Context-aware Advertisement in Rapid Transit Systems

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***Abstract*—The businesses of today believe on marketing oriented trend. Quality of marketing is equally important as the quality of the product and relevant metrics. Quality of Marketing depends on targeting the right person. Due to latest innovations in technology every aspect of human life adopted significant changes. In marketing also, significant changes in trends are considered. In this paper, we are presenting a model for advertisement using latest technology. This model is based on the concept of Internet of Things (IoT). The target audience of the advertisement are rapid transit systems users. The model is designed using agent-based modeling (ABM) technique. We are using the Overview, Design and Details concept of ABM. This paper present a way to target right person for the advertisement. In this model, IoT provides the input data and the data is manipulated using pattern mining.**

I. Introduction

As information technology (IT) grow up and becomes an essential part of firm's operations, its role in traditional business decisions needs to be reconsidered. This role is especially relevant for an offline business when they are deciding on the optimal advertising expenditure. In this article we study to optimize the advertisement strategies to target the relevant customers in a specific area. The idea is to target the customers often visiting the area of specific brand. Information and communication technologies (ICTs), such as mobile phones and the Internet, have become increasingly pervasive in modern society and can be very helpful for the companies to advertise their brands. These technologies provide their users with more flexibility with respect to when, where, and how to travel. Understanding the influence of ICTs in our mobile information society (Raubal, 2011) will be essential for updating environmental policies for our task, and maintaining sustainable mobility and transportation (De Souza e Silva, 2007). Moreover, ICTs have provided a wide range of spatio-temporal data sources, which can be used for geographic knowledge discovery and data mining in studies on geographic dynamics, such as human travel behavior and mobility patterns (Miller, 2009; Song, Qu, et al., 2010; Yuan, 2009). Although several spatio-temporal datasets (e.g., georeferenced mobile phone data) only provide incomplete data with relatively low resolution and few individual attributes, and it is important to determine how much and to what extent we can extract knowledge from sparse data sources, as well as dealing with uncertainty in sparse datasets but still the extracted information is ver helpful in determining the behavior of person towards a specific brand.

Due to the widespread use of mobile communications, there have been several studies focusing on acquiring geographical knowledge from georeferenced mobile phone data and use that knowledge for different purposes. For example, Ahas' social positioning method (SPM) combines both location data and social attributes of mobile phone users to study the dynamics of urban systems (Ahas & Mark, 2005; Ahas et al., 2007). Gonzalez, Hidalgo, et al. (2008) studied the individual trajectories of 100,000 mobile phone users based on tracked location data in six months, providing new insights to understanding the basic law of human motion. However the social network is way more expanded these days and almost everyone is connected through this network and the data extraction from social network can be quite helpful in determining the behavior of the individual as well as a group of personnel traveling in a specific area and advertise the brands related to them. Although the point of consideration while advertising is customer but our proposed method is not only going to help customers but also to the companies advertising their brands to only those relevant to them which decrease the cost in terms of money and effort exerted while advertising their brands to those who are not even interested. When it comes to the shopping there are many factors that affect the behavior of the customer. We have divided the factors in two main states 1) individual state 2) external/environmental state. The first state is the description of individual activity state focusing on the age group, daily routine, occupation, emotional state and income level etc. while the second state is description of the external factors effecting the individual's life in which we shall be focusing on the society, friends circle, and travel patterns etc.

The remainder of the article is organized in following pattern section 2 is the literature review conducted to provide the summery of the work already done in fields under discussion section 3 is the proposed methodology to resolve the problem section 4 is the evaluation results to validate our work and

section 5 contains the conclusion and future research direction.

II. Background

We have reviewed our literature in three main point of views Agent Based Modeling(ABM), travel pattern detection and advertisement strategies.

A. Agent based Modeling:

Agent-based modeling is considered to be a powerful simulation modeling technique that helped in solving many problems in the last few years, including applications to real-world business problems. The core objective of using Agent Based Modeling is to represent the activities and processes involved in collaborative environment. Agents should be obviously more than just a simple software package or program but it is bit unclear where the boundaries lie. This is the demonstration of a general problem present in AI of defining 'intelligence' [1]. According to Anumba, C. J., et al Agents shall not only be like that their actions are only the results of their environment but they should have capability of taking initiative following a goal directed behavior.

