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Activity based approach to travel demand modelling: An overview

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Abstract

Economic growth in the major cities of developing countries creating employment opportunities and hence these cities are becoming the major livelihood destinations to the people. This migration from rural areas to urban areas imposes sustained pressure on their major cities to satisfy the increased social, economic and infrastructure needs. This increased urbanization trend and changes in socio-economic status of the society have put tremendous pressure on the transport infrastructure. These conditions are expected not only to influence people's travel behaviour, but also further making it more complex. Due to the limitations of traditional models, planners and policy makers insisted more on specific solutions which deal with the life style and attitudes of the people. Understanding these behavioural aspects is the main motivation behind the development of activity based travel demand models. Activity based approach address complex decisions concerning multiple dimensions of various trips and activities. This paper reviews the limitations of conventional travel demand modelling process along with the capabilities of activity based travel demand models. On the top of that, various potential contributions of representative activity-based approaches for improving the state-of-the-practice are presented here. Further, some of the future directions are highlighted in the development of travel demand models.

Keywords: Urbanization - Travel demand models – Activity based approach – Operational activity based models
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1. Introduction

Urban sprawl is the major problem in the developing world. Between 1950 and 2005, the global propoportion of urban population increased from 29 to 49 percent and is expected to reach 60 percent by 2030 (DESA, 2006). Though urbanization is driving the economies of most of the cities in developing countries, the negative impacts of this urbanization on the environment and transportation is becoming a serious concern to the planners. Further, the issues related to urbanization in developing countries are different from developed countries. Urbanization in developing countries is highly dynamic in nature and this imposes sustained pressure on their major cities to satisfy the increased social, economic and infrastructure needs. Heavy migration from rural areas leads to rapid growth of private and public transportation services, causing unacceptable traffic congestion and environmental degradation in major cities of these countries. This increased urbanization trend and changes in socio-economic status of the society have put tremendous pressure on the transport infrastructure. Hence this issue has become major concern for planners, policy makers and environmentalists, etc. These conditions are expected not only to influence people's travel behaviour, but also further making it more complex. Hence, specific solutions must be proposed for these particular situations and they should deal with the life style and attitudes of the people.

Traditionally, transportation planners insisted more on developing new infrastructure to cater to the increasing travel demand. During the past few decades, however, researchers shifted their focus from development of new infrastructure to make transport system sustainable to meet new demand. This can be achieved by the effective management of travel demand by using efficient travel demand models. The first generation of travel demand models were developed during 1960's and are popularly known as four stage models because travel is considered to be the result of four sequential decisions: 1) trip generation 2) trip distribution 3) mode choice and 4) route choice. Due to their own limitations like aggregate methodology and lack of behavioural aspects, trip based four step travel demand models have become ineffective. The limitations of conventional four step travel demand models have discussed in detail in the next section. Dissatisfaction with the forecasting accuracy of these models leads to the development of two new approaches viz. Disaggregate travel demand models and Activity based travel demand models (Jovicic, 2001). Basic methods of disaggregate choice modelling, and their application to travel demand is well documented by Ben-Akiva and Lerman (1985). Though disaggregate travel demand models flourished during this period, they have maintained a fundamental error of the four step models of analyzing each trip independently of other trips made by the same individual. This limitation has become significant in the light of the need to assess a set of policy issues, including congestion pricing, teleshopping, etc. The trip based aggregate and disaggregate approaches have become less appropriate due to their inherent drawbacks to predict the effects of potential behaviour changes like substitution of out-of-home activities with in-home activities, chaining of individual trips into home-based tours and changing the timing of activities and trips. Understanding these behavioural effects is the main motivation behind the development of activity based travel demand models, which have emerged in late 1980's and became a dominant modelling approach.

