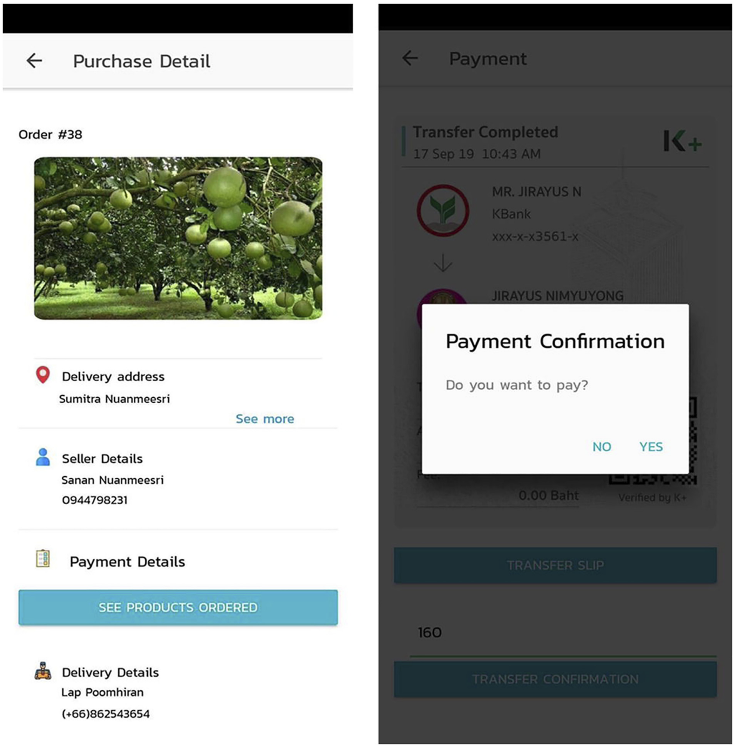

Figure 10.
Example of ordering screen.

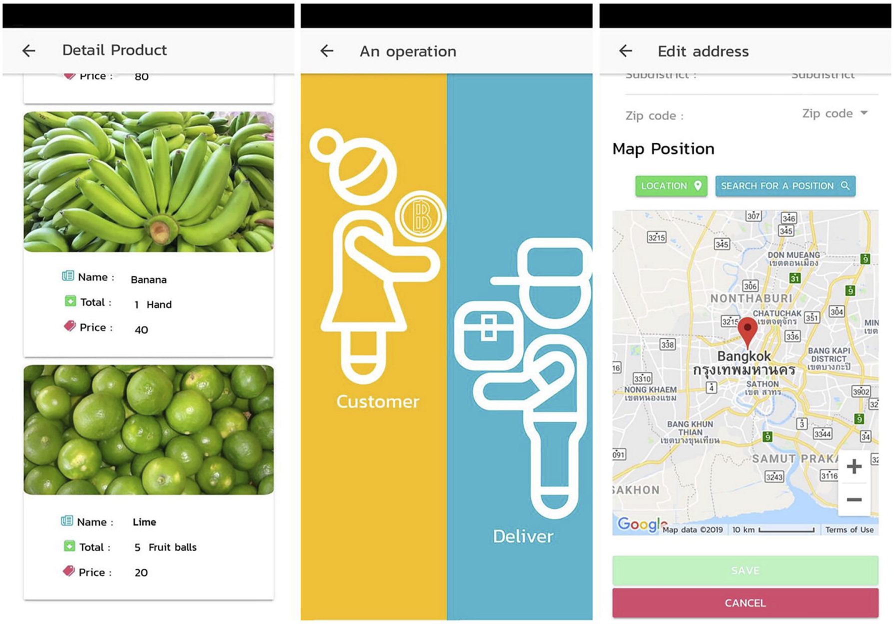

Figure 11.
Example of product, delivery detail and map location screen.

was completed by all of the participants, the guest speaker gave the answers and stated where the training materials were published and could be downloaded. This included the mobile application demonstration video which was published on social media for the senior users to review and gave further information about the application.

In the evaluation of the mobile application online questionnaire, the data obtained was analyzed to gain the mean value, the standard deviation value and percentage.

