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UNIVERSITY OF CALIFORNIA,
IRVINE

Experiments With A Computerized Self-Administrative Activity Survey

DISSERTATION

submitted in partial satisfaction of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

in Civil Engineering

by

Ming-Sheng Lee

Dissertation Committee:
Professor Michael G. McNally, Chair
Professor Wilfred W. Recker
Professor Reginald R. Golledge

2001

The dissertation of Ming-Sheng Lee is approved,
and is acceptable in quality and form for
publication on microfilm:

A handwritten signature in black ink, appearing to read 'McNally', written over a horizontal line.

Michael G. McNally, Committee Chair

A handwritten signature in black ink, appearing to read 'Recker', written over a horizontal line.

Wilfred W. Recker

A handwritten signature in black ink, appearing to read 'Golledge', written over a horizontal line.

Reginald R. Golledge

University of California, Irvine
2001

DEDICATION

To

my family and the memory of my grand parents

謹以此論文獻給我最親愛的家人及對祖父母的回憶

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CURRICULUM VITAE

Ming-Sheng Lee

Education:

- Doctor of Philosophy, Department of Civil and Environment Engineering, University of California, Irvine. March 2001.
- Master of Science, Department of Civil and Environmental Engineering, Pennsylvania State University. May 1996.
- Bachelor of Science, Department of Agricultural Engineering, National Taiwan University, Taipei, Taiwan. June 1991.

Work Experience:

- Project Assistant. Assisting Dr. J. C. Chern at the National Taiwan University on the national project promoting the research and practice of High Performance Concrete in Taiwan. September 1993 to June 1994.
- Sergeant of Taiwanese Army. August 1991 to June 1993.

Academic Research Experience:

- Graduate Student Researcher to Dr. Michael G. McNally: Research on 1999 – 2000 UCTC supported project, Putting Behavior in Household Travel Behavior Data: An Interactive GIS-based Survey via the Internet (Year 2).
- Principle Investigator of the 1998-1999 UCTC Dissertation Award Project. A Household Survey via an Internet GIS for Models of Activity Scheduling.
- Graduate Student Researcher to Dr. Michael G. McNally: Research on 1998 – 1999 UCTC supported project, Putting Behavior in Household Travel Behavior Data: An Interactive GIS-based Survey via the Internet.
- Graduate Student Researcher to Dr. Michael G. McNally: Research on 1997 – 1998 UCTC supported project, Modeling the Dynamics of Activity Scheduling via a GIS.
- Research Assistant to Dr. Konstadinos G. Goulias at the Penn State University: Research on GIS-based travel demand modeling, travel behavior, and accessibility analysis.

Presentations:

- Lee, M., and McNally, M. G. (2001) "Experimenting with a computerized self-administrative activity survey: evaluating a pilot study" Presented at the 80th Annual Transportation Research Board Meeting, Washington D. C., January 7-11, 2001.
- Lee, M., Doherty, S. T., Rindt, C. R., and McNally M. G. (2000) "Conducting an Interactive Survey of Household Weekly Activities via Internet " Presented at the 9th International Association for Travel Behavior Conference, Gold Coast, Queensland, Australia, July 2 – 7, 2000.
- Lee, M., Doherty, S. T., Sabetiashraf, R., and McNally, M. G. (2000) "iCHASE: An internet Household Activity Scheduling Elicitor survey" Presented at the 79th Annual Transportation Research Board Meeting, Washington D. C., January 9-13, 2000.

- Lee, M., and McNally, M. G. (1999). "Application of space-time prisms for measurement of accessibility" Presented at the 38th annual WRSA meeting, Ojai, California, February 21-24, 1999.
- Lee, M., and McNally, M. G. (1998). "Incorporating yellow page databases in GIS-based transportation models" Presented at the ASCE Conference on Transportation, Land Use, and Air Quality, Portland, Oregon, May 17-20, 1998.
- Lee, M., and Goulias, K. G. (1997). "Accessibility indicators for transportation planning using GIS." Presented at the 76th Annual Transportation Research Board Meeting, Washington D. C., January 12-16, 1997.

Publications:

- Lee, M., and McNally, M. G. (2001) "Experimenting with a computerized self-administrative activity survey: evaluating a pilot study" To appear in Transportation Research Record.
- Lee, M., and McNally, M. G. (1998) "Application of space-time prisms for the measurement of accessibility", Working Paper, AS-WP-98-2. Center for Activity Systems Analysis, Institute of Transportation Studies, University of California, Irvine.
- Lee, M., and McNally, M. G. (1998). "Incorporating yellow page databases in GIS-based transportation models" Proceedings of the ASCE Conference on Transportation, Land Use, and Air Quality, Portland, Oregon, May 17-20, 1998.
- Lee, M. (1996) "Analysis of accessibility and travel behavior using GIS." Master's Thesis, The Pennsylvania State University.

Honors, Fellowships, Research Grants:

- Honorary Mention for the 4th Springer Verlag Prize Award, awarded by the Western Regional Science Association for the paper, Application of space-time prisms for measurement of accessibility, presented at the 38th annual WRSA meeting.
- Software Grant, MapObjects and MapObjects Internet Map Server, awarded by the Environmental Systems Research Institute, March, 1999.
- Doctoral Dissertation Fellowship, awarded by the University of California Transportation Center, 1998 –1999.

Professional Memberships and Extra Curricular Activities:

- Member, Western Regional Science Association, 1998 - present.
- Associate Member, Institute of Transportation Engineers
- Student Member, American Society of Civil Engineers
- Rugby football representative team of the National Taiwan University, 1987 - 1991. MVP of the National Collegiate Tournament, 1991.

ABSTRACT OF THE DISSERTATION

Experiments With A Computerized Self-Administrative Activity Survey

By

Ming-Sheng Lee

Doctor of Philosophy in Civil Engineering

University of California, Irvine, 2001

Professor Michael G. McNally, Chair

The process of activity scheduling is crucial to the understanding of travel behavior changes. In-depth research is urgently needed to unearth this process. To reveal this process, a new computer program, REACT!, has been developed to collect household activity scheduling data. The program is implemented as a stand-alone program with Internet connectivity for remote data transmission. It also contains a GIS for location identification and a special feature that traces the decisions in scheduling process. A pilot study was conducted in Irvine, California to evaluate the program performance. Experience from the pilot study validated the program's capability of guiding participants to complete data entry tasks on their own, thus the objective of reducing the cost and human resource of such a computerized survey is achieved. Other positive results regarding objectives of reducing instrumental biases and expanding program capabilities were also obtained. Areas for improvement were also identified.

Based on the pilot data, activities with shorter duration were found more likely to be opportunistically filled in a schedule already anchored by their longer duration counterparts. In addition, the situations (e.g., location, involved person, and day of the week) under which an activity occurred were found related to its scheduling horizon. Analyses were also performed to validate that the above findings hold in the presence of a third factor (i.e., in-home vs. out-of-home, and work/school vs. non-work/school). Additionally, analysis of tour structure reveals that a certain portion of trip-chains was formed opportunistically. The proportion of opportunistic stops tends to increase as stop sequence increase. Travel time required to reach an activity is also positively related to scheduling horizon of the activity, with distant stop being planned earlier.

CHAPTER 1 INTRODUCTION

1.1 Background

The existing transportation planning models, often termed the four-step procedure, were originally developed to perform regional highway analyses, especially to forecast the impact brought by major highway additions on the existing network. The development of these models was motivated by the goal of increasing the nation's mobility, with the construction of the interstate highway system as the embodiment of this goal (Larson, 1992). Beginning in the 1960s, non-highway legislation has played an increasing role in the development of the nation's transportation programs. With enactment of the Clean Air Act Amendments of 1990 (CAAA) and the Inter-modal Surface Transportation Efficiency Act of 1991* (ISTEA), the requirements that the transportation planning methodology needs to achieved are dramatically changed. The CAAA and ISTEA focus on strategies promoting more efficient use of the existing transportation facilities for air quality control. The impact of such strategies can not be estimated by the existing travel forecasting models. In addition, the socio-demographic structure is also different from that in the 60s. The effects on travel behavior caused by increasing phenomenon such as the two-worker and single parent households, increasing car ownership, telecommuting, and flexible work hours are not taken into account in the

* ISTEA was reauthorized as the new Transportation Equity Act for the 21 Century in June 1998.

current models. Recognizing the inadequacies of the current models, the U.S. Department of Transportation and the Environmental Protection Agency established the Travel Model Improvement Program (TMIP) in 1993 (Weiner and Ducca, 1996). The purpose is to improve passenger and freight travel analysis models for federal, state, and local agencies. Researchers in this field are challenged to devise new modeling approaches for the next generation.

Spurred by the same policy concerns that instituted the TMIP, in 1995 four federal agencies (Transportation Research Board, Federal Highway Administration, Federal Transit Administration, and Bureau of Transportation Statistics) jointly sponsored the Conference on Household Travel Surveys: New Concepts and Research Needs. The purpose of the conference was to determine the direction of future activities in transportation data collection by reviewing existing travel surveys and examining new concepts and research need. Five concurrent workshops were conducted. Each of them represents an emerging research area in household travel surveys, including: (1) non-response issues, (2) interactive stated-response methods, (3) survey methodologies, (4) data collection issues, and (5) new technologies. Based on the workshop discussion, future research needs centering on the five themes were recommended (TRB, 1996).

Echoing the calls for innovative research in the recommended areas, Lawton (1996), in another federally sponsored conference (i.e., the 1996 Conference on Activity-Based Travel Forecasting sponsored by the Federal Highway Administration, the Federal Transit Administration, the Office of the Secretary of Transportation, and the U.S. Environmental Protection Agency) noted the inefficiency of the current data collection methods and stated, "We should seriously evaluate the use of more carefully chosen,

smaller samples, using direct contact and paying for cooperation (their time). Data collection needs to be automated (laptop, etc.), and we need to design interactive stated-response experiments that key directly from revealed data at the same collection time.”

1.2 Problem Statement

Fueled by the federally directed initiatives, in recent years there has been a growing interest in experimenting with new approaches for household activity/travel surveys. These experiments can be generally divided into two groups. One involves the applications of new technologies, such as Global Positioning Systems and handheld computers, to obtain high-resolution personal travel data (Battelle, 1997;Guensler and Wolf, 1999). Such data has promise to improve the fidelity of existing travel models, and may also help address certain issues related to current models' inefficiencies. These data, however, do not contain information other than outcomes of travel decisions and thus can only be considered upgrades of the conventional travel diaries. Over thirty years of research in the field of travel demand modeling with revealed outcomes data has resulted in behavioral models bearing little behavior, as Gärling et al. (1994) argued that such models are "confined to what factors affect the final choice, whereas the process resulting in this choice is largely left unspecified". To put behavior back to models that are intended for replication of human behavior, research is urgently needed to advance current understanding of the behavioral process, often termed household activity scheduling, that determines when, where, with whom, and for how long a person would engage in various activities. Axhausen and Gärling (1992) stressed the importance of this process by arguing that it is at the core of travel behavior changes. Effects of

transportation policies such as tolling, congestion pricing, and travel demand management measures depend on how people would adjust their daily activity and travel pattern to changes to their everyday lives. They also argued that the process is “largely unknown” and new methods should be developed to conduct in-depth study of the process.