The main aim of behavioural analysis is to develop the capability of predicting the individual responses due to changes in their travel environments. Activity based travel demand analysis is the one which focuses on various patterns of travel behaviour and considers travel for carrying out the activities that are distributed in time and space. All the travel decisions are based on activity type; hence understanding the activity behaviour is primary for perceiving the travel behaviour. Some of the researchers put their efforts to understanding the activity travel behaviour and developed or in the process of developing full pledged activity based travel demand models. In this paper, author made an attempt to throw some light on the ongoing research on activity based travel demand models.

2. Limitations of traditional four-step approach

Trip based approach uses trips as the unit of analysis and considers that an individual's daily travel pattern is an aggregation of independent trips. Due to its independent behaviour, the traditional four stage travel demand method clearly neglects the interrelationship in the various dimensions of different trips such as time, destination, and mode choice. Further, the scheduling of trips and the resulting inter-relationship in the attributes of multiple trips were ignored in all steps of the trip-based method. The advances in the field of telecommunications and internet facilities lead to the substitution of several out-of-home activities with equivalent in-home activities. The conventional methodology focuses only on trips by ignoring spatial and temporal interrelationships and considers each trip as an independent entity. This ignores the behavioural fact that people choose their travel plan ahead by considering entire trip chain, not each individual trip separately. Hence, this methodology cannot accommodate impacts of substitutions between out-of-home and in-home activities on the overall travel patterns of people.

RDC Inc. (1995) mentioned that the primary problem with trip based approach is the internal inconsistencies. Trip generation and trip distribution phase needs some adjustments since in most of the cases they do not match each other. Since the model calibration uses inefficient data in the form of zonal averages, the parameter estimates of models are inefficient. Further, traditional four-step models were developed when available computational capabilities were very limited and statistical theory for model estimation was not well advanced. As a result, model calibration procedures adopted inefficient data use which led to inefficient parameter estimation. Lack of behavioural foundation is another major limitation of four-step model (Kitamura et al., 1995a). For example, congestion pricing is implemented in one area, prompting some travelers to choose other destinations. This change in trip attraction cannot be captured by the four-step procedure because trip attraction is determined in the trip generation phase which is insensitive to congestion pricing. Also the issues of induced trips and suppressed demand are difficult to address within the structure of the four-step procedure. The four-step procedure does not incorporate the time-of-day dimension or is incorporated in only a limited way. Generally, time is introduced at the end of the traffic assignment or at the end of the trip generation step by applying time-of-day factors to 24-hour travel volumes (Bhat and Koppelman, 1999). Further, trip based approach completely ignores the fact that travel demand is a derived demand and the connection between trip and activity is completely missing in this approach (McNally, 2000). Trip-based methodologies ignore individual interactions in trip making at household level, thus failing to capture linkages among trips of household members. Complex results of policy actions cannot be captured by the simple and statistical approach of trip-based methods, which essentially work at the aggregate level and not at the more behavioural and disaggregate individual level. Overall from this section, it is clearly understood that the four step methodology has their own limitations in analyzing traveler behaviour oriented sustainable transportation policies. This puts a requirement on the traveler behaviour oriented demand models to be able to forecast travel impacts under various policy scenarios. This highlights the need for an alternative approach that can incorporate improved behavioural dimension and can analyze sustainable policies.

3. Activity based approach to travel demand modelling

During the 1970's, transport planners turned their focus from infrastructure development to the travel needs of a person, and they came up with two new approaches i.e. disaggregate trip based travel demand models and activity based travel demand models (Jovicic, 2001). The basic idea underlying modern approaches to travel demand modelling is that travel is the result of choices made by individuals or collective decision making units such as households (Horowitz et.al, 1986). Disaggregate models, also called as second generation travel demand models have taken the attention of researchers during the 1980's and 1990's. Though disaggregate approach and activity based approach are two individual areas of research, academicians focused more on the development of an activity based travel demand modelling approach due to the fundamental errors of disaggregate approach, which analyze each trip independently of other trips made by the same individual.