4. Results

In this section, we provide the results of learning outcome scores, comprehension aspect and user experience aspect.

4.1 The evaluation from the learning outcomes

The effectiveness of the application learning outcome scores were obtained from the 60 respondents via a test before and after the training. There were 10 questions in each test with the questions and the answers switched to ensure difference between the tests. The results showed that the respondents, post training, had better learning results when compared to the results prior to training, as shown in Figures 12–14.

4.2 The effectiveness evaluation the mobile application from comprehension aspect and user experience aspect

The evaluation indicators for the developed mobile application was assessed by 60 respondents who made up the test group in terms of the comprehension and user experience aspects. The data was analyzed to find the mean value and the standard deviation value according to the scoring criteria of the Likert Scale [21] to rate, as shown in Table 3.

The evaluation results collected from the sample showed that, in terms of comprehension and user experience, the comprehension aspect was determined to have a mean of 4.56 and a

Rating criteria	Meaning
1	There is content consistency and the application works.
0	Uncertainty in content consistency and application workability.
−1	No content consistency, nor it cannot work.

Table 2. Rating criteria for content consistency and application workability.

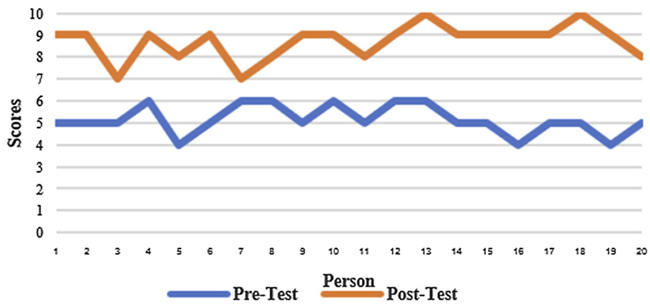

Figure 12. The learning results of the mobile application utilization by farmers.

standard deviation of 0.50; and the user experience aspect was rated with a mean of 4.60 and standard deviation of 0.49. This indicates that the mobile application is an effective tool at a high level, the arithmetic mean was 4.58 and the standard deviation was 0.49, suggesting that the supply chain mobile application in relation to marketing, product distribution and location-based logistics for elderly farmers and buyers was at the highest level, as presented in Table 4.

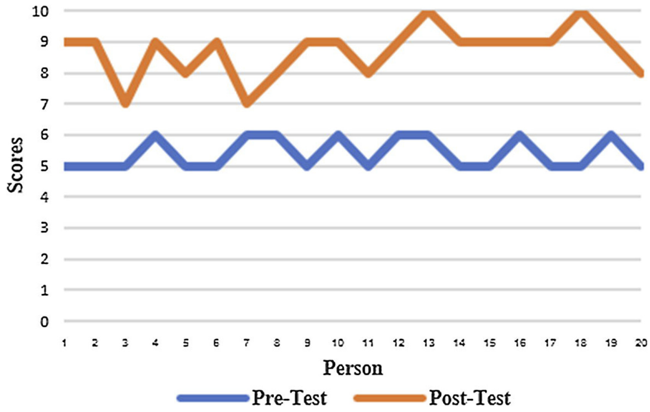

Figure 13.
The learning results of the mobile application utilization by product distributors.

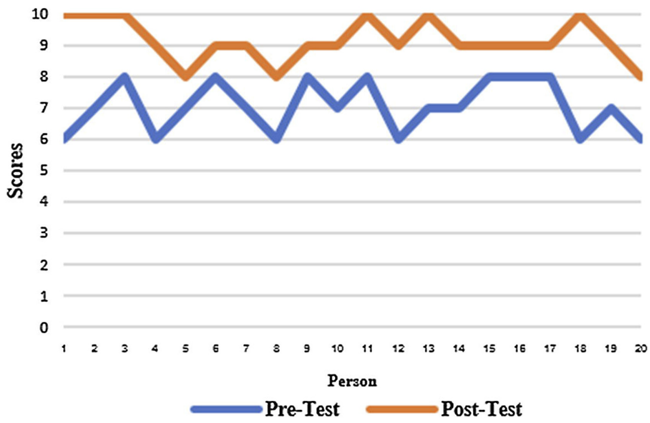

Figure 14.
The learning results of the mobile application utilization by product consumers.