Agent based modeling is considered an approach that is being used in epidemiologic literature [16]. Machine learning techniques are quit useful to implement the behavior of the agents [17]. Agent Based Models (ABMs), using a complex systems approach, provide a method for examining dynamic interactions of social and demographic actors at both micro and macro levels [18]. Haghnevis et. al. presented a formal agent-based modeling (ABM) platform that enables managers to predict and partially control patterns of behaviors in certain engineered complex adaptive systems (ECASs). The approach integrates social networks, social science, complex systems, and diffusion theory into a consumer-based optimization and agent-based modeling (ABM) platform [19].

The Agent based modelling approaches are used in many fields ranging from economics and social sciences [21] to biology and diverse engineering areas [22]. When the system being modelled is complex, modular and decentralized, changeable, and defined at the time of design, ABM is a well-fitted method of modelling [23]. Some models about optimal control to determine the speed of transport systems are discussed in literature. Under the optimal control approach, research studies are mainly grouped into two categories: exact solution algorithm and heuristic algorithm [24]. Another framework [25] for cooperation in intermodal freight transport chains as multi-actor systems.

And when it comes to the domain related to negotiation of the agents Rosenschein and Zlotkin [4] distributed this domain into three subdomains task orientated domains (TODs), state orientated domains (SODs) and worth orientated domains (WODs), here each subdomain is a generalization of the previous one. TODs are very simple in these the activity of the agents is based on the set of assigned tasks it has to accomplish. WODs are the domains where worth is defined by the agents for each state available. Here goals can be more flexible and making concessions is also allowed. An example would be agents in an e-marketing place where the goal for a company may be to obtain the maximum price for a within time span b. The chances of deadlocks and conflicts a present here too nut here the environment is more bargaining.

B. Pattern Detection:

Majid, Abdul, et al. stated in their article that the pervasive use of digital cameras and sharing the photos on the social network such as flicker makes a lot of geo-tagged photos available to on the Web. On the basis of the geo-tagged photos and experienced shared over social network they got the traveling preference of the user and proposed a new method to recommend user new tourism places relevant to them [5].

According to Yoon et al. it takes time for the travelers to digest and put together the collected information for use[6]. In May 10 2016 Beijing Transit issued smart cards to traveling personnel to pay through it. They mined the data of individual to reduce the involved complexity in travel pattern and make cluster. Baysian decision tree was used to extract the boarding changes in boarding volumes between two transactions conducted consecutively and evaluated this information combined with historical data of the speed profiles extracted using GPS to get the probability of the potential stop. Further Density based Spatial Clustering of application with noise (DBSCAN) was used to get the travel pattern of individual in efficient way [11].

According to chun et al. data mining methods based upon the input from past data available for the prediction of the short term movements of the important currencies, interest rates, or equities has been studied by the researcher to build a quantitative trading tool to improve the trading to make it efficient [7]. Banks have huge databases containing the transactions and other personal details which can be used for predictions but human resources are not enough for this so a data mining technique is necessary to detect the pattern of the customer and predict about the profile of the customer [8].

Lui et al. proposed a technique named Mining data Record (MDR) to mine the web pages data they extracted the html tags to build the tag tree and trained there system on the different dmains like book, travel, auction, software and jobs and they also compared the results with other two techniques OMINI and IPEAD and when it came to prediction OMINI only detected 6 out of 46 pages correctly and IPEAD predicted 14 pages correctly while MDR predicted 44 correctly. In predicting patterns IPEAD does not work for similar record but MDR is very good at detecting boundaries. [9]

C. Advertisement Strategies:

According to Tseng et. al. the brand equity for a traveler behavior is dependent on the following three points (1) frequent visits to that place, (2) time span spend there during visits and (3) recommendation frequency of the destination[10].

In a study Brand equity of a tourist place named Bali was measured in five measurement variables i.e. (1) knowledge about brand (2) image of the brand (3) associations of the brand (4) observed quality of brand and (5) loyalty to that brand. They concluded that by maintaining equity of the brand can help in getting the loyalty of the visitors, choosing the right area to be targeted and advantage over the competitors.[12] Building on Keller's brand positioning, brand resonance, and brand value chain models, A study have been conducted in which impact of the brand management process fast paced advancement in technologies, digital development, and constraints related to environment and social activities have been discussed. They concluded their discussion suggesting that responsiveness according to user needs, innovation in the products and being responsible are crucial attributes in management of brands equity. They also suggested that global macro changes demand to concentrate on specified brand equity for both the purposes to meet the expectations of the consumers evolving day by day and to be in competitive state and achieve high performance in market [13].