The amount of literature on activity based travel demand modelling has been growing significantly over the past two decades. Activity based modelling is the one which provides better understanding of the nature of the individual and household decisions concerning activities and travel. The main motivation for the development of activity-based approach to travel demand modelling is deeper understanding of individual travel behaviour and to provide a model that is sensitive to emerging policy issues like congestion pricing, land use etc. Activity based approach provides a more fundamental and comprehensive framework to illustrate the realistic representation of travel behaviour than the trip based aggregate and disaggregate modelling approaches. An activity can be defined as a physical engagement of an individual in something that satisfies his or family needs. Activity-based approach views travel as derived demand; derived from the need to pursue activities that are distributed in time and space (Jones et al., 1990). Travel demand is attributed by explaining and analyzing individual's and households' activity decisions. These decisions include questions like whether, where, when, how, for how long and with whom activities are conducted. The interdependencies among these decisions are explicitly taken into consideration in activity based approach. The ability of realistic representation of travel behaviour in this approach leads to not only recognizing the interactions among a series of individual trips, but also capturing the connections between trips made by different household members (RDC Inc., 1995).

Another important notion of the activity based approach is focusing on the problems of human behaviour in time-space context, which was studied by the researchers Hagerstrand (1970) and Chapin (1974). Their contribution to the time-space analysis is the main concept behind the activity pattern studies (Ettema, 1996). Hagerstrand (1970) well explained this notion by using the concept of the time-space prism. It says that all actions of individuals have connection with time and space. If the facilities are situated at specific locations, the amount of travel required for the completion of activities imposes some constraints on engaging in such activities. These space-time constraints limit the activities that could be participated by the individual and direct them to which activities are eventually performed. Another important issue is that activity demand is significantly affected by the household, as most of the households consist multiple persons and their individual decisions are constrained or influenced by the other members of the household. Chapin (1974) theorized this concept of considered household as a decision making unit. According to him, individuals are first motivated to act then to make choices. All the activity and travel decisions are outcome of a scheduling process. These scheduling decisions are motivated by the individual’s desire to satisfy personal needs through activity participation. People sequentially connect their activities in a continuous domain of time and space because of constraints that limit their activity schedule choice.

Fox (1995) mentioned that “the activity based approach studies travel in the context of daily household activity patterns”. Analysis of these activity/travel patterns is the major goal of an activity based travel demand model and a day is usually considered as the basic unit of this analysis. McNally and Recker (1987) defined the activity-travel pattern as the revealed pattern of behaviour represented by travel and activities over a specified time period. These activity/travel patterns are referred to as household activity patterns that arise from the scheduling and execution of household activity programs. Activity based travel demand models strongly emphasize individuals activity scheduling behaviour. Another important goal of activity based modelling is to identifying the decision mechanisms that individuals use to decide about the activities they perform and the trips they make when integrating many different decisions related to activities and trips into a single activity schedule. Further, activity based approach incorporates the effect of household socio-demographic variables in modelling, which allows examination of changes in travel patterns over time due to changes in socio-demographics of individuals. Spatial, temporal, transportation, and personal interdependencies can also be modeled in activity based approach (McNally, 2000).

The above discussion clearly indicates the expansion of the analytical scope of activity-based approach compared to other trip based approaches. This naturally leads to increased levels of difficulty in the analysis because activity engagement is a complex behaviour. Conventional travel survey data do not offer sufficient information on activities. Such data limitations might be the reason for minimal efforts made to explain the travel behaviour over a time period. The complexity is multiplied because modelling travel behaviour is not only limited to modelling time allocation into activity categories but also model activity engagement episodes for travel demand analysis. Although, activity based models have gained much popularity in the developed world, owing to the unique social issues and data requirement, this approach is yet to gain acceptance in developing countries.

4. Conventional approach vs Activity based approach

The comparison between main modelling steps in the conventional four-step travel demand model and activity based travel demand model structures is described in this section. It can be inferred from the discussion that activity based models cover all dimensions of conventional four-step models; and adding numerous additional details that are advantageous for policy evaluation (Davidson et al., 2007).

