Edge AI Assists Smart Package Delivery Management for Smart City

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Abstract

The goal of developing a city into a smart city is to enhance the standard of living by providing smart services with the cooperation of Artificial Intelligence (AI).Conventionally, we utilized cloud AI (centralized AI), which is implemented at the data center but the cloud AI-based solutions utilize a large amount of bandwidth to transfer data to cloud datacenter and high latency to providing smart services. So, we need to bring AI to the edge nodes which is located nearest to the origin of data such as base station to solve the aforementioned issues. Thus, in this paper, we propose an edge AI assists smart delivery service to enhance the quality current package delivery process for the future smart city. The main goal of this paper is to minimize the package delivery duration. Finally, we test the proposed scheme by using the Python-based simulator and the simulation results verify that our proposed scheme reduces the delay of delivery compared to the existing approaches.

1. Introduction

Currently, the term smart city obtains enormous attention in academia, industry and government sectors. The purpose of developing a smart city is to enhance the citizen's living standard by providing various types of smart services such as smart public transportation service with the cooperation of Artificial Intelligence (AI). AI can be denoted as the combinations of various type of specialized machine learning algorithm for problem specific-tasks such as content caching [1-3]. Also, the current package delivery service is not effective enough for both retailers and customers. Mostly, the customers require same-day shipping services with free or minimum cost. Also, retailers experience the last mile delivery cost which is nearly fifty percent of the total shipping cost. Therefore, a giant company like Amazon seeking to improve its delivery service and reduce the last mile delivery cost by utilizing the Big Data, Artificial Intelligence (AI) and crowdsourcing [4]. Big data is normally described by the three V's models; volume, variety, and velocity [5], which refer to the tremendous amount of data, different types of data, and speed of the streaming data, respectively. With the aid of the Big Data platform, we are able to do the predictive analysis and efficiently train the various types of problem-specific machine learning algorithms. Also, due to the crowdsourcing, any person who has signed up at the crowdsourcing platform can participate package delivery process and then the participant will gain the service delivery fees.

The classical AI (cloud AI) needs high demands in terms of energy, memory and computing resources. So, the computing paradigm is moved from a centralized cloud computing solution to distributed edge computing to provide real-time, low-latency services. Thus, in this paper, we mainly focus on efficient package delivery service and propose the edge AI assists smart delivery service to enhance the quality current package delivery service. The goal of this paper is to minimize the duration of delivery. Our contributions are summarized as follows:

- We formulate the package delivery delay minimization problem.
- We proposed reinforcement learning based job assignment algorithm for packages deliver to minimize the delivery delay.

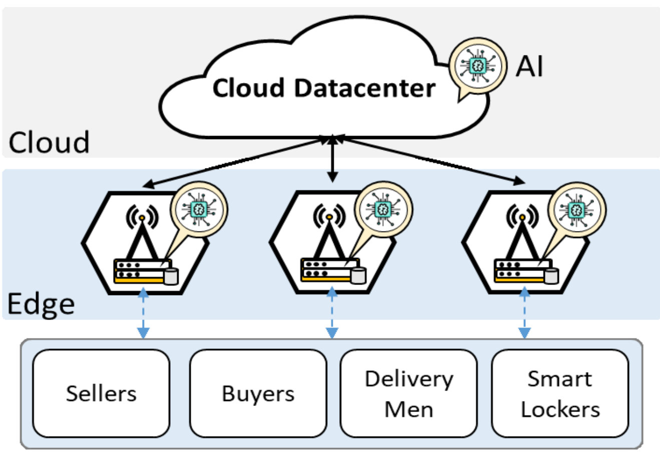

Figure 1 System Model

2. System Model

The system model is shown in Fig. 1 and it includes cloud datacenter, AI enabled base station, retail shops (sellers), consumers (buyers), individual delivery men, and smart lockers. The component at the cloud data center is responsible to manage the global packages delivery routes and the components at the AI enabled base stations are responsible to manage the local packages delivery routes. The smart lockers are denoted as $O = \{1,2,..,o\}$, $\forall o \in O$ and those lockers are owned by third party service providers and placed at the metro stations, bus stations, apartments, convenience stores and etc... In here, smart lockers play the main role to provide an efficient delivery service by serving as the pickup point for all individual deliver men. Then, the individual delivery men who are registered at our platform can be denoted as $U = \{1,2,..,u\}$, $\forall u \in U$. In this paper, we assume that all the smart lockers have the same capacity to store the small packages. Additionally, the retails shops, individual delivery men and smart locker providers are already registered on our system. Hence, our proposed system can provide real-time delivery information such as product pickup point's information, and current location of the ordered products to retail shops, individual delivery men.

2.1. Overview Processes

The overview delivery process from the retails shop to the consumer is shown in Fig. 2. As shown in Fig. 2, the processes can be listed as follows;

1) The seller at the store requests the delivery service to the predefined location. The edge node assigned the delivery men based on the current location of the delivery men and the store to pick up the packages.
2) The delivery man picks up the package at the store and brings to the smart locker which is located at the station A.
3) Then, the other delivery man picks up the package from the smart locker and take the metro.
4) The delivery man drops the package at the smart locker located at station B.
5) the other delivery man pick up from the station B's locker and bring to the destination apartment, and
6) Delivery man drop the package at the apartment's smart lockers.