Now with the most advanced technologies being applied to data collection, bolstered with favorable incentives and funding for improvement of urban travel models, a remaining problem with collection of urban travel data is precisely what sort of data is necessary in developing and testing theory and models. Five years have passed after the Household Travel Survey Conference, and very few applications were positioned in the recommended research areas related to data contents, such as interactive stated-response methods and survey methodologies. This second group of data collection experiments is about the development of innovative approaches to extend the dimension of data contents. The current state-of-the-art application in this direction is perhaps the Computerized Household Activity Scheduling Elicitor (CHASE) program developed by Doherty and Miller (2000). CHASE is unique in that it collects data on the household activity scheduling process for a week long period. Members of sample households would run the program on the provided laptop computers everyday to record activities from their initial plans to final actions. CHASE was tested in several experimental surveys and proved to be an efficient data collection tool for study of household activity scheduling. It also has the potential to be used in the aforementioned computerized household survey envisioned by Lawton (1996). However, several critical areas hindering the practical use of the program have been identified (see literature review for details).

1.3 Proposed Research

The primary goal of this research is a fundamental examination of the behavioral process that results in revealed travel behavior. To reveal this process, a new computer program, REACT!, is developed and utilized in a pilot study to collect data for a study of the determinants of travel and activity behavior in households. REACT! is based on the structure of CHASE with the entire process from pre-travel plans to post-travel diaries being recorded for a week, but its shortcomings are addressed with advanced software technologies. The result is a program that utilizes the Internet for data transmission, and a GIS for location recording, respondents can thus use their own computers to input data. Other advancement is also made in terms of reducing instrumental biases and expanding program capabilities. It is expected that the collected data can facilitate the identification of fundamental relationships among a comprehensive set of revealed variables on travel and activity participation, leading toward, not models of behavior, but a better understanding of the critical variables, relationship, and rules that govern the revealed behavior. Various statistical techniques are applied with the pilot data for this exploration of behavioral determinants, and consequently validation of the survey approach will also be achieved. After the pilot, shortcomings of the current application are examined and changes required for the program to be used in a larger scaled survey are recommended.

1.3.1 Research Hypotheses

The main theme of this study is using a computer program for data collection on the process of household activity/travel decision-making. The feasibility of such an approach has been verified by CHASE. Hypothesis testing in this thesis will thus be focused on the verification of how REACT! can address inefficiencies of CHASE. Whereas a detailed review of these inefficiencies is necessary for elucidation of the ideas, however, it is delayed until the chapter on literature review. A brief summary is provided instead to illustrate the hypotheses. First, since a laptop installed with CHASE has to be placed in a household for a week, it is difficult to expand sample size in a given period of time. It is hypothesized that with certain amount of financial compensation, respondents are willing to participate in the survey by installing REACT! in their computers. Entailing in the first hypothesis is the second one that postulates the feasibility of a self-administrative computerized survey. Specifically, it is hypothesized that respondents can complete the survey on their own with help from a user-friendly program design and other supplemental materials, such as automatic instructional messages, online help, and user manuals. Second, CHASE introduced a serious instrumental bias by enforcing respondents to lay out complete activity plans before they actually took place. That is, if a respondent indicated there would be a specific activity sometime in the surveying week, the program would not let respondents proceed unless all details of this activity are elaborated (see literature review for details). In fact, people's plans are not necessarily fully elaborated. The transactional opportunistic model of planning behavior (Meyer and Rebok, 1985) postulated, with empirical evidence, that everyday plans are only partially elaborated prior to the execution, assuming they are elaborated at all. The final outcome

of this plan involves a dynamic transaction between the partial plan and action. Facets of the transactional opportunistic model will form the third hypothesis of this research. REACT! allows respondents to enter just the known details about activity plans. Attempts will be made to extensively verify if people apply these principles in scheduling activities. Finally, activity locations recorded with CHASE did not have sufficient resolution, since respondents were asked to enter numbers of pre-defined zones as surrogates of the locations (i.e., users need to locate the zones on a provided map by themselves). To address this inefficiency, a unique procedure is designed, that includes a built-in GIS, for participants to record activity locations. The fourth hypothesis is related to the feasibility of this procedure. It is expected that respondents can follow the procedure and the intensity of geo-coding the collected data can be minimized.

The above four hypotheses are associated with the effectiveness of the program and the proposed survey approach. Another important objective of this research is the analysis of the behavioral process that resulted in the revealed outcomes. It is hypothesized that a structure exists in the household activity scheduling process. That is, some types of activities tend to be deliberately or routinely arranged earlier than others, whereas these other activities are often left free in terms of scheduling and planned on a shorter time horizon, or eventually executed in an impulsive fashion. Note that Cullen and Godson (1975) formulated and tested a similar hypothesis. However, data collected with REACT! are essentially different from theirs and hence the interpretation of the hypothesis testing will also be different.

1.3.2 Research Approach

The REACT! survey process is divided into two self-completing data entry stages: Initial Interview and Weekly Activity Diaries. Initial Interview is a series of questionnaires intended to collect demographic information of the households. The process of activity scheduling is collected in the Weekly Activity Diaries. Participants of the survey have to install the program and finish the Initial Interview before the Sunday evening when the recording of Weekly Activity Diaries begins. On the beginning Sunday evening, respondents should indicate activities that they know they would do throughout the surveying week. Then everyday in the week respondents would update what actually happened during the day. If the final outcomes were different from the corresponding plans, the program would automatically issue questions prompting for reasons and decision timing of such changes. The completed data would be transmitted daily to the survey administrative survey via the Internet for examination of validity. This process is repeated everyday for a week until the next Sunday.

The pilot survey is targeted to collect 50 households, with adults entering data for themselves and their children (see the chapter on program evaluation for details). As a pilot study, it is not intended to collect a sample that can represent the general public. In fact, it will not be cost-effective to pursue such a sample before the validity of the program and the proposed survey approach is verified. Furthermore, the exact nature of the biases can only be understood after examination of the pilot data. It is thus proposed to derive the pilot sample from a university community for the ease of administrative effort. If the proposed methodology is proved to be valid, a follow-up survey of the same approach will greatly benefit from experience gained from this limited sample.

Analysis of the resultant data will utilize multi-way contingency tables (Wickens, 1989). for attributes of an activity (e.g., activity type, location, duration, and type of participants) can be properly handled as categorical. The inter-relationship between an activity's scheduling horizon and its attributes will be extensively examined for identification of the hypothesized structure of activity patterns.

1.3.3 Research Contribution

This research is aimed at the exploration of activity/travel behavior from a different angle. Two interconnected contribution can be identified. First, the proposed survey approach is designed to address inefficiency of existing survey methodologies. Experience gained from this study will serve as the foundation for an extended survey of the same approach. Not only could the methodologies be further polished but also would the contents of the collected data be more precise and critical. Second, analysis of the pilot data will improve the understanding of the behavioral process behind the decisions of travel and activity participation. Despite the limitation of the pilot sample, the value of the analysis results is not to be questioned, for the current understanding in this aspect of behavior is very limited. In addition, if patterns can be identified in a group of people whose lives are loosely structured (i.e., student families may have less constraints than regular working families), it can be expected that more distinct patterns would be revealed in a sample derived from typical working families.

1.4 Organization

This thesis is dedicated to an in-depth investigation of the household activity scheduling process, drawing much knowledge and experience from past behavioral models of urban passenger travel. In order to demonstrate the urgent need for research effort in this direction, the review of literature, presented in Chapter Two, provides critiques of existing models, and based on their inefficiencies, issues needed to be addressed in a new data collection effort are identified. These issues are reflected in the detailed consideration for program design and presented in Chapter Three with a complete view of the proposed design, including program functionality and justifications.

The implementation of the program in the pilot survey is presented in Chapter Four. Characteristics of the sample and study area, issues related to survey administration, and evaluation of the program with the resultant data are fully elaborated in this chapter with a critique of the program performance. Empirical analysis of the collected data for identification of scheduling structure is presented in Chapter Five. The final chapter summarizes the experience and contribution of this study, and subsequently future research projects extending the scope of this thesis on are proposed.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

In order to demonstrate the urgent need of research into the behavioral process of household activity scheduling, the review of literature begins with critiques of conventional travel models from which a different approach, the activity-based, has been set off. The demonstration goes on to show that models of the household activity scheduling are central to activity-based travel modeling. Inefficiencies of existing models are subsequently reviewed, and more importantly, data issues are further examined with a review of past data collection efforts dedicated to the exploration of scheduling processes. Experience gained from these past efforts constitutes the main structure of the proposed research.

2.2 Trip-based to Activity-based Travel Analysis

Travel, viewed in theory as derived from the demand for activity participation, has long been practically modeled from a trip-based perspective, namely trips, rather than activities, are the units of analysis. Average daily number of trips by purposes are first generated and distributed on a zonal basis. Total number of trips between any given pair of zones are subsequently loaded onto the transportation network, resulting in two sets of

network traffic estimates, one representing peak hour traffic and the other non-peak. Despite its well-known deficiencies (Stopher, 1993), this approach continues to be the primary analytical tool for urban transportation planners and policy makers alike. By the mid 1970s, travel demand researchers had recognized the need for more behavior-oriented models as the conventional approach failed the evaluation of policies unrelated to construction of major transportation facilities (Brög & Erl, 1981). A new analytical framework, generally referred to as the activity-based analysis, was gradually formed as the result of this arisen discontent with existing models.

The activity-based approach to travel behavior analysis was inspired by the work of Hägerstrand and his colleagues in Sweden three decades ago (Hägerstrand, 1970; Lenntorp, 1976). They pointed out that the activities individuals perform to maintain existence in society have both spatial and temporal attributes. Although certain activities may occur simultaneously, more often they exclude each other and are executed in a sequence in which each activity has to be carried out within a given duration, at a certain place, and in presence of other individuals. Within this time-geography framework, the first step of developing models of individual spatial behavior is to define a region bounded by these constraints in time and space (i.e., known as a Space-Time Prism, see Figure 1 for an example). Life of an individual can thus be depicted as a continuous path passing through the trajectory of constraints and the bounded regions of opportunities. Hägerstrand argued that it is possible to deduce reasons as to why a particular individual chose one path over another when the constraints are identified.

Figure 1 A Space-Time Prism

Many of the false assumptions and shortcomings of the conventional travel models (i.e., both aggregated and disaggregated trip-based models) were exposed when travel is placed in this constraint-based framework. McNally and Recker (1986) summarized activity-based researchers' criticism of the trip-based models as:

- (1). Ignorance of travel as a demand derived from the need to participate in activities
- (2). Misrepresentation of travel behavior as a pure choice process, while ignoring the effect of a wide range of constraints (e.g., accessibility, mobility, and coupling constraints) on this decision process
- (3). Inadequate specification of the interrelationship among travel, activity participation, and activity scheduling

- (4). Reliance on the concept of utility maximization as the only choice-making strategy, neglecting substantial evidence relative to alternative strategies and habitual behavior
- (5). Misspecification of the choice set, resulting from the ignorance of how constraints limit choice alternatives

The activity-based approach links travel in a city to the fulfillment of the needs for activity participation. Travel is explicitly viewed as a derived demand, with consideration of how a trip is related to a specific activity, and when, where, with whom, and for how long this activity is conducted. Three important concepts, derived from the time-space framework, formed the theoretical foundation of the activity-based approach to travel behavior (Golledge, 1997):

- (1). Travel choices are constrained in time and space.
- (2). Trip generation is the outcome of the decision to participate in an out-of-home activity.
- (3). Time budgets for activities and travel are constant.