Trip production models in the conventional approach are replaced with a daily activity-travel pattern model in activity based approach that takes into account various inter-relationships and trade-offs across generated tours and trips during the day. The daily activity pattern model is sensitive to the travel environment and accessibility when it is compared to trip production models in the conventional approach. In the activity-based modelling framework, conventional trip attraction models take a form of location-choice zonal size variables within a destination choice modelling framework. These size variables are segmented by making a distinction between primary and secondary destinations. Conventional models fail to incorporate such a distinction when using sequential estimation processes to model trip attraction and distribution.

Trip distribution step in the conventional four-step approach models all the non-home based trips as independent, while in the activity/tour based framework, locations of origins and destinations of non-home based trips are properly linked to the location of the corresponding home-based trips in the same tour. Further, in conventional approach, mode choice for the each trip is modeled separately thus creating numerous illogical mode combinations while in activity/tour based modelling approach, mode choice decision (whether to choose public transit or private vehicle) is properly modeled at the level of the entire tour.

Another major advantage of the activity/tour based approach over the conventional approach is the fully consistent modelling of time-of-day choices across different tours during the day and for different trips in the same tour. This makes the activity/tour based models sensitive to policy measures and changes in any particular time period and able to track the impacts of these changes to all other dimensions of travel demand while the conventional models are unable to track all these effects and are insensitive to the time-of-day policy measures. Network assignment procedures implemented in the activity/tour based approach are currently in the same manner as in the four-step models. Hence, the output of an activity/tour based micro-simulation model is aggregated into conventional trip-table format before assignment.

5. Alternative modelling approaches

Having discussed about the set of requirements for incorporating activity-based travel theory into a travel demand model, this section advances to the review of the alternative modelling approaches developed in the literature by many practitioners in attempts to bring activity-based travel theory into practical forecasting model. Important research and development efforts of experts over the last few decades on activity based travel theory leads to development of different categories of models like econometric models, rule based models, markov models and microsimulation models. The fundamental weakness of the Markov approach is that it is based on a decision sequence tied to the temporal activity sequence. This renders it unable to represent adequately a decision process that is governed more by commitments and priorities than by sequence. The introduction of econometric and statistical approaches gives better decision framework than the markovian models. Econometric models are the most popular models of travel demand forecasting. These models are also known as utility maximizing models, which use system of equations for the generation of choice as decision outcome. But this econometric modelling approach, does not explicitly model the behavioural mechanisms underlying activity engagement and travel. The models with utility maximization framework based on the unrealistic assumption like an individual has full information about various alternatives and can arrive at optimal solution. In addition, these models specify only the factors affecting final choice but neglect the processes resulting in these choices. Although, the rule based modelling approach offers more flexibility than econometric models in representing the complexity of travel decision-making and the resulting schedules may be fairly incomplete in scope the major components of the schedule are not modelled. Therefore, they are not conditioned by the long term urban and lifestyle processes resulting will be incomplete schedule.

Microsimulation is an emerging trend in the field of activity based modelling, which conceptualized activity- tours, activity prioritization, activity classification, and the potential role of spatial and temporal effects much better. In microsimulation approach the choices of an individual are simulated dynamically based on the underlying behavioural models driving household and individual decisions (Miller and Roorda, 2003). Microsimulation systems provide a means of forecasting the impacts of a given policy at many different levels, including at an individual level, at a sub population level, and at the aggregate population level. They are best suited for joint allocation of activities, task allocation and vehicle allocation and activities and travel decision subjected to constraints. To date, partial and fully operational activity-based microsimulation systems are developed for simulating the activities of individual objects as they evolve over time. Some of the operational activity based models are explained in the next section.

