## Influence Maximization Through Social Networks and Minimizing the Cost Incurred in the Last Mile Delivery

## Abstract

Social networking sites have attracted millions of users in the recent years and current research shows that the role of social media on user's purchase decisions is pleasantly surprising. Marketing companies explore several strategies with a fundamental goal of increasing sales; one such popular emerging strategy is Social Media Marketing. Among huge number of online social networks, 90% of the company's target their customers through Facebook then followed by Instagram which is expected to grow to 47% in 2020 (Marketing and digital budget, 2019). It is also observed that 45% of the marketing budget is spent in online marketing where, 25% of it is utilized for marketing through social media. Sales of a product can be accelerated not only through advertising and but also by enhancing the customer satisfaction. 'Not delivered on time' is on the top of the complaint list from online customers (Jie et al. 2015). Last mile is the costliest segment in the supply chain and this stimulates delivery efficiency improvement. The current research proposes models for maximizing the influence to purchase products using social networks. Worldwide, most of the market sectors are experiencing rapid growth in online sales leading to incorporate various delivery options in the last mile delivery. Therefore, we also deal with the problems that effects last mile delivery mostly in urban areas.

Social networks are not only used for advertising but also for propagating the information using the network connections. In this research, the concept of estimating the influence when it is advertised through social networking page. How the comments received on these posts affect the sales of a product is captured through a mixed influence model. Furthermore, this research builds models for maximizing the influences in two ways. One way is to offer the products for free or at discounted prices for selected influencers to propagate the influence. Maximizing the influence of individuals on a social network is obtained through greedy discount approach. Another way is to maximize the influence in a social network by hiring few users in the network to propagate the information. First, this study is significant that it considers the concept of forgetfulness and also the impact of consecutive activation of seeds in a given time period. Second, mixed integer programming model is formulated to maximize the gain by considering the gain attained by influencing the people and the cost incurred to execute the strategy. Models developed to capture the influence maximization through social media also needs an effective last mile delivery system to meet the customer satisfaction levels in a given time interval. Therefore, we also carried out our work in the area of last mile delivery especially on the problems of customer deliver in urban areas. In this regard, we develop a model to capture the effect of high raised buildings on delivery time in last mile delivery. Hard time window constraints along with delivery options are considered to attain customer satisfaction. Emphasis is put on considering the vertical travel time taken by a delivery person to deliver the goods in high rise buildings. Three dimensional vehicle routing problem with Time Windows and Delivery Options (3-DVRPTW-DO) is discussed and formulated to minimize the cost incurred in last-mile networks. The final objective is a real world case study of vehicle routing problem in Indian postal system. Shifting delivery section of all post offices in a division to 3 nodal post offices and introducing e-bikes to deliver the articles are the critical issues in East Kolkata postal division. This problem is formulated to minimize the cost incurred in overall system by optimizing the number of postmen and the e-bikes in the system.

The proposed models in this thesis include Valence Aware Dictionary and sEntiment Reasoner (VADER) algorithm for sentiment analysis on the Facebook review comments. Maximizing the influence by providing free or discounted products to influencers is solved by using greedy discount approach. Memetic Algorithm (MA) and Genetic Algorithm (GA) are employed to maximize the influence in considered real world networks by hiring the eligible users to propagate the information. 3-DVRPTW-DO is solved using FAST- Neighborhood based Crowding Differential Evolution (FAST-NCDE) algorithm. In this technique niching is integrated with locality sensitive hashing method to perform better than Neighborhood based Crowding Differential Evolution (NCDE) algorithm. Genetic Algorithm is used in order to solve the problem of introducing e-bikes into Indian postal system. In GA, we employed Partially Mapped Crossover and Inversion Random Gene Inserted Beside Nearest Neighbor Mutation for better results for this specific case study. The focus of the research is mainly on identifying the various key problems in the area of advertising and last mile delivery with a motivation to enhance the product sales and the delivery system in urban areas then followed by the mathematical formulations, validating the results and developing key insights and critical issues.

**Keywords:** Influence Maximization, Social Networks, Vehicle Routing Problem, City Logistics