Early applications of activity-based models were focused on explanation of behavior rather than its prediction, and very often they were targeted to find empirical evidence on the conventional approach's fallacies. In this era, the activity-based approach was often characterized as fragmented and lacking a unified methodological framework. A profusion of concepts and methods were developed as researchers carved out portions of the problem by forming partial theories or modeling applications based on segments of

the entire decision-making process. Researchers have pursued a stream of research with themes such as (see Pas, 1986):

- (1). The analysis of activity demand
- (2). The scheduling of activities
- (3). The investigation of constraints on activity and travel choices
- (4). The spatial-temporal dynamics of activity/travel decisions and how they relate to one's role in the household
- (5). The overall effect of household structure (e.g., lifestyle, lifecycle, role) on individual activity/travel

By the 1980s, researchers began to take the much-needed step toward the integration of all partial theories. Several volumes and review papers (e.g., Stopher et. al., 1981; Carpenter and Jones, 1983; Kitamura, 1988) were results of this consensus among research communities. On the center of the integrated view of activity/travel is the process, often termed household activity scheduling, that links all the segmented behavioral aspects to a cohesive decision stream. Since then, significant advancement have been made in terms of modeling of the household activity scheduling. Various analytical techniques were applied to this problem, attempting to close the gap between theory and practice of the activity-based approach.

2.3 Models of Household Activity Scheduling

Activity scheduling defined by Axhausen (1995) represents “the joint choice of the time, duration, location, mode, and route for a sequence of activities drawn from a given set of aware activity needs”. The purpose for the modeling of activity scheduling is to derive estimates of the “joint choices” made by individuals. Household activity scheduling extends the context of activity scheduling by considering the effect of the interaction among household members on each member’s schedule. In the past decade, models of household activity scheduling became a focal point among researchers as the objectives for travel demand modeling changed. Currently, emphasis of transportation policies is travel demand management (i.e., efficiently using existing facilities to fulfill people’s needs for activities rather than increasing the means for travel). New policies require the evaluation of how people would temporally and spatially adjust their travel behavior, which is conditioned on their decisions of activity participation, when the supplies in the activity/transportation systems were changed (Karash and Schweiger, 1994). With these policies the modeling of household activity scheduling as interdependent decisions becomes more important to practical demand modeling than ever before.

Two general approaches have been applied to the modeling of household activity schedules. The first one follows the utility maximization (UM) framework rooted in the economic theory of consumer choice. The second one adopts a construct known as production system in the context of artificial intelligence (AI). In the past decade, the concept and techniques of production systems have evolved to a set of new tools, agent-based simulation, capable of mimicking how individuals behave in a complex system.

Although agent-based simulation has not been applied to the modeling of household activity scheduling, there is a tremendous potential for such an application.

2.2.1 Models of Utility Maximization

The UM approach has long been used by travel demand researchers to model transportation mode and destination choices. Various attempts have been made to apply this framework to models of household activity scheduling. Becker (1965), Ghez and Becker (1975), and Winston (1982) hypothesized that a household's decisions of time allocation on activities are made by observing the principle of maximizing utility. Damm and Lerman (1981) formulated a theory of the urban workers' activity scheduling behavior which consists of a sequence of decisions, including the participation in an out-of-home, non-work activity and the duration of the activity. Although these models address the issue of how activities are scheduled, they are limited in the dimension of time. Issues related to activities in the planar space, as well as the means of traversing the space were not addressed. In the family of utility-based models, nested logit models appear to be appropriate candidates for models of household activity scheduling. Ben-Akiva and Bowman (1995) formulated a daily activity schedule hierarchy accommodating decisions of time, destination, and travel mode. The significance of the nested structure is estimated simultaneously as nested logit models using full information maximum likelihood estimation. The strength of this approach is its tractability, demonstrated by two separate applications utilizing regular travel/activity diaries from Portland and San Francisco Bay Area (Bradley et al., 1998 and 2001). PCATS (see Kitamura, 1996 for an overview) decomposes the scheduling process to a sequence of

choice probabilities. Nested logit models are used sequentially to produce the choice probabilities of activity types, destination, and mode. PCATS has also been applied with real-world data in Japan (Kitamura et al., 2001).

Despite the tractability of the UM framework in modeling travel related choices, it has been argued that this approach is not suitable for models of household activity scheduling. There are two primary reasons for this. First, to make the discrete choice models tractable, it is assumed that a choice maker knows all available alternatives, considers all factors, and evaluates the utility within himself/herself to make the final choice. These assumptions ignore the limited ability of humans in processing information required for problem solving (Simon, 1990). Consequently, models adopting the principle of economic rationality may produce results that are indeed behaviorally impossible, especially in a choice context as complex as scheduling activities. Second, Gärling et al. (1994) argued that such models are “confined to what factors affect the final choice, whereas the process resulting in this choice is largely left unspecified”. The treatment of the process as a black box imposes severe limitations on the utility-based models. Not only the accuracy of the model, but also the ability of such models in examining the impacts of various policies rely heavily on the goodness of sampling.

2.2.2 Computational Process Models

In view of decision making as a process of problem solving, activity scheduling falls into the type of cognitive activity known as “planning” in cognitive science. For example, people plan how to get to work in the morning, where to eat lunch, and what to

do in the evening. Planning is defined as finding a sequence of actions to accomplish a specified goal. The cognitive model of planning proposed by Hayes-Roth and Hayes-Roth (1979) caught the attention of practitioners by showing that the activity scheduling process can be modeled by an approach other than maximizing utility. They demonstrated the process of how a college student plans a hypothetical day's errands. Many other techniques in the context of AI can be applied to the problem of planning. Originally developed by Newell and Simon (1972), a production system attempts to mimic the internal process of human problem solving. It uses a set of rules and an inference engine to solve problems. The rules are specified in the forms of condition-action pairs and the inference engine chooses the applicable rules for the problem (Tracy and Bouthoorn, 1997). Unlike the UM approach, a production system takes into account the limited cognitive resource a person can allocate for plan development. However, it is applied to a complex choice problem, it is difficult to derive enough accurate rules for a final choice (Vause, 1995). However, if enough rules can be derived to screen out the obviously infeasible choices, the development of a production system is justifiable. In a complex choice problem, this makes the modeling tractable by reducing the choice dimensions. Utility-based models and/or micro-simulation can subsequently be used to seal the gaps left by the production systems. The difficulty to find behavioral rules for activity scheduling comes from the lack of suitable data. The existing travel/activity diaries are inefficient for this purpose, since they contain only revealed behavioral outcomes. A household activity/travel survey emphasizing the decision-making structure rather than the resultant choices is urgently needed.

Several existing models of activity scheduling can be seen as variations of the production systems. Some of these models incorporate the calculation of utility or any other satisficing criteria with a rule set. They are usually referred to as computational process models (CPMs), of which production systems are one example. STARCHILD by Recker et al. (1986a and 1986b) establishes rules that take into account the interaction among household members and physical time-space constraints to eliminate unacceptable schedules. A set of feasible schedules is elicited from all possible alternatives. Utility-based models are then applied to this filtered choice set to obtain a final choice. Although STARCHILD is considered one of the most elaborate systems for simulating household activity schedules, it suffers from the same criticism as the UM approach in that the filtering of all feasible alternatives is not behaviorally reasonable.

SCHEDULER can be considered a true production system. It was first proposed by Gärling et al. (1989) as a conceptual model and then operationalized in Golledge et al. (1994) and Kwan (1994). The model is built upon the problem solving structure envisioned by Newell and Simon. The limited ability of humans in processing information is explicitly modeled by decomposing a human memory system into a long-term calendar, a short-term calendar, and a cognitive map. The calendars delineate the duration of information storage and frequencies of decision-making. The long-term calendar contains a list of activities that have to be performed in a certain time period. After an internal procedure, which includes sequencing, mental executing, and conflict resolving, a subset of activities is generated and assigned to the short-term calendar for immediate execution. The cognitive maps are used to delimit the possible alternatives in planar space. Feasible destination choices are only those that can be remembered. For

each activity in the short-term calendar, the nearest neighbor heuristic is applied to determine activity locations. Over-simplification of human behavior is the main shortcoming of the SCHEDULER. The model can only handle certain simplified scenarios. This restricts the model from being applied to real-world modeling.

SMASH (Ettema et al., 1993) explicitly attempted to balance the strength and shortcomings of STARCHILD and SCHEDULER. It inherits from SCHEDULER the concept of calendars and further posits the existence of an activity agenda within the long term calendar. The process of scheduling is divided into discrete states. A state corresponds to a schedule that contains a certain number of activities at specific locations. The process of scheduling is modeled as successively altering the schedule (i.e., adding, deleting, relocating, or re-sequencing activities) from the initial state, which contains no activity. A utility value is calculated at each state. If no change of schedule can result in a net increase in utility, the process stops and the last schedule is assumed to be the final schedule. SMASH uses another AI technique, heuristic search, as the strategy for seeking of the final state. The intention is to observe the fact that people, when faced with complex problems, tend to use heuristic rules to find a satisfactory, but not necessary optimal solution. As an additional advancement, Ettema et al. (1995) overcame the data problem by developing an interactive, computer-assisted experiment to collect data required for validation of the model. Respondents were asked to indicate their stated-responses to the virtual scheduling scenarios tailored especially for the SMASH model.

Although each of these models has its strength, many important elements in the process of generating and scheduling activities are either left unspecified or derived from arbitrary assumptions. These shortcomings can be categorized into two major groups.