6. Operational activity based models

Till date, many experts have worked in the area of activity based modelling and developed several operational models. Arentze and Timmermans (2004) developed a fully operational computational process model called ALBATROSS for Netherlands region. The ALBATROSS stands for A Learning BAsed TRansportation Oriented Simulation System and is an alternative to econometric pattern modelling, extending the computational process modelling approach with simulation capabilities for large numbers of households and individuals. This model is capable of predicting the activity-travel pattern of individuals. This is a scheduling model and has a sequential decision making approach. This model only focuses on activity scheduling of adults in the household where possible interactions between them are taken into account.

STARCHILD stands for Simulation of Travel/Activity Responses to Complex Household Interactive Logistic Decisions. STARCHILD (Recker et al., 1986a, 1986b) is developed to examine the formation of household activity-travel patterns. STARCHILD belongs to the group of activity schedule building models. Choice set generation and choice of an alternative are the basic steps in this model. A multinomial logit model is developed for representing utility maximizing choice among the remaining alternatives. Startchild’s strong side is the generation of the choice set and weak side is it relies more on external data set describing the activity program.

SMASH (Ettema, 1996), Simulation Model of Activity Scheduling Heuristics aims at describing individual’s activity scheduling behaviour. Smash builds an activity schedule through an iterative procedure using activities for the existing activity program in two phases namely, schedule adjustment and schedule acceptance. The choice between schedule adjustment and schedule acceptance is implemented in a nested logit structure.

FAMOS, Florida Activity Mobility Simulator developed by Ram Pendyala (2004) includes two primary components: the Household Attributes Generation System (HAGS) and the Prism-Constrained Activity–Travel Simulator (PCATS). Using zonal socioeconomic data and household travel survey data, HAGS generates/synthesizes households and people within households. PCATS models activity and travel patterns for each person synthesized by HAGS. The activity–travel records simulated by PCATS can be fed directly into any dynamic traffic assignment algorithm to simulate traffic flow on a network. Thus, the current version of FAMOS is capable of replacing the trip generation, trip distribution, and mode choice steps of the traditional four-step modelling process. A major drawback of PCATS lies in its sequential structure for the estimation of activity attributes. A potential problem with this approach is that different modelling sequences may offer quite different estimation results.

Kitamura et al. (2000) presented a model referred as the Synthetic Travel Pattern Generator (STPG), a sequential, simulation approach to the generation of daily activity-travel patterns. A computer code was developed and daily travel patterns were generated by Monte Carlo simulation. The objectives of this model are two-fold. Firstly, it aims at demonstrating the synthesis of individuals' daily travel patterns in practical manner; secondly it attempts to examine discrepancies between observed and simulated travel patterns. The STPG system comprises a number of model components for computing the probabilities. A group of multinomial logit models are designed to determine the work or school location for each individual who is employed or a student. After establishing the probabilities from these models, the system sequentially generates the activities according to the probabilities through Monte Carlo simulation. The validation results suggest that overall the models perform well for non-workers. Higher discrepancies are found for workers and students.

TASHA, Toronto area scheduling model for household agents developed by Miller and Roorda (2003) is a micro-simulation based model and is capable of generating the activity-travel characteristics of all individuals in a household for a day. This model uses conventional travel survey data. Firstly, this model generates activity episodes and then organizes these episodes into the schedules of persons in a household. The output of the model systems shows the activity-travel patterns of the individuals. Further, authors proposed some refinement in the form of improvement in some of the choice models.

Having discussed the various computational process models, subsequent sections dwell on model systems developed based on discrete choice modelling with utility maximizing concept. Apart from few criticisms, this approach is very much useful in developing operational activity based travel demand models.

PORTLAND model (Bowman, 1995) is a system of disaggregate logit and nested logit models assuming a hierarchy of the model components, with five types of models in the hierarchy. The day activity schedule model is a nested multinomial logit (NMNL) model consisting of two models i.e. the day activity pattern model on the higher level and the tour model on the lower level. The Portland tour model is NMNL model for itself. The Portland model predicts activity schedules for each individual in the population applying the methodology of a synthetic population. Weaknesses of this model are incompleteness, coarse schedule resolution, and misspecification of utility functions, model structure and availability. The model misses interactions in the individual's behaviour between modeled and un-modeled activities.