3. Problem Formulation

In this section, we formulate the product's delivery as product delivery duration minimization problem as follows;

$$\min_{x,y} \sum_{i}^{I} \sum_{j}^{J} \sum_{k}^{K} a^i + x_u^i (p_{u,j,k}^i + d_{u,k,o}^i) + y_o^i \sigma_o^i , \qquad (1)$$

$$\textit{Subject to:} \quad \sum_{i}^{I} y_o^i \sigma_o^i \leq c_o, \quad x, y \in \{0,1\},$$

where a^i is the duration of requesting the product delivery and product i picking time by delivery men $u \in U$. The pickup process duration to pick up product i by deliver men u from the location j to the pickup point k is denoted as $p_{u,j,k}^i$. The delivery process duration to pick up product i by delivery men u from the location k to the smart locker o is denoted as $d_{u,k,o}^i$. The decision variable whether the product i deliver by delivery men u or not is denoted as $x_{ij} \in \{0,1\}$. The duration of product i stayed at the locker o is denoted as σ_o^i. The decision variable whether the product I is placed at the locker o or not is denoted as $y_{ij} \in \{0,1\}$. Then, we define the constraint where the smart locker o cannot store the products more than its capacity.

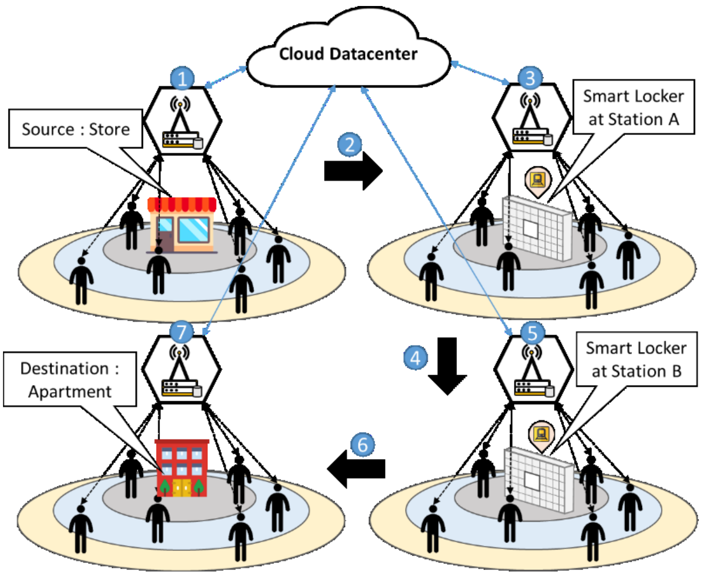

Figure 2 Overview process

4. Delivery Task Assignment for product delivery duration minimization

In this section, we solve the optimization problem (1) by using the heuristic algorithm where the goal is to minimize the duration of product delivery. The proposed delivery task assignment algorithm is presented in Algorithm 1.

Algorithm 1: Delivery Task Assignment

1: **Input:** location of $O = \{1,2,..,o\}$, current location of $U = \{1,2,..,u\}$, $\forall u \in U$, location of source and destination to deliver product i, location of edge nodes
2: **Output:** list of delivery men to deliver product i

3: Optimize the package delivery routes based on source and destination information ▷**Cloud Datacenter**
4: Return the Edge nodes list and Smart lockers list to manage the delivery process of product i

5: Locally optimize the package delivery duration based on location of $O = \{1,2,..,o\}$ and $U = \{1,2,..,u\}$ ▷**Each Edge**
6: Return the delivery men list to deliver product i

5. Performance Evaluations

In this section, we examine the performance of the proposed scheme and the current scheme with python based simulator. In this simulation, we consider 1000 products to deliver, 10 retailers (assign 100 product per each retailer), 1000 individual delivery men and 300 smart lockers. Initially, we build the grid with a size of 600 x 600 miles. Then, we randomly designate the smart lockers locations, delivery men locations, and delivery source and destination locations. To run the simulation of the current scenario, we assign the average packets delivery duration from the range 22 hours to 72 hours. Also, to simulate the proposed scheme, we construct the delivery routes graph based on the locations on the grid. Then, assign the duration on each connecting link based on their distances. The simulation is shown in Fig. 3, where the proposed scheme outperforms than the current scheme.

6. Conclusion

In this paper, we proposed the edge AI assist smart package delivery service for the smart city where we improve the efficiency of the current delivery process by combining with the individual delivery person with the help of AI. There are several challenging issues to deploy the proposed scheme to work together with the current delivery process are as follows, i) we need to solve the complicated path planning problem and ii) we need to solve the package delivery service fees distribution problem among each delivery man. Therefore, as for the forthcoming work, we will more focus to solve the aforementioned challenging issues.

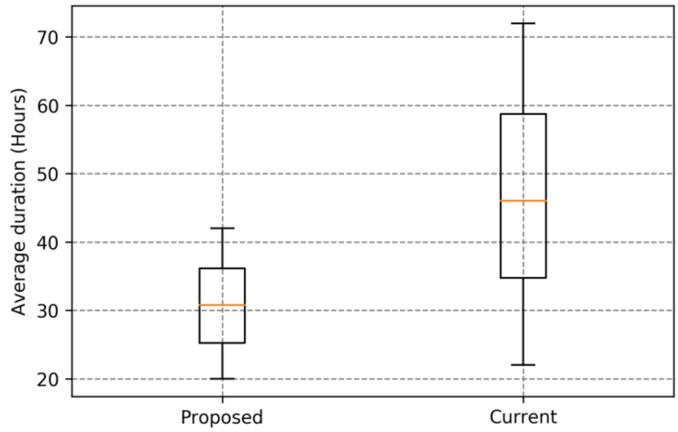

Figure 3 Comparison of average package delivery between Current and Proposed scenario

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