First, the activity generation process is not considered in the models. Recker et al. (1986a) noted that an individual's observed activity pattern is derived from the interaction between his/her activity program and scheduling decisions. However, the generation and allocation decisions are beyond the scope of their STARCHILD model. The operational model of STARCHILD derives the activity programs from observed daily activities, then applied the decision structure of scheduling on these activities. In terms of SCHEDULER, a long-term calendar is used to store the list of activities. However, it is difficult to operationalize the concept of calendars, since the time periods for a "long-term" and a "short-term" are not specified. To test the scheduling structure of SCHEDULER, Kwan (1994) used the list of activities recorded in an individual's travel diary as the surrogate of the short-term calendar. No treatment of the activity generation is provided by SMASH either. It arbitrarily gives a list of activities to the respondents in an experimental setting to collect responses for testing of the hypothesized scheduling mechanism. If observed activities are the only sources that can be used to construct activity scheduling models, no matter how behaviorally sound the process of scheduling is, the accuracy of the model is still subject to the goodness of sampling. A better treatment to the process of household activity generation and allocation has to be incorporated into the modeling framework to relax the restraint. Second, the dynamics of scheduling behavior is not captured by the models reviewed. As noted by Hayes-Roth and Hayes-Roth (1979), problem solving is a two-stage process consisting of planning and control. In the planning stage, an individual predetermines a sequence of actions to accomplish a specified goal. The execution of these actions is monitored and guided in the control stage to a conclusion that satisfies the individual. Existing models only

accomplished the modeling of the planning stage. Although the conceptual model of SCHEDULER indicates the existence of feedback from schedule execution to schedule formation, this feedback loop is not modeled in its current incarnation (Golledge et al., 1994). Ettema et al. (1995) also noted that SMASH only considers the activity scheduling process preceding the actual execution of activities. Recker et al. recognized that an activity pattern contains both planned and unplanned activities. STARCHILD attempts to model the existence of unplanned activities by postulating that "individuals consider their potential in unplanned activities when selecting an activity schedule." It is interesting to note that, under this assumption, individuals essentially "plan" (i.e., consider) the occurrence of the "unplanned" activities. According to the transactional opportunistic model by Meyer and Rebok (1985), everyday problem solving is a process involving a dynamic transaction between plans and actions. An observed activity pattern is essentially the solution of an individual's scheduling problem. If activity scheduling models are to be used to produce the "best guesses" of individual activity patterns, the modeling of the interaction between the original schedule and its execution has to be considered.

2.2.3 Agent-based Simulation

The concept of agent-based simulation is similar to the game theory in economics that utilizes role-playing entities in a simulation system for exploration of macro-level properties. An agent is any actor in a system, capable of generating events that affect itself and other agents (Minar et al., 1996). More specifically, an agent can be thought of as a software entity capable of autonomous proactive and reactive social behavior. Agent-

based approach is a direct descendent of the thinking that resulted in the aforementioned production systems. For example, the issue of behavioral rationality under resource limitations raised by Simon (1990) can be explicitly addressed by building the imperfect information and limited reasoning ability into each agent and observe the emerging patterns and properties at the system level. Unlike the macroeconomic equilibrium models that estimate particular system properties based on choices made by one "representative" agent (i.e., symbolized by the maximization of a specific objective function), an agent-based model usually consists of a collection of interacting agents in an artificial world representing the problem domain (e.g., a specific market of the economy). Fallacies of equilibrium models with one representative agent can be directly addressed with such an approach. For example, conventional traffic assignment models hypothesize the existence of an omniscient agent (i.e., every one in the system uses the same decision rule). In reality, travelers operate in very subsets of the system and interact with those around them. Cycles and fluctuations of the system such as congestion and accidents emerge not as results of some substantial shock to the system and an individual's reaction to it, but as a natural interaction and adaptation, together with occasional small changes or "mutations" in the behavior of some individuals. The evolution of such equilibriums may be chaotic. However, although endogenous fluctuation arises very naturally in a context of many interacting agents, the evolution of such a system could be relatively stable. In a complex world, a natural idea of an equilibrium would not be a particular state, but rather a distribution over states, reflecting the proportion of time the system spent in each of the states (Kirman, 1992).

Agent-based modeling has appeared in the literature of many different disciplines. O'sullivan and Haklay (2000) presented an overview of existing applications and elaborated their potentials and limitations for spatial analysis. Among the application reviewed, the one most relevant to urban transportation planning is the TRAnsportation ANalysis Simulation System (TRANSIMS) developed by the Los Alamos National Laboratory for the TMIP (Smith et. al., 1995). Utilizing sophisticated AI techniques, TRANSIMS brings the concept of multiple agent simulation into practice by simulating the commuting behavior of the residents in a city with virtual traffic phenomena, such as acceleration, deceleration, and lane-changing of individual vehicles, being anticipated and observed in the simulation. It has to be noted that TRANSIMS requires as inputs, for each individual in the city, a set of activities in time and space. In its current application with data from Portland, Oregon, the generation of individual activity schedules is actually achieved with the utility-maximizing, representative agent approach rather than simulation of rational multi-agents (Bradley et al., 1998). In fact, there is yet to be a functioning application of agent-based simulation in the context of household activity scheduling. Huisman and Forer (1998) formulated a conceptual work attempting to utilize artificial agents for assessment of university students' action-space following Hägerstrand's space-time framework. They demonstrated the work with a hypothetical example involving generation of simplified daily activity schedules for 20 hypothetical students. Marca et al. (2000) suggested a systematic scheme of utilizing Swarm, an agent-based simulation software developed at the Santa Fe Institute (Minar et al., 1996), for simulation of individual daily activity patterns. However, the challenge of realizing such a scheme for simulation of human behavior lies in how well human decision-making is

built into agents' knowledge structure. Formally known as the architecture of an agent, this internal structure governs the agent's perception, reasoning, and action in a specific problem-solving domain.

Researchers in the field of AI have proposed various agent architectures intended to solve real-world problems with autonomous systems. Many of these have the potentials of being applied for simulation of human activity scheduling behavior. Hayes-Roth and her colleagues continued the work in late 70s and developed several agent architectures rendering active agents in real-time systems (Hayes-Roth, 1993; Hayes-Roth et al., 1994; Morignot and Hayes-Roth, 1995). These architectures accommodate real-time improvisation and affiliation with other agents, two of the most important features in human everyday activities. One particular framework of interest integrates both the goal achievement orientation of the traditional AI with the survival instinct of new AI so the agents could act on their own within a given environment (with its opportunities) (Hayes-Roth et al., 1994). This work postulates the use of motivation as (1) a control mechanism for internal and external goal selection and (2) an internal mechanism for goal generation. A motivation is generated based on the functional state of the agent (e.g., its battery level, the time, its estimated activity) that produces a need (i.e., the strength of the motivation). An agent designer can program the agents in a way that they recognize the features of the environment (e.g., opportunities for achieving its goals), and accordingly adjust its own motivational profile that in turn determines the agents' immediate goals and ensuring action. Because its resemblance with human thinking, the architecture is flexible enough to accommodate human decision rules governing the formation of daily activity patterns.

Another agent architecture bearing great potential for simulation of household activity scheduling is the multi-agent improvisation devised by Anderson (1995 and 1997). Improvisation is an important strategy used by human in the scheduling of everyday activities. It is shown that improvisation can be a flexible means for machine decision-making under resource limitation in real time (Anderson and Evans, 1994). Improvisation agents can rely entirely on their routines when knowledge or decision-making resources is scarce, and if resources are available, agents can also perform deliberated reasoning about available alternative actions based on the perceived environmental features. Anderson's approach involves the use of constraints (e.g., physical constraints, requirement, expectation, preferences) to reduce the amount of deliberation required in problem solving. Constraints also control the recollection of knowledge and create perceptual focus, both functionalities lead to satisfactory solutions with minimal resources. Anderson (1997) argued that the improvisation approach is naturally suited to the agent-based modeling, because the behavior of an agent can be changed by installing different constraints in the agent program without changing the fundamental agent architecture. That is, multiple agents each possesses a different behavioral pattern can be achieved with minimal computational resources. It is noted that in addition to the tractability in computation, Anderson's approach is specially suited for simulation of human activity schedule because the architecture is based on strategies people use in their everyday activities such as the reliance on routines and preferences. This strength of the multi-agent improvisation is perhaps the weakness of Hayes-Roth's framework, which is actually designed for real-time systems intended for important real-world problems (e.g., automatic intensive care systems).

In addition to a suitable agent architecture, the attainment of a tractable set of behavioral rules is also a challenge for agent-based models of activity scheduling. The existing travel/activity diaries are inefficient for this purpose, since they contain only revealed behavior. A household activity/travel survey emphasizing the decision-making structure rather than the resultant choices is urgently needed, if an agent-based simulation of household activity scheduling is to be realized.

2.2.4 Inefficiencies of existing models

Based on the review of existing activity scheduling models, one common shortcoming can be recognized in all existing models: the treatment of the decision process governing the resultant activity patterns was problematic. The process was either treated as a black box (e.g., utility maximization), or with theoretical models that have not been validated due to lack of practical data (e.g., rule-based approach). Kurani and Kitamura (1996) noted the shortcomings of existing models are rooted in the lack of research into the nature of activities. Over decades the community of activity analysis has mainly relied on the observed activity/travel diaries for research. What have been left out of survey questionnaires were questions such as the motivations for participation in a given activity and the decisions as to when, where, how often, and for how long to engage in that activity. A common remedy for these missing elements is to make static assumptions. For example, it is assumed in the models reviewed that duration of activities are fixed and certain activities have fixed time windows for execution. Such an assumption is the embodiment of the conventional wisdom that categorizes activities as mandatory or discretionary. The purpose of this classification is to capture the existence

of a binding effect that confines people in time and space. However, the chemistry of the spatial and temporal binding effect may not be as straightforward as the words mandatory and discretionary literally suggest. The situations under which the activities take place and the strategy used by a decision maker to solve problems are each factors affecting the decisions. It is not difficult to find that people often leave work (i.e., an activity universally regarded as mandatory) early to avoid traffic, knowing that they are supposed to stay until its ending time. If the theory of activity/travel behavior is to be advanced, the dynamic characteristics of the scheduling environments should receive the same amount of attention as the final choice. Especially, if agent-based models, which seems to be the appropriate counterpart of TRANSIMS, are to be used in the future, data on the entire decision process need to be collected. In addition to detailed "behavioral" data, there also is a need for "cognitive" data. The cognitive resource an individual uses for decision making needs to be explored. For example, the identification of a person's cognitive map is important in modeling of his/her destination choices.

2.3 Collecting Data on Activities

Before the practice of household travel survey began in the early 1950s, transportation planning, which was not fully developed to the type of regional planning process performed today, relied mainly on roadside surveys that obtained the origin and destination information from travelers. During the 1960s and 1970s, travel diaries derived from household survey were widely used as the four step planning process became a mainstay in regional planning. Since then, occasionally when major surveys took place, the instruments of travel surveys were marginally changed to reflect the behavioral

fallacies of the conventional models (Stopher, 1995). Alternatives to travel diaries are time budgets and space-time budgets traditionally used in ecological studies of life-style and leisure (Golledge, 1997). A time budget is a set of records tracking a person's use of time throughout the recording period, typically ranging from a day to a week. It often contains the sequencing, timing, and duration of the person's activities. If locations of activities were also collected, such data were referred to as space-time budgets. Activity records in a budget can describe either the entire time-use pattern of the surveying period, or just a specific type of events, such as out-of-home activities within the period. Travel diaries can be considered a variation of space-time budgets for they often contain only time-use patterns of out-of-home activities. For example, origins, destinations, purposes, modes, and types of trips are common elements of a travel diary.