DENVER model developed by Sabina et. al. (2007) takes advantages of proven approaches used in other activity based models. This approach includes microsimulation of the daily activity patterns of individuals in a synthetic population, determination of regular workplaces and school locations in relation to the home location, modelling of the times of day, destination, and modes of tours and trips, and the use of conventional static highway and transit assignment procedures. A set of discrete choice models is used to analyze longer term travel decisions such as workplace location and auto ownership, as well as shorter term decisions such as person level daily activity patterns, and tour and trip level travel decisions.

Jakarta model system (Yagi and Mohammadin, 2009) is based on discrete choice modelling with utility maximization approach. The main model components are the daily activity pattern choice by primary activity, primary tour type, and number and type of secondary tours. A two level nested logit structure was proposed and the lower level models are conditional on higher level models. The basic inputs to the model system are household data, zonal data, network data, and input from vehicle ownership model. The basic output consists of OD trips by time of day, by mode etc.

Comprehensive Econometric Micro-simulator for Daily Activity-travel Patterns (CEMDAP) model has been developed by Bhat et al. (2001, 2002). As the name suggests, CEMDAP is a software implementation of a system of econometric models that represent the decision-making behaviour of individuals. The system differs from its predecessors in that it is one of the first to comprehensively simulate the activity-travel patterns of workers as well as non-workers along a continuous time frame. The overall framework adopted in CEMDAP comprises two major components: the generation-allocation model system and the scheduling model system. The purpose of the generation-allocation model system is to identify the decisions of individuals to participate in activities, as motivated by both individual and household needs. The scheduling system uses these decisions as input to model the complete activity-travel pattern of individuals. Based on the distinction made between the representations of worker and non-worker patterns, separate scheduling model systems are proposed for workers and non-workers.

Though, many studies have reported in the above literature review, most of them are concentrated in developed countries. This section of review tries to identify the studies undertaken in developing countries, especially in Indian context. Srinivasan (2005) studied the impacts of locational difference on women's travel behaviour. Travel related attributes like trip frequency, travel time, and mode choice were applied to compare the travel behaviour of men and women. At the end, the study recommended the need for integrating land use and transportation systems for effective planning. Srinivasan and

Rogers (2005) studied the travel behaviour of low income households in Chennai. They observed that travel duration, travel cost, trip frequency and mode choice were affected by the location of houses in the city. Further, Srinivasan et al. (2007) analyzed the vehicle ownership choice and mode choice behaviour of individuals and found that household and individual socio-demographics influence the mode choice over time. Bindhu (2006) developed a time-space diary for collecting activity-travel survey data and analyzed the activity-travel characteristics of Thane city individuals. Further, Subbarao (2014) suggested an overall framework for the development of an activity based travel demand model and also developed models for some of the choice models like mode choice, trip chain choice and activity-travel pattern choice. Utility maximization based econometric modelling framework has been used for development of these models. These studies provides state of the art practice to enthusiastic researchers to understand the way to proceed further in the area of activity based travel demand modeling.