Krush et al. (2014) explored the connection available between marketing and resources of the sales (e.g. capability of sales and dashboards for marketing) and sensemaking, and the combinational effects on performance of the firm. Their study explored that capability of sales and using dashboards for marketing explicitly contribute to performance of firm and it also have an interactive effect with the sensemaking. In addition to this, sensemaking can effect both growth in firm and efficiency of the cost. For marketing scholars sensemaking is important as it plays a vital role in knowledge capabilities of the firm and make firm more successful and sound in facing changes occurring in the market. These studies confirm how important it is for sale and marketing operations to integrate [14].

Zhao et al. (2015) discussed the preconditions for the success of first product launched in the market and the association to existing resources of the firm, and investigate about the strategy of positioning of the product that can mediate the effects of technical resources, marketing resources, and startup expertise of the founding team on the success of the product. The authors claimed that impact of the founding teams with more prior experience is smaller than the founding team with less prior startup experience [20].

III. Context-aware Ad. Manager Model

We used Agent Based Modeling (ABM) approach to model our research. In brand management first we need to identify the agents. Our agents are as follows users, Brands, travel vehicles, and stations. A user in our system is connected to the stations he/she travels, user is also connected to the social media where we share our locations our likes and dislikes and express our emotional states Fig. 1. When a person go to any station he/she will be able to watch adds running on the screen but those adds are relevant to them are not is a big question mark. People ignore such ads which are not relevant to them. We discussed three strategies to improve ads mechanism to display them on the screen.

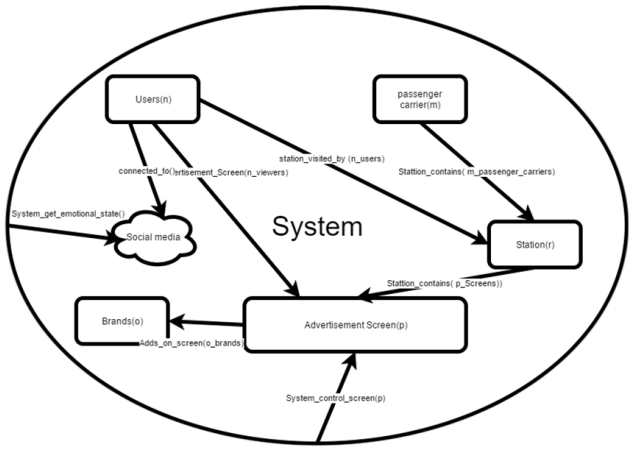

Fig. 1. Generic Model of Context-aware Ad. Manager

We propose a model Fig. 2 in which we generate a map against the users motion getting location data from the GPS of the smart phones they are using and mining the that data combined with the social media, station location, brands location, and advertisement screen locations to predict the adds to be displayed on the screen on the different times and different stations.

This model takes user travel history from mobile phone GPS data logs, persons' personal information from travel company Metro in our case, and social behavior of the person from the links user has provided while signing up for the Metro card. All this information is processed by the Density Based Spatial Clustering of applications with Noise (DBSCAN). DBSCAN detects the patterns and make clusters of it. These clusters are then further extracted in two main form (a) Spatial Clusters: Clusters according to location patterns (b) Temporal Clusters: Clusters according to time patterns followed by the users. On the bases of these clusters we divided the ad display tasks in four preferences.

A. Behavioral modelling using ODD model

1) Overview :

- **Purpose**

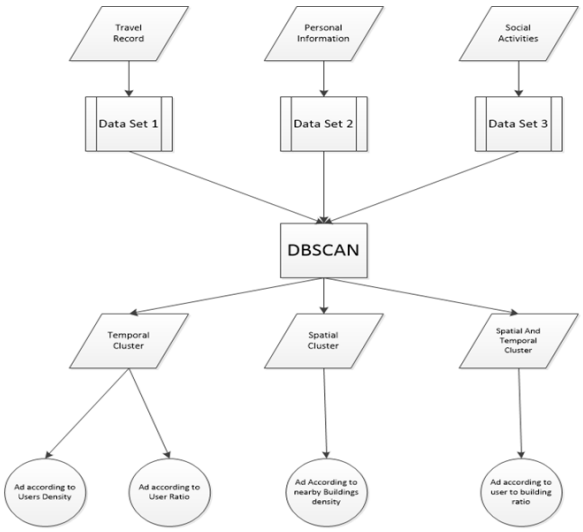

Fig. 2. Proposed Model

The purpose of the model is to explore the behavior of the people traveling across the stations and to find more effective and efficient ways of the advertisement strategy. Under what conditions the ads shall be displayed on the station screens? How can the travel patterns combined with their social media activities of people describe the behavior of the people? And how it is helpful in advertisements?