Advancement in activity-based analysis is largely resulted from the empirical evidence provided by the diary-type of data. Upon the transition of travel models from trip-based to activity-based perspective, time-use diaries are even more valuable since they not only contain essential trip-making data but also provide marginal information needed for activity-based models. However, as concluded in the review of existing modeling approaches, a major step is needed toward an in-depth investigation of the scheduling process. In the past, very few applications collected information of the scheduling process prior to the final outcomes. The lack of effort is largely due to the substantial monetary investment involved in a large-scale survey. Two notable efforts are both 'proof-of-concept' type of research. Although these two applications are not large enough for inferences of the entire population, they represent a significant advancement in the understanding of scheduling process. The first one was reported in Cullen and

Godson (1975), involving a unique time budget tailoring for the authors' hypothesis about the ways in which individuals' time-space decisions are structured. The second one is the Computerized Household Activity Scheduling Elicitor (CHASE) survey conducted by Doherty and Miller (2000). Experience gained from these two researches constitutes the main structure of this thesis.

2.3.1 The Structure of Activity Patterns

Following Hägerstrand's (1970) framework, Cullen and Godson positioned the objectives of their work to the investigation of the structure of individuals' activity patterns. The term "structure of activity patterns" refers to a wide range of decisions entailed in the way people conduct their daily activities. At the minimal, 'structure' can be interpreted as the sequence by which various activities entered one's daily activity scheduling process. They formed the renowned activity-peg hypothesis by stating:

"Activities to which an individual is strongly committed and which are both space and time fixed tend to act as pegs around which the ordering of other activities is arranged and shuffled according to their flexibility ratings. Any periods of the day that were left free after this process are either scheduled in a later, shorter planning period, or are ultimately occupied by 'spur-of-the-moment' activities or 'do nothing'".

The authors set out to test their hypotheses by collecting a data set that contains information about the priority and flexibility of activities. 336 respondents were drawn from the academic staff and students of a college of London University as part of a more

applied study of university contact and location factors. The instrument was based on a recalled, one-day time budget administered by interviewers on weekdays, but a set of specially designed questions were attached to each activity record. These questions are:

- (1). Beginning time (of the time-use record)
- (2). Ending time
- (3). Primary and secondary activities (i.e., if there were two concurrent activities in the period)
- (4). Travel mode (for travel events)
- (5). Location
- (6). Number of participants
- (7). Type of participants (i.e., work associates, household members, and friends and relatives)
- (8). To what extent was this activity planned?
 - a. arranged with others
 - b. planned but not involving others
 - c. routine
 - d. unexpected
- (9). Could you have done anything else at that time?
- (10). Could you have done this activity at some other time?
- (11). Could you have done this elsewhere?

(12). Could you have been elsewhere at that time?

The interview began with respondents recalling what they had done during the day (i.e., answering questions 1 to 8). In terms of activity typology, if the nature of the activity, its location, or participants changed from one time period to another, two separate episodes should be recorded. Travel was treated separately as a single event (i.e., it occupies a row of time use records). When two activities were performed at a same time slot, interviewers would put them in the same record, but distinguish them with the primary and secondary tags. The objective of the question on planning level (i.e., question 8) is to determine the degree to which each activity was premeditated. Instead of a Yes/No dichotomy, the four pre-defined responses were intended for respondents to create a more distinct difference between routine activities and those that were objectively planned.

When the diaries were completed, the interviewers would ask respondents one additional question: to indicate a set of activities that organized their days by being the most important and having to be done at a fixed time or location. Note that the interviewers would not show the completed diary to respondents at this time. Instead, they would explicitly inform respondents that answers to this question should be a "subjective impression of your day". After this supplemental question, the interviewers would ask question 9 to 12 for every activity in the diary, except for travel. The four "Could you have" questions were designed for respondents to indicate how activities were 'fixed' in the day. Question 9 was aimed at finding out if respondents had other alternative activities, while its counter part (question 10) was intended to investigate how

flexible was the timing of a chosen activity. The next two questions work in a similar manner with concerns of spatial fixity.

Various statistical techniques were applied to the resultant data. In general, results of the analysis supported the 'activity-pegs' hypothesis. Formal work activities appeared to be the most important structuring events of the day. Activities with commitment to other people (e.g., work and social) also tended to be the most prioritized episodes. However, priority was also given to routine activities under certain circumstances for these activities seem to contribute to one's physical and mental comfort. Spatial fixity of activities is more common than temporal fixity, but spatially fixed activities were not generally felt to be the 'structuring' events about which the days were organized. Activities arranged with others were the most constrained in time and space, and routine activities were also felt to be tightly constrained, especially in terms of locations. Some days of the week seemed to be more flexibly scheduled than others by being filled with domestic and small group social activities.

Cullen and Godson carefully addressed the issues that may arise when the findings of this study are to be compared to a sample of typical working families. The most significant difference should be that the working days of a regular sample are likely to be more highly structured, for university staff and students are generally considered to have less rigid constraints in terms of schedules. However, because everyone is bound to have some free time to schedule their own activities, it is expected some features of the scheduling structure will hold, at least in a long-term horizon (e.g., a week). The authors noted that the purposes of the study are to demonstrate the validity of the approach and to illustrate how routine and deliberated choices could shape activity patterns. If patterns of

behavior can be identified in a group of people whose lives were less constrained, it may be easier to distinguish and predict behavior of those with rigidly circumscribed life styles.

2.3.2 CHASE

The main objectives of the original CHASE were to explore a household's activity agenda, from which all activities are drawn, and to track the entire process of when and how activities from the agenda are added, deleted, and subsequently modified in a week long period. These were accomplished through a household interview, self-completing data entry of a weekly activity schedule through the CHASE program, and a follow-up interview. 40 households from Hamilton, Ontario, Canada were recruited to participate in a pilot survey. Up-front interviews were conducted on weekends (before Sunday evening) and lasted 1.5 to 2 hours. The program was installed on three laptop computers rotated amongst households on a weekly basis. Laptops were dropped off on Sunday evening and picked up the following Sunday evening. In the pilot survey, follow-up interviews were arranged for collecting laptops and reviewing if users recorded complete schedules for the week. No additional questions were asked.

2.3.2.1 The up-front interview

The purpose of the interview is to obtain information on household demographics, available transportation modes, and residential information along with the household's activity agenda. A household's activity agenda is the set of activities in which the

household members participate on a weekly basis. Table 1 lists the activity classification used in CHASE. Based on this table, household members were asked to describe, in their own words, the specific activities of each type that they perform, along with their attributes, such as frequency, locations, and involved person.

BASIC NEEDS	WORK/ SCHOOL	HOUSEHOLD OBLIGATIONS	SERVICES	JUST FOR KIDS
Night sleep	Work	Cleaning/maintenance	Doctor	Tag along with parent
Wash, dress, pack	School	Meal preparation	Dentist	Play, socializing
Home prep meals	Daycare	Chauffeuring	Other professional	Homework
Bagged lunches	Volunteer work	Chauffeuring and passively observing	Personal (Salon, barber, laundry)	With babysitter
Restaurants (family, spouse, alone)	Special training	Attending to children	Banking	Other just for kids
Delivered/picked-up meal	Other work/school	Pick-up involved person	Video store	
Coffee snack shops		Other errands	Library	
Other basic needs		Other obligations	Other service	
SHOPPING	RECREATION/ ENTERTAINMENT	SOCIAL	OTHER	
Minor groceries (<10 items)	Exercise or active sports (aerobics, fishing, cycling, walking, etc.)	Visiting	Tag along travel	
Major groceries (10+ items)	Movies/theatre	Hosting visitors	Pleasure driving	
Housewares	Other spectator events	Cultural events		
Clothing personal items	Playing with kids	Religious events		
Drug Store	Parks, recreation areas	Planned social events		
Mostly browsing	Regular TV programs	Bars, special clubs		
Convenience store	Unspecific TV	Phone/e-mail >10 min		
Pick-up meal	Movie video	Helping others		
Other shopping	Relaxing/pleasure reading/napping	Other Social		
	Hobbies (crafts, gardening, etc.)			
	Other rec/entertainment			

Table 1 Activity Classification of CHASE (Source: Doherty and Miller, 2000)

Data obtained from the interview were entered by the interviewer into computerized database forms. This database is linked to the CHASE program so the

alternatives reported in the interview can be included in common Windows elements such as pull down lists. Later in the schedule reporting session, users can select one of the alternatives without typing in texts.

2.3.2.2 Schedule tracing via the CHASE program

After the up-front interview a laptop was left at the surveying household and respondents were trained to use the CHASE program to report their weekly activity scheduling process. Figure 2 shows the main user interface. This interface was built upon a day-planner software component that displays schedules in a calendar format with time scale on the left. Participants were asked to login the program at least once a day for the entire week. On Sunday night, they would add activities anywhere in the calendar (from Monday to Saturday) that they have already thought about doing before launching the program. On Monday, they would enter data through the program what they had done for the day. Respondents were then asked to review the activity lists for the following days (Tuesday to Saturday). If any changes to these future activities were known at this moment, they should report the changes. The same process will continue every day until Saturday.

Activity Scheduler			
Exit Add Modify Delete Help			
	Thursday	Friday	Saturday
03:00 PM	■ Work, McMaster (Zone 1)	■ Work, McMaster (Zone 1)	
03:15 PM			
03:30 PM			□ Shopping, Mall (Zone 45)
03:45 PM		□ Soccer, Same as previous	
04:00 PM			
04:15 PM			
04:30 PM			
04:45 PM			
05:00 PM	□ Banking, Bank (Zone 4)		
05:15 PM	■ Groceries, Store (Zone 2)		
05:30 PM			
05:45 PM	■ Meal Prep, At Home		
06:00 PM		■ Restaurant, Pizza (Zone 9)	
06:15 PM	■ Eating, At Home		
06:30 PM			
06:45 PM	■ Playing, At Home		
07:00 PM			
07:15 PM			
07:30 PM	■ Attend to Child, At Home		■ Visiting, Toronto

Figure 2 The Main Interface of CHASE

2.3.2.3 Areas of improvement

Despite the efficiency demonstrated in the original CHASE survey, several areas for improvement have been identified. First, a laptop computer needs to be placed in a household for the week-long duration of the survey and field workers were required to deliver laptops and carry out the up-front interviews. In order to expand sample sizes and reduce costs, such an approach would need to be augmented through the use of home-computers and/or remote access to the program. The interview also needs to be computerized. Second, although the calendar-like interface greatly accelerated the process of entering activity schedules, it is not known if such an interface biased the decision process. It is reasonable to suspect that, if a time-table is presented to the respondents, they might be tempted to “fill-up” the gaps by inserting plans they wouldn't

have made under normal circumstances. To be more specific, when they see their activities laid out on the time dimension, it may encourage them to arrange things better, resulting in more scheduling steps which they would not otherwise have made. Third, CHASE does not allow the respondents to leave certain attributes undetermined in the pre-travel plans, except in the case of mode and travel time information. In reality, people's plans often remain only partially elaborated. According to Meyer and Rebok's transactional opportunistic model, human planning and problem solving behavior has three salient features: (1) plans are only partially elaborated prior to the execution, assuming they are elaborated at all, (2) problem solving is a process involving a dynamic transaction between plans and actions, and (3) subsequent plans are very much dependent on feedback from prior executions and reflections on the relative efficiency of those executions. Modifying the survey program to allow for this partial elaboration would enhance the opportunities for understanding the nature of activity scheduling process. Finally, the program would benefit from a systematic procedure to assist the entry of activity locations and spatial choices, in CHASE specified by pre-defined zone numbers on a map booklet.