7. Policy and econometric analysis using activity based model systems

Davidson et. al (2007) made a comparison between the conventional four step travel demand models and activity based models and they inferred that activity based models covers all the aspects of conventional four step models, in addition to that activity based models adds some additional features which are advantageous for policy evaluation. Daily activity-travel schedules of individuals, which are obtained from the activity based models helps in tracing parking places, parking demand and further including various parking schemes (Davidson et. al., 2007; Vovsha and Bradley, 2006). The operational activity based travel demand models discussed in the earlier section are also handled some of the policy issues (Manoj and Verma, 2013). Some of the references are exposure analysis using Albatross model system (Beckx et. al, 2009), equity analysis using San Francisco model system (Castiglione et. al., 2006), Land use policy analysis using Portland activity based model system (Shiftan, 2008), Emission analysis using PCATS model system (Kitamura et. al., 1997), User benefit study using MORPC system (Schmitt, 2006), CBD area pricing scheme and Emission analysis using Jakarta model system (Mohammadin and Yagi, 2006). The activity based travel demand models attached to the various policies are useful for analyzing impact of different policy scenarios. These scenarios very much useful in arriving the right mix of policies. Further, Mohammadin and Yagi (2006) reported the capability of activity based travel demand models in predicting the secondary effects of various policies like health impact assessment of congestion pricing policy. Before planning any facility, we need to know the utilization of the facility, so that the benefits (may be monetary or social) associated with the implementation of the facility. Though conventional four step models are capable of doing such analysis, but their limitation in policy analysis may lead to over prediction or under prediction of benefits and costs of projects. Overall, activity based travel demand models can be used as a tool for analyzing travel demand management policies and econometric studies.

8. Conceptual framework for activity based travel demand model

Based on the review of various studies reported in the area of activity based travel demand modelling, this study proposed a conceptual framework for an integrated activity based travel demand model. Econometric modelling approach is considered as most agreeable and the same is used in developing the operation activity based model. Figure 1 shows the conceptual framework for an integrated activity based travel demand modelling system. The developed modelling system is motivated from the various