- **Entities, state variables and scales**

Our model consists of a set of entities, state variables and scales as described below

1) Traveling persons Pi
2) Brands Bj
3) Stations Sk
4) Each brand and station is characterize by their location Lk
5) Each traveling personnel has a two state variables: his check-in location C_{IN} and check-out location C_{OUT}
6) There is a global variable of hour of the day Th
7) The distance D between the stations is not specified as we designed a generic model

- **Process overview**

The processes in our model are the patterns of the persons traveling from one station to another station in different times, persons visiting the brands, and persons liking the ads. On each time step person move from one station to another while station and brands observe at each time step as if some persons has visited a specific place.

2) Design concept : In our model the basic principal that is addressed is the idea of relevant advertisements on the screens. The screen are going to adapt a specific type of ads at the time according to the changes made in the environment by other agents like the type of persons coming to the station at specific time. This adaptive behavior is modeled by simply observing the previous travel history of the persons using that track.

Our model does not include the direct interaction among the traveling personnel. As at a time traveling toward a station in the peak hours there is a probability that people will be of the same profession. This probability is going to help in the decision making of Density Based Spatial Clustering of Application with Noise (DBSCAN) algorithm and will be helpful in making clusters afterwards.

- **Emergence**

This idea emerged from the concept of utilizing the rapid transit systems for advertisement. Rapid Transit Systems are one of the most rushy area during whole day. Hence, we can target the most appropriate audience at these stations.

- **Observation**

In this model we observe the user movement pattern. The decisions will be made based on the user feedback and movement.

- **Adaptive behavior**

If user provides positive feedback or remain silent then the ads will continue. Otherwise, more relevant ads will be put to him.

- **Sensing**

We will sense the motion of the users and the frequency of the users. Also, we will sense the trend of the users.

- **Prediction**

Prediction will lead to the decision making. The system will predict appropriate ad. for specific target.

- **Interaction**

This model will keep the interaction of different stakeholders like service provider, customer and broker.

- **Stochasticity**

The movement and task of the users varies. Hence, this system will deal with such a variability.

3) Model Details :

- **Initialization**

The distance between the stations were initialized at the start of the model. The persons initialized at the start of the model were 1000, stations were initialized to 7, and brands were initialized to 10 at each station. The persons (agents) were initialized according to real world information about the type of buildings around the stations at the peak hours $T1$, off-peak hours $T2$ and night times $T3$ which has almost $3:2:1$ ratio respectively.

- **Input**

The brands feedback will provide the input data to the system.

- **Sub models**

The adapting behavior of the screens sub model defines what exactly is going to be displayed on the screen it only takes the

inputs in the clusters forms and the decision making is based on the type of times we decided. This sub model decide whether to display ad according to the density of the people on the station or the density of the buildings surrounding it. The decision of whether to display ad according to density of the people on station or according to the type of the buildings surrounding the station is decided by the variable Th which actually tell the density of the people at that time of the day at a specific station.

Here are some of the preferences we used

Ads according to Maximum number of audience:

In this technique probability of the number of users will define the type of ads to be displayed on the screen of the station. For example if there are n total personnel predicted at that time of the day and according to our algorithm let a,b and c be the number of personnel related to different profession then the ad to be displayed is calculated as

$$\frac{hieghestOf(a,b,c)}{n}) \longleftrightarrow ad_{ToBeDisplayedOnScreen} \tag{1}$$

Ads according to audience ratio:

In this technique ads shall be displayed in ratio of the audience predicted at that time of the day. For example if there are n personnel on the station and, a and b be the number of audiences predicted at that time of the day then ads shall be displayed in ratio of the audiences available. Screen shall be shared by the ads according to the ratio of the audiences detected.

$$P(a/n) > P(b/n) \longleftrightarrow TOS(a) > TOS(b) \tag{2}$$

Here $P(a/n)$ is the probability of a while TOS function returns the Time On Screen value for each ad.