Table 3.
Scoring criteria for evaluating the mobile application.

Scale	Range of Weighted Mean	Level of effective mobile application
5	4.51–5.00	The highest
4	3.51–4.50	The high
3	2.51–3.50	The medium
2	1.51–2.50	The little
1	1.00–1.50	The least

Assessment indicators	$\bar{x}$	SD	Level of effective mobile application
1. Comprehension aspect			
1.1. Promotion and distribution of products	4.60	0.49	Highest (92.00%)
1.2. Enabling connections between buyers and distributors	4.62	0.49	Highest (92.33%)
1.3. Free distribution and transactions	4.52	0.50	Highest (90.33%)
1.4. Knowledge of the distribution network	4.52	0.50	Highest (90.33%)
Total	4.56	0.50	Highest (91.25%)
2. User experience aspect			
2.1. Increases in trading productivity	4.53	0.50	Highest (90.67%)
2.2. Sources of income	4.58	0.50	Highest (91.67%)
2.3. Encouragement of sales	4.62	0.49	Highest (92.33%)
2.4. Financially support	4.67	0.48	Highest (93.33%)
Total	4.60	0.49	Highest (92.00%)
Overall	4.58	0.49	Highest (91.63%)

Table 4. Result of evaluation the mobile application from comprehension aspect and user experience aspect.

5. Conclusion and future work

This research led to the development of a one-stop service supply chain mobile application focusing on the marketing, product distribution and location-based logistics for elderly farmers and their buyers in accordance with the Thailand 4.0 economic model. The researchers had studied, analyzed and collected data on agricultural product distribution in the supply chain which specifically focuses on marketing, distribution and logistics by exploring major routes with Dijkstra's Algorithm, and proposing the minor routes with the application of the Ant Colony Algorithm, for the transportation of products. The accuracy rate was found to be 97%. Then, the mobile application was designed and developed by evaluating the effectiveness of the developed mobile application with the assistance of five experts who had expertise in information technology and business. The evaluation was performed by the use of Index of Item-Objective Congruence (IOC). The evaluation results show that each content received the IOC scores of no less than 0.8. To put it simply, the developed application is congruent with the distribution of products in the one-stop service supply chain focusing on marketing, product distribution and location-based logistics for elderly farmers and consumers in agreement with Thailand 4.0, a value-based economy. Next, the developed application was demonstrated to a sample consisting of elderly farmers, distributors/contractors, and buyers that were interested in the application. Their learning outcomes were evaluated by pre- and post-training tests. The findings indicate that their learning outcomes post training were better than that prior to training. This indicates that the users successfully learned how to use the application. After evaluating the effectiveness of the application, it can be seen that the comprehension aspect had the arithmetic mean of 4.56 and the standard deviation at 0.50, respectively. This suggests that the effectiveness of the application for user comprehension was rated at the highest level. Concerning the user experience, the arithmetic mean was 4.60 and the standard deviation was 0.49, suggesting the application had the effectiveness in user experience at the highest level. Overall effectiveness of both aspects had an arithmetic mean of 4.58 and the standard deviation at 0.49, showing that the users rated the effectiveness of the supply chain mobile application at the highest level for marketing, product distribution, and location-based logistics. That is, the mobile application could be effectively used as a tool to support elderly farmers in distributing their agricultural products in the one-stop service supply chain.

As far as future research is concerned, the intention is to explore more shortest path algorithms by applying Bellman Ford's and Floyd-Warshall's Algorithm then comparing this to Dijkstar's Algorithm. Furthermore, the mobile application will be improved to allow automatic matching between buyers and suppliers. For example, if elderly farmers post their product for sale, the application will automatically find and match customers who have previously requested to buy some agricultural products in the system. Finally, the application will conduct an automatic search for distributors available to deliver agricultural products within the specified distance area.

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Corresponding author
Sumitra Nuanmeesri can be contacted at: sumitra.nu@ssru.ac.th