2.4 Proposed Research Approach

The goal of this research will be achieved with two separate tasks. First, data collection on the process of household activity scheduling will be accomplished with a new program that addresses inefficiencies of CHASE. Many advanced software technologies such as Internet and GIS will be integrated with this new program to tackle the shortcomings. The survey procedure will follow that of CHASE, but data entry tasks

will be entirely computerized and guided by online instructions. The program also attempts to reduce instrumental bias by allowing for partial elaborated plans. Second, data analysis along the line of Cullen and Godson's work will be pursued by examining the inter-relationship between an activity's attributes and the timing it enters the scheduling process.

CHAPTER 3 PROGRAM DESIGN

3.1 Introduction

Taking advantages of new technologies, this research proposes to carry out a household activity/travel survey with a computer program. CHASE provides an ideal structure to frame the proposed new program. The objectives of the program design are thus based on inefficiencies of CHASE. The most urgent improvement over the current CHASE approach is to reduce the cost and human resource associated with using laptops as survey instruments. One potential way of resolving this dilemma is to conduct the survey via the Internet. Not only can the program be distributed through the Internet, but also can administration of the survey be remotely conducted. The design process began with evaluation of system architectures for one that meets the unique requirements entailed in a household survey. Effectiveness of the design will be evaluated after the pilot study, and hence description of the evaluation is delayed until the following chapter.

3.2 System Architecture

Currently, there are two distinct remote computing systems that can operate across the Internet: Web-based and Fat-Client applications. A Web-based application is sometimes referred to as a thin-client, because most of the computational processing was

performed within a remote Web server. Any computer with a Web browser and Internet connection can access data records residing on the server end. Although a Web application's ability to reach a broad spectrum of users makes it an idea system to implement a survey application, there are several limitations. First, interactivity between an application and users is slow and limited. Data need to be frequently transferred back and forth between a client and server with users waiting for the arrival of new data, prior to proceeding with the survey. Second, the stability of Web applications is subject to the amount of network traffic. Third, users have to remain on-lined for the entire survey session. Consequently, survey participants have to absorb the connection cost for the time they run the survey.

A remote computing system that performs most of the data processing within its client is usually referred to as a fat-client system. Programs operating within a client computer and capable of being connected to a remote server is by definition fat-client applications. The fat-client approach is suitable for screen intensive applications like CHASE that demands fast interactive data entry. Data transmission can be performed only at the time of login and logout so data entry time is not affected by the speed of Internet connection. In addition, stability and performance of the application will not be damaged by the occasional network traffic congestion. The downside is that clients will have to install the program in their computers. However, this can be amended by streamlining the self-installation process and packaging un-installation utility with the program.

3.3 Program Features

The new program, REACT!, is implemented as a fat-client system because it provides the desired speed and stability. This architecture also facilitates the use of versatile graphical user interfaces that substantially reduce the time needed for comprehension of the program and entry tasks. The inefficiencies intrinsic to the program's reliance on client computers are amended by the built-in Internet connectivity and self-executing installation, un-installation capabilities. REACT! inherits the structure of CHASE by dividing the process into two self-completing data entry stages: Initial Interview and Weekly Activity Diaries. Initial Interview is a series of questionnaires intended to collect the same information as those collected in CHASE's up-front interview. The process of activity scheduling is collected in the Weekly Activity Diaries. Participants of the survey have to install the program and finish the Initial Interview before the Sunday evening when the recording of Weekly Activity Diaries begins. Data collected from the interview will be automatically written to the main database linked to Weekly Activity Diaries. Thus, participants can enter details (e.g., activity titles, locations, and other people involved) of an activity by selecting from what they have entered in the interview. Typing is not necessary for most of the entry items.

3.3.1 Initial Interview

When users launch the program for the first time, they will be guided to complete the Initial Interview. Questions asked in the initial interview are categorized into the following 7 groups. Question groups 1 to 4 are related to the entire household. Only the

first person (i.e., who started the Interview) in the household needs to answer these questions. Next member to do the interview will begin from group 5.

- (1). Household Information (Figure 3): Users will enter their home address and answer the following questions:
 - a. Do you own or rent the household?
 - b. What's the type of your household (e.g., condo, apartment, and townhouse)?
 - c. How long have you stayed at the current residence?
 - d. What's your annual household income?
- (2). Frequently Visited Locations (Figure 4): This form is intended to collect a list of locations the respondent household visits at least once per month. This list will be available to respondents when they need to indicate activity locations in the Weekly Activity Diaries. In addition, the list enables researchers to grasp respondents' action space and to gain better understanding of their spatial behavior. Users will select from the provided list of local activity locations and built their frequent locations. The description of each location consists of three elements: name of the place, crossing streets, and landmarks. If a desired location is not included in the provided list, users can choose to enter this location by typing the address, closest intersections, or pointing it out in a built-in GIS (Figure 5).
- (3). Household Vehicles (Figure 6): On this form users enter the make, model, and year of the vehicles in the household.

Initial Interview (Click at the yellow page to get online help)

Household Information:
You have the option of not answering these questions. If you don't feel comfortable answering any of them or they do not apply to you, please select Undisclosed/NA

[Help](#)

Please enter your home address:

Click within each box and type in your address →

Street Address:

City:

State: Zip:

Don't type in the following boxes; click at the triangle to select your answers ↓

Do you own or rent the house?

What's the type of your house?

How long have you stayed at the current residence?

What's your annual household income?

[Exit for now and continue later](#) [Back](#) [Next](#) [Finish](#)

Figure 3 Household Information

Frequently Visited Locations:

1. Please review the list of locations on the left and select the ones you visit at least once per month, and move them to the list on the right by pressing the right arrow button.

2. Be sure to move (Home) to your Frequently Visited list.

Locations in the area:

Location Description	City
(Home)	
Allon Square on Alton and Jeffrey (Ben and Jerry, Z-Pizza, OCTFCU, Ralphs)	Irvine
Arbor Village Center on Walnut and Jeffrey (Irvine Taiko, Weinerschnitz)	Irvine
Campus Plaza on Campus and California (Albertson's)	Irvine
Culver Plaza on Irvine Center Dr and Culver (99 Ranch, Petco, Three D)	Irvine
Harvard Place on Main and Harvard	Irvine

Frequently Visited Locations:

Frequently Visited Location

3. If you don't see a location here, click the button --> **Add a location not in the list**

Exit for now and continue later **Back** **Next** **Finish**

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Figure 5 The Built-in GIS for Location Indication

Household Vehicles:

Help

1. Click on the **[Add Vehicle]** button.
2. Click at each box to enter required information (see Example below).
3. Repeat steps 1 and 2 for each additional vehicle.
4. If you entered a vehicle by mistake, click at the vehicle and click **[Delete Vehicle]**.

Delete Vehicle

4

Make	Model	Year	Seater

Finish

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- (4). Household Members (Figure 7): The first person in the household to run initial interview will enter the first names of all household members. A copy of individual database for each member will be generated to store personal information and activity diaries.
- (5). Member Information (Figure 8): Every adult member in the household will enter his/her personal information on this form, including: gender, age, license to drive, relation to household head, education level, employment status, hours worked in a typical week, occupation, student level (if the person is a student).
- (6). Activities Information: This group of questions is intended to investigate what activities each household member usually does (i.e., at least once per month). Attributes (e.g., typical frequency, duration, time windows, locations, and involved persons) of these activities will also be explored. Within this group there are 5 subordinate forms:
 - a. Activity Selection (Figure 9): Users will first select their typical activities (i.e., performed at least once per month) from the list of activities provided (see Table 2). If an activity is not in the list, they can always add one by themselves. The selected activities will be written to REACT!'s central database. Within the database, survey administrators can designate what attributes of a specific activity they are interested in investigating. If users select these activities, they will have to enter on the following subordinate forms the attributes that the investigator designated.

Household Members:

Please add the name of your household members (including yourself) to the following list:

1. Click on the [Add Person] button
2. Enter the name of the household member in the blank spot in the list
3. Repeat steps 1 and 2 for each remaining household member

Add Person

Household Members	
Name	

Exit for now and continue later:

Back

Next >

Finish

Figure 7 Household Members

Initial Interview (Click at the yellow page to get online help)

Member Information

Please enter information about:

Gender: Age: (yr) ☐ Check this box if you are licensed to drive

Relation to Head of Household:

Education Level:

Employment Status:

Hours worked in a typical week: Example: 40

Occupation:

Is this person a student?

School Level
 School Name
 School City

Figure 8 Member Information

Initial Interview (Click at the yellow page to get online help)

Activity Selection For:

John

Help

1. Please check all the activities this person typically does (at least once a month).
 2. The activities currently checked are defaults. Please do not uncheck them.
 3. Be sure to review the list all the way to the end and select Work if you are employed !!!

☒	(Don't know/Don't remember)	I don't know / I don't remember
☐	(Eat/Sleep/Wash)	Dining out at restaurants
☒	(Eat/Sleep/Wash)	Meal (at home or at work)
☒	(Eat/Sleep/Wash)	Night sleep
☐	(Eat/Sleep/Wash)	Snack
☒	(Eat/Sleep/Wash)	Wash/dress/pack
☐	(Household Obligation)	Attending to children (at home)
☐	(Household Obligation)	Cleaning/Maintenance (at home)
☒	(Household Obligation)	Filling out REACT survey
☐	(Household Obligation)	Meal preparation
☒	(Household Obligation)	Other household obligations
☐	(Household Obligation)	Pick-up/drop off others
☐	(Household Obligation)	Pick-up/drop-off kids

4. If an activity you typically do is not in the list, click this button to add this activity.

Add a New Activity

Exit for now and continue later **Back** **Next** **Finish**

Figure 9 Activity Selection

Category	Activities	Category	Activities
Eat/Sleep/Shower	Night sleep Shower/dress/pack Dinning out at restaurants Snack Breakfast Lunch Dinner (at home)	Recreation/ Entertainment	Jogging, biking, roller-skating Fitness center Golf Spectator sports Bars Movies in theaters Watching videos Regular TV programs Browsing Web sites Relaxation/Rest Hobbies at home (crafts, gardening, and others) Pleasure driving
Work/School	Work School (only if you are a student)		
Household Obligation	Meal preparation Cleaning/Maintenance (at home) Pick-up/drop-off kids Pick-up/drop off others Attending to children (at home)	Social	Visiting Hosting visitors Phone/email (over 10 minutes) Church and other religious events Volunteer work
Services & Errands	Medical care Personal services (Hair, nails....) Professional services (dry clean, auto repair...) Banking/ATM Post office/Shipping Library Gas station	Only for Children	Sleep (for children) With parents (or others in my household) Shower/dress/pack (for children) Snack (for children) Dinner (for children) Lunch (for children) Breakfast (for children) Attend practice/lessons (for children) School related activities (for children) School (for children) Play (or study) with other children Play (or study) on his/her own With baby sitters Day care center (preschool, kindergarten)
Shopping	Video rental store Major Grocery (10+ items) Minor Grocery (<10 items) Housewares/clothing/personal items Drug Store Mostly browsing Convenience store		

Table 2 Pre-defined Activity List

- b. Activity Frequency (Figure 10): On this sub-form users will enter typical frequencies for the activities designated by the investigator. For example, major grocery (over 10 items): 2 times every *week*.
- c. Activity Duration (Figure 11): This form is designed to collect information about the typical duration of certain activities. For example, jogging: 30 *minutes*.
- d. Activity Time and Day (Figure 12): This form asks users the typical time windows on which they would do certain activities. Users have to indicate if a specific activity usually occurs on a fixed time and day. If it does occur on fixed time and days, they have to enter the fixed days and time windows. If not, they will select the days and time on which it could occur.
- e. Activity Locations (Figure 13): On this form, users will select a list of locations at which they can perform a certain activity.
- f. Involved Persons (Figure 14): If other persons occasionally do this activity for the current interviewee (so he/she can do something else), the interviewee needs to select them from a provided list (i.e., it contains the interviewee's household members and an extra option labeled as "People outside my household"). In addition, if the interviewee usually does this activity with other persons, they also need to be indicated from that list.