Ads According to the nearest Buildings to the station:

In this technique preference is given to the buildings available near the station. A station is mostly filled by the people working in the areas near to that station so it would be a good idea that the ads shall be displayed according to the nearest buildings and the time at which people mostly use the station to go to those buildings. Let d be the set of buildings and t be the set of time spans at which the station is filled with the people going to those buildings.

$$d(i) \bigwedge t(j) \longleftrightarrow ad_{ToBeDisplayedOnScreen} \tag{3}$$

Where i and j are the indices of the sets a and b and

$$(timeFor(d(i)) = t(j)) \longleftrightarrow (i = j) \tag{4}$$

Ads according to Building ratio:

In this technique ads shall be displayed in ratio of the building around that station if according to prediction people from the different buildings visit the station at the same time of the day. Then the ads shall be displayed according to the number of people predictively visiting the station and going to that building. Let d be set of the building a,b be the number of visitor of that building on the station then mathematically it can be represented as

$$(a(d(i)) > b(d(j))) \rightarrow (TOS(d(i)) > TOS(d(j))).\because i \neq j \tag{5}$$

Cost Evaluation:

We evaluate the cost of ads in two main points (1) density of the visitors and (1) density of the buildings near by

Cost according to Density of the Visitors:

In this case we calculate the cost of the ads keeping in mind the density of the users in the office starts and end times. Let V_R be the relevant user view Let $C(V_R)$ be the cost of the relevant view Using these two we can calculate the Total cost of the Ad like.

$$TotalCost = \sum_{i=1}^{n} V_R * C(V_R) \tag{6}$$

Where $C(V_R)$ can be calculated as

$$C(V_R) = (SingleUserPersecondviewcost) * (TotalTimeinSeconds) \tag{7}$$

Cost according to Density of the Nearby Building:

In this case we are going to calculate the cost of the ads being displayed in terms of the building surrounding it as in off days or even office times visitors only visit a station according the buildings nearby. For this purpose we need to define the station business factor which is the value of the station at that time of the day. Let, SBR be the Station Business Factor, T be the total time the ad is being displayed, and PR be the per second rate of the ad then.

$$TotalCost = P_R * SBF * C_A \tag{8}$$

Here C_A is the Ad Cost which can be calculated as

$$C_A = P_R * T \tag{9}$$

IV. Scenario

Let's consider the scenario of Rawalpindi-Islamabad Metro Bus System in Pakistan. This rapid transport system has total length of $22 kilometers$ with $24 stations$. An average $0.1 million$ passengers per day use this transport. Normally, passengers traveling on regular basis use metro card. Based on that metro card their daily entering and leaving stations can be recorded.

Suppose, a student of Bahria University Islamabad named as Usama has residence at 6th-Road Satellite Town Rawalpindi. Often, he enters the 6th-Road station between $8:30am$ to $9:00am$ and checkout at Kechahri station between $8:50am$ to

$9:20am$. Similarly, Usama enters Kechari station at $5:00pm$ to $5:30pm$ and leaves at $5:20pm$ to $5:50pm$. On weekend and in holidays, Usama visits Saddar and 7th-Avenue as well. Depending upon this information we can send him relevant ads. Let's say Subway has a branch in F-8 and Usama moves in that direction from the nearest station Kechahri. Then, the add of the Subway will be appropriate for Usama. Similarly, if Usama provides feedback that the Subway ad. is not relevant to him then, other ads. according to his interest should be sent. Also, Cabinet Computer at 6th-Road announces a discount on laptops. So, this ad. should also be sent to Usama.

Now, we have a problem that how these ads. will be managed by the broker in case of more number of appropriate ads. for specific user. For this purpose our model introduce different schemes. These ads. can be managed based on either the audience ratio or the cost. The formulas described in the model can be used to calculate these factors.

V. Conclusion

The study has proposed an effective method to improve advertisement strategy. We used travel data of the persons to identify the patterns and to get help in decision making of which ad to be displayed on any screen. After the evaluation the results have shown that the travel patterns of the persons is quite helpful in determining the behavior of the person which in turns can be used to make decision about the advertisements strategy to a specific group of people. We also calculated the cost of the ads to companies according to the number of audience available at any time of the day.

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