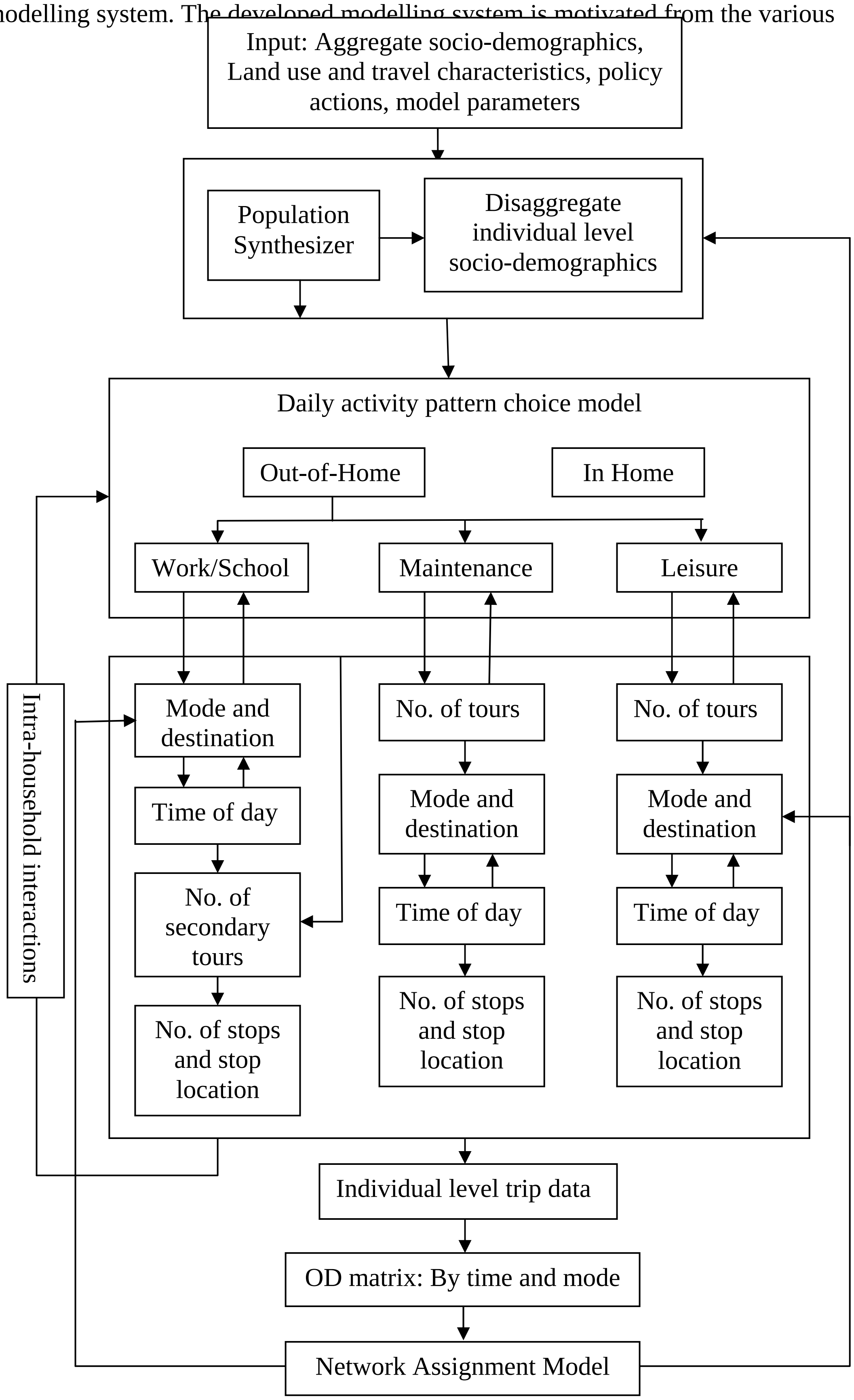

Figure 1. Integrated activity based travel demand modelling framework

earlier studies conducted by the eminent researchers (Bowman, 1995, 1998; Bowman and Ben-Akiva, 2001; Yagi and Mohammadin, 2009; Manoj and Verma, 2013). The model system includes a population synthesizer and a daily activity pattern model. The model takes aggregate level population data and land use transport data as the base year input and policy actions for the forecast year. The aggregate level socio-demographics data is then converted into disaggregate level households and individual data by using population synthesizer. Outputs from the population synthesizer are passed into the daily activity pattern choice model. The model determines whether the activities are conducted at home or out-of-home along with household interactions. Out-of-home activities are classified as Mandatory activities (work/school), maintenance and leisure activities. Further, models for predicting mode choice, time-of-day choice, destination choice, secondary tours etc. are included in the scheduling level. This model generates output in the form of individual records and can be aggregated into OD matrices by time-of-day and by mode. Network assignment will receive this data and produces level of service data and other parameters after assigning the aggregate flow on to the network. Though, the above framework is derived from the various operational activity based models, it has to be validated based on the data obtained from the actual activity-travel survey specific to the study area. According to the activity and travel behaviour of the individuals especially in the developing countries, there is a need for modifications in the proposed framework suitably.

9. Summary and conclusions

This review starts with the discussion on urbanization effect on the mjaor cities in developing countries. The problems associated with the urbanization in developing countries are very dynamic in nature. Hence, many cities in those countries have been suffering from worsening traffic congestion and environmental degradation in the city centers and most of the radial corridors which are cause by high urbanization tend and unbalanced transportation systems. Due to conceptual deficiencies of the traditional trip based modeling, these conditions are becoming even worsened. This leads to emergence of the activity based modeling system. Hence, a critical review of the traditional four step travel demand model is provided for better understanding of drawbacks in four step model. Further, a detailed review of the literature focusing on approach to activity based models and its emerging trends are discussed. Activity based approach considers travel is a derived demand and it focuses on individual activities. On reviewing this approach, it was observed that this approach can incorporate behavioural dimensions and interactions between individuals and household decisions over course of time. In addition, the review explored the available operational activity based travel demand models. The review found that most of activity based models are used the microsimulation approach for prediction, which enhances its predictive capability. Further, the review designates that the activity based travel demand models are capable of dealing with various policy issues and their impact on the society which the traditional travel demand models are unable to deal with. Overall, our review indicates that the activity based approach is in the initial stage of development when it comes to developing countries context. Hence, in this review, author suggested an overall framework for the development of a prototype activity based travel demand model. But this framework need to be modified according to the characteristics of the study area and observed travel behaviour of the individuals.

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