Initial Interview (Click at the yellow page to get online help)

Activity Frequency Setting For: Help

How often do you do the following activity?

Activity Title: Activity 4 of 6

time(s) every

Example: 5 time(s) every Month

** If you don't feel comfortable answering this question, please select Undisclosed/NA in the time unit box.

Figure 10 Typical Frequency of An Activity

Initial Interview (Click at the yellow page to get online help)

Activity Duration Setting For:

Typically, how long does it take for you to finish the following activity? [Help](#)

Activity Title:
 Activity 4 of 6

Typical duration of this activity:

** If you don't feel comfortable answering this question, please select Undisclosed/NA in the time unit box.

Figure 11 Typical Duration of An Activity

Initial Interview (Click at the yellow page to get online help)

Activity Time and Days Section For:

John

Activity Title: Work/School : Work

Activity I of 6

~ If you don't feel comfortable answering the question just click [Next] and don't change anything.

Does this activity occur on fixed day(s) of the week?

Which Days:

☐ Monday ☐ Tuesday ☐ Wednesday ☐ Thursday ☐ Friday ☐ Saturday ☐ Sunday

Does this activity have a fixed start/end time?

Start Time: Hour: 1 Min: 00 AM PM

End Time: Hour: 1 Min: 00 AM PM

Exit for now and continue later

Back

Next

Finish

Figure 12 Typical Time Window of An Activity

Initial Interview (Click at the yellow page to get online help)

Active Locations Setting Page For: **John**

Activity 1 of 4: **Shopping : Major Grocery (10+ items)**

Activity 2 of 4

Frequently Visited Locations

Location	Description
☐	Campus Plaza on Campus and California (Albertson's)
☒	Heritage Plaza on Walnut and Culver (Ralphs, Burger King, ALB Hardware)
☐	Irvine Village Center on Irvine Center Dr. and Jeffrey (Irvine Dance Academy, Pt.)
☐	my church

Typical Locations for this Activity

Campus Plaza on Campus and California (Alberts)
Heritage Plaza on Walnut and Culver (Ralphs, B)

If you can not find the location in this list, click [More Locations]

More Locations

If you don't feel comfortable answering this question, just click [New] and don't change anything.

Exit for now and continue later Back Next Finish

Figure 13 Typical Locations of An Activity

Initial Interview (Click at the yellow page to get online help)

Involved Persons Setting Page For **John** Who are the other persons involved in the following activity? Help

Activity Title: **Shopping : Major Grocery (10+ items)** Activity 2 of 2

== If you don't feel comfortable answering the question, just click [Next] and don't change anything.

If other persons occasionally do this activity for you (so you can do something else), please check them in the following list:

☒ Mary ☐ People outside my household

If you usually do this activity with other persons, check them in the following list:

☒ Mary ☐ People outside my household

Exit for now and continue later Back Next Finish

Figure 14 Typical Involved Persons of An Activity

- (7). Transportation Modes (Figure 15): Users will select the modes they use from a list of local transportation modes, including walk, ride with others, van pool, car, local bus, bicycle, and commuter rail.

Initial Interview (Click at the yellow page to get online help)

Transportation Modes For: [Help](#)

Please check all transportation modes that this person uses:

- ☐ Undisclosed / NA
- ☒ Walk
- ☐ Carpool with other
- ☐ Van pool
- ☒ Car
- ☐ Local bus
- ☒ Bicycle
- ☐ Commuter rail

*** If you don't feel comfortable answering this question, just click [Next >] and don't change anything.

If you want to answer this question, don't click [Next >] before you finish checking the transportation you use !!!

[Exit for now and continue later](#) [< Back](#) [Next >](#) [Finish](#)

Figure 15 Transportation Modes

3.3.2 Weekly Activity Diaries

Weekly Activity Diaries containing two separate graphical user interfaces for interviewees to record their activity scheduling process. Weekly Calendar (Figure 16) is used to record activity intentions before they occur, and Daily Calendar (Figure 17) is to

keep track of what activities actually occur during a day. Instructions on how to enter data to the calendars are given to users through an automatic slide show (Figure 18) that launches itself when the program is turned on after Initial Interview is completed.

Figure 16 Weekly Calendar

Daily Calendar
Edit Help

Any Day Activities

View Calendar

Any Day

Cleaning/Maintenance (at

Start ?-End ? Dur: 0

Final Schedule

View 12/10/00

12/10/00	
12/11/00	
12/12/00	
12/13/00	
12/14/00	
12/15/00	

Tentative Schedule

View Calendar

Mon 12/10/00

Major Grocery (10+ items)

Start ?-End ? Dur: 0

Work

09:00 AM-05:00 PM Dur:

I've completed the entire schedule (all the way till 12:00AM) OK

I've entered what happened so far (but it's not 12:00AM yet) OK

Figure 17 Daily Calendar

Figure 18 Automatic Slide Show

3.3.2.1 Weekly Calendar

On the Sunday evening when the surveying week begins, users will be taken to an empty Weekly Calendar on which they will enter activities they know they will do on each day of the coming week. To minimize the potential "fill-up" bias (i.e., encouraging unnecessary planning by showing respondents time tables), a Weekly Calendar does not contain a time scale as CHASE (see Figure 1). In addition, before the calendar shows up, there are always highlighted messages in the automatic slide show warning respondents not to intentionally plan and enter more activities than those they have known before they run the program. Each adult member in the household will have a separate calendar to work on. Interviewees enter known activities to the calendar by activating the Activity Information entry form (see Figure 19). Note that users can leave details of an activity (e.g., time, location, and duration) as "I don't know" if they are not sure about them at the moment. Activities intended for the future appear in a stack of boxes, showing known details (Figure 20). The "Any Day" list of activities in Figure 20 is for user to enter activities that will be done in the week but the date has yet to be determined. The "Any Day" column will remain on screen, whereas the remaining days can be viewed by scrolling when needed. If a respondent enter a specific activity that the survey administrator is interested in investigating why the activity will be done on a particular day, a dialog box will show up to request this information from interviewees (see the section on decision tracing dialog for details).

Activity Information

Activity Information

1. Click here to enter the name of the activity ->

Enter Activity

don't know / I don't remember

2. If you selected [Other...], type in a brief description of that activity here ->

3. Click here to enter the location for the activity ->

Enter Location

(I don't know)

4. Select the day of the week for this activity ->

Monday

5. Do you know the time of this activity?

☐ Yes
☒ No

Enter the duration of this activity

[?] Hours and [?] Mins

If you don't know how long this activity will take, you can leave the question marks in the boxes.

6. Check the persons who will be/were with you at the activity (Leave it blank if you don't know yet or you are the only person involved)

☐ Mary
☐ People outside my household

OK

Cancel

Figure 19 Activity Information

Figure 20 Stacks of Pre-Travel Plans

3.3.2.2 Daily Calendar

At the end of each day in the week, interviewees will be taken to the Daily Calendar as soon as they turn on the program. On this calendar, activities indicated for the current day are listed in a stack of boxes on the Tentative Activities column (on the left hand side). "Any Day" activities are listed in the same fashion on the right hand side. The Final Schedule for the current day is placed in the middle with a specific time scale. It is noted that displaying the current day's schedule along a standard time line (as in the original CHASE survey) is not subject to the "fill-up" bias at this stage, as these activities have already been executed. Users first review the Tentative and Any Day activities and identify those that were actually executed in the current day. Then they need to activate the Activity Information form to specify all the details about these activities. Immediately after they enter all the details, a series of dialog boxes containing questions may show up if an activity was executed in a way different from their intention (see the section of Decision Tracing Dialogs for details). When questions in the dialog boxes are answered, they can move this activity to the Final Schedule by pressing down the left (from Tentative to Final) or right (from Any Day to Final) arrow buttons. Interviewees will continue to finish their Final Schedule by adding activities and travel events (Figure 21) that actually occurred but were not indicated as either the Tentative or Any Day activities. Occasionally, question dialogs may also show up if respondents have entered certain activities that the survey administrators are interested in investigating.

Travel Information

1. Select transportation:

2. Type in here the origin and destination of this travel (For example: from home to work; from home to Los Angeles)

3. Select the day of the week for this travel:

4. Enter the departure time of travel: ☐ AM ☐ PM

5. Enter duration of travel: Hours and Mins

6. Who will be/were the passengers?
(Leave it blank if you don't know yet or you are the only person involved)

☐ Mary

☐ People outside my household

Figure 21 Travel Information

After users finish updating their Final Schedules to the current time, they will be taken back to the Weekly Calendar and asked to review the activities for the subsequent days and update them if changes have been made (e.g., a new appointment has been scheduled for one of these day). Before users see their Weekly Calendars, the automatic slide show will launch again to warn interviewees not to intentionally plan and change activities if they have not learned or thought about the changes before they run the program. When changes are made, the question boxes will show up again to trace the

reasoning process. The process of updating Daily and Weekly Calendars will continue everyday until the coming Sunday when the survey ends.

3.3.2.3 Record Keeping

REACT! is designed to record every single scheduling step. For example, when an activity is added to the calendars for the first time, a unique ID is assigned to this activity record marked a sequence number '1' and a letter 'A'. If this activity is later modified or deleted, another record with the same ID will be generated and marked with sequence number '2' and letter 'M' or 'D' (i.e., denoting modified and deleted, respectively). With this scheme, the evolution of each activity from plan to action can be easily traced in the resultant database by sorting activity ID and sequence number. Note that the way of marking each record with letters denoting entry types follows CHASE, but the sequencing of related activity records is a unique feature in REACT!.

3.3.3 Decision Tracing Dialogs

REACT! is implemented with mechanisms intended to trace decisions involved in everyday activity scheduling. When a respondent manipulates a specific activity record in a certain way, a series of dialog boxes will show up to trace the decision process underlying the manipulation. 9 different questions will show up as soon as interviewees change or add a specific activity record in their Daily Calendars. Table 3 lists each specific manipulation and its corresponding question. In the current implementation, no question will be issued to any addition or changes involving basic activities such as night

Activity Manipulation	Question ID	Questions Triggered
An intended activity was canceled during the day.	1	Why did you cancel this activity?
An activity was executed at a time different from the intended.	2	Why is the time different from what you entered before?
An intended activity is postponed.	3	Why is the day different from what you entered before?
An activity was executed at a location different from the intended.	4	Why is the location different from what you entered before?
A specific activity is added to the Weekly calendar.	5	Why do you want to do this activity on this day?
An activity not known before the day was executed during the day.	6	You did not enter this activity before. Why did you do this activity at the time?
The start or end time of an executed activity was originally left as "I don't know".	7	You did not enter the time for the activity before. How did you decide to do it at this time?
The location of an executed activity was originally left as "I don't know".	8	You did not enter the location for the activity before. How did you decide to do this activity at this location?
An "Any Day" activity was executed or it has been scheduled on a certain day in the week.	9	You did not know on which day this activity would be done. How did you decide to do it on this day?

Table 3 Decision Tracing Questions

sleep, shower, and regular meals (except for dinning out at restaurants). If a respondent performed more than one manipulation on a single activity record, all the triggered questions will show up sequentially. Each of these questions will appear in a dialog box (Figure 22). It is important to note that interviewees are warned that they should not force themselves to come up with reasons. In case the decision was made without much

reasoning, they can always select an option called "No specific reasons". Depending on the answer selected, subsequent dialogs can be triggered to trace other information that may be relevant to the decision. First, the timing when the decision was made may be asked with the dialog box in Figure 23. This dialog may be followed by a simple question "Do you often make such a decision in a similar situation?". Finally, the last dialog (Figure 24) may be used to question if respondents ever thought about anything as the benefit of the manipulation.

Why did you cancel this activity?

You can check more than one from the following. But, PLEASE DO NOT FORCE YOURSELF TO COME UP WITH A REASON NOW. If you don't think that you ever thought about anything at the time, feel free to choose "No specific reasons".

- ☐ The previous entry was a mistake.
- ☐ I forgot to do it.
- ☐ It was due to delay of previous activities (or previous).
- ☐ I had to do other things.
- ☐ No specific reasons. I just felt like to stop it.
- ☐ The decision involved other people. (For example, other people took care of it for me, or I was asked to do something else.)
- ☐ -- Other reasons:
- ☐ I don't know how to answer this question.

* If you select an answer that is followed by an option box, please select one from the box to complete this answer.

** If you select (Other reasons), please describe the reason in the following text box.

If this is the first time you see this question, please click Help to get instruction.

Figure 22 Decision Tracing Dialog Box

When did you made the decision of deleting this activity?
 Select one from the followings:

- ☐ This question does not apply (I did not make a decision or the entry was wrong)
- ☐ During the activity
- ☐ Right after the end of previous activity
- ☒ During the previous activity
- ☐ Earlier in the day
- ☐ Before the day
- ☐ Earlier in the week
- ☐ I don't remember
- ☐ Other (please describe briefly):

Figure 23 Decision Timing Dialog

Have you thought about...

Have you thought about any of the followings as benefits to your decision of doing this activity at this time?

You can check more than one from the followings. But, if you don't think that you ever thought about anything at the time, feel free to choose "I was not thinking about anything".

- ☒ This question does not apply (I was not my decision)
- ☐ I could spend less time in traveling
- ☐ I could have more time to rest or do other leisure activities
- ☐ I could take care of other things (which might be more urgent or important)
- ☐ I was not thinking about anything
- ☐ * Other:

* If you check [Others], please type in the box a few words to describe what you were thinking.

If this is the first time you see this question, please click Help to get instruction.

Figure 24 Decision Benefit Dialog

3.3.4 Send Data Utility

When all the adult members in a household finish recording their activity diaries, the last person will establish Internet connection then activate the Send Data utility of REACT!. Although the central database of REACT! is capable of being served from a remote database server, currently the databases reside on the clients' end to achieve privacy and efficiency with a minimum deployment cost. When Send Data is activated, the program will compress the database of the entire household with encryption. The data package will be labeled with the household's ID and current date and sent to the survey administrative server via FTP. The ID and date on each package will enable investigator to monitor the progress of each participating households and examine the validity of the data. The entire Send Data process is performed automatically without user intervention. When it finishes, users will receive notification to exit the program for the day.

3.4 Summary of REACT! Design

The basic survey approach of CHASE is maintained with REACT!, with the behavioral process from pre-travel planning to post-travel updating being recorded for a week long span. However, CHASE's shortcomings are addressed, leading to three main design objectives of REACT!:

- (1). Reduce the cost and human resource associated with using loaned laptops as survey instruments
- (2). Address potential instrumental biases

(3). Expand program capabilities

To address the first objective, a self-administrative survey design paradigm is adopted where respondents use their own computers to input data with the program providing guidance. In addition, since the survey administrators can remotely conduct the survey over the Internet, sample size can be more effectively expanded with moderate cost. Instrumental biases are reduced with the special features of the program's graphical user interfaces and other components. The third objective involves two experimental features to be implemented with REACT!: a GIS component for location indication and a series of dialog boxes to trace scheduling decisions. The former can streamline the processes of location specification and geo-coding, while the later is intended to collect responses from users as to why they made certain schedule changes.

CHAPTER 4 PILOT STUDY AND PROGRAM EVALUATION

4.1 Introduction

The major purpose of the pilot study is to test and evaluate program performance through a small set of sample households. Prior to execution of the pilot study, the prototype of REACT! went through a month (from late February to the end of March, 2000) of beta testing with 9 households. The testing was intended to detect errors and inefficiencies of the program. During this period, 2 to 3 households were recruited each week to participate in the testing, and program was incrementally modified each week until the pilot version was completed.

The survey was officially classified as Exempt Research (i.e., does not require extensive human subject review) by the Institutional Review Board of the University of California, Irvine (UCI). As a result, minors could not be involved in the study and adults were asked to enter data for their children under 18. Although it is desirable to have older children access the program by themselves, the Exempt Research classification gave the survey administrators the flexibility to adjust survey procedure for better participation rate and better data quality without experiencing a lengthy review process.

4.2 Study Area and Survey Procedure

A total of 47 households completed the pilot study from April to June, 2000. During the process, 4 households were withdrawn by the survey administrator before they completed the survey, because they did not run the program within the designated time*. Most of the participants were students residing in two student communities, located adjacent to the main campus of UCI. A small number (i.e., 4 households) of participants were non-students living in an apartment complex several miles away from UCI. The center of the study area, the city of Irvine (population 136,600 in 1999), is located about 40 miles south of Los Angeles. Irvine and two of the neighboring cities, Costa Mesa and Newport Beach, form a large, thriving area with numerous opportunities for most activities (Figure 25). In the pilot study, the study area includes these three cities and a part of Tustin, a city adjacent to Irvine containing several popular shopping complexes (Figure 26). Locations within this area were pre-defined for users to indicate their activity locations (see program design for details). In addition, the GIS component displays map of the study area when users activate the component for location indication.

The pilot was executed in the following manner. First, flyers and emails bearing the same messages (see Appendix) were sent to residents in the study area. In addition, a Web site (www.its.uci.edu/~react) was established to give potential participants a brief introduction of what questions and tasks they should be expecting from the survey. Interested participants would contact the survey administrator by phone or email. A package containing REACT! installation CD and other administrative materials (i.e.,

* Because of the concern that some respondents might not follow the instructions carefully, the survey consent form was phrased to reserve the survey administrator's right of withdrawing participants. See Appendix for the official survey consent form.

Figure 25 The study area within Orange County

survey consent forms, instruction on when to run the program, user manual, and program installation guide) was subsequently sent to each participant. After that, participants would execute all the tasks on their own, although a dedicated phone line was available for technical support. The survey administrator would occasionally send out email to alert interviewees potential mistakes they might make on a specific day. Emails would also be sent to remind participants if investigators detect individuals who forgot to send in data

on the previous day. After the survey ended, a set of questions was sent by email to every participating household asking for their evaluation of the program (see User Evaluation below).

Figure 26 The Study Area

Participants in the pilot were financially compensated. In the first month of the survey, the advertised compensation rate was: single persons receive \$25 dollars and married couples receive \$50 dollars. However, participation rate was low (seven households finished) and some participants also indicated that compensation was not sufficient. A new compensation scheme, adjusting for the time and effort spent by

different types of households, was later advertised: single persons receives \$40 dollars; singles with children receive \$60 dollars; married couples without children receive \$80 dollars; and married couples with children receive \$100 dollars. Over 50 households responded to the new advertisement and 40 households completed the survey in four weeks.

A special procedure was designed for parents to enter data for their children. The purpose was to investigate how children's schedules affect parents' without substantially increasing entry load for parents. First, in the Initial Interview, a category of activities was defined for children (see Table 2). Parents were asked to select exclusively from this category to describe what their children typically do. Before the surveying week begins, parents should indicate when their children would be engaged in activities away from them, such as school, school events, or day care centers. Everyday in the week they would update their children's activities in the same way as they would do for themselves, except for that decision tracing dialogs would not appear during children sessions.

4.3 Program Evaluation

The purpose of the pilot study is to test and evaluate program performance. Throughout the survey, testing of the program was accomplished successfully as respondents were able to finish the required tasks without difficulty. Evaluation of the program was conducted by examining characteristics of the collected data for inferences of program effectiveness. For example, daily data entry time was calculated to assess how efficiently the program was used. In addition, a user evaluation survey was also

conducted to obtain direct feedback from respondents. Note that the survey was conducted in two different stages, initial interview and weekly diaries, each with its own purposes and unique design. Assessment of effectiveness is thus made separately according to how well each component served its purposes.

4.3.1 Initial Interview

The initial interview is intended to collect household and personal information and to set up individual activity programs. Information collected in this part of survey is more straightforward than recording of activity diaries. For indication of activity locations, REACT! incorporates a unique procedure that combines a GIS component. The resultant data offer insight as to what are the more efficient ways for people to report location in computerized surveys.

4.3.1.1 Household and Personal Information

Perhaps because the data entry forms utilized mostly common graphical user interfaces, no question has ever been reported during the process. Although respondents could skip questions they did not wish to answer, they answered most questions that applied to them. The most notable exceptions are household income (5 households selected not to reveal), home address (1 household did not enter), and age (1 single adult did not answer). Among the 47 households (81 adults, 16 children), 14 of them are single adult households (one with a child). There are also 20 couples without children and 13 couples with 1 to 2 children. Ten of the children are under 3 years old and six of them are

between 6 and 16. For all the adults who indicated their ages, the average is 28.6. The oldest is 55 while the youngest is 20. Educational levels of all respondents are in general high. Over half (45) of the adults are either working on or have a master's degree or higher. 28 have bachelor's degrees. The remainders (8) are either graduated from 2 year colleges or currently undergraduate students.

4.3.1.2 Recording of Locations

In the Initial Interview, respondents were asked to select from the provided list of 24 commonly visited locations, including various shopping complexes in the study area, and to build their frequently visited locations. These pre-defined locations were all geo-coded. If a location was not included in the provided list, users could record it by choosing one of the three input methods: typing the address, typing the closest intersections and/or landmarks, or pointing it out with the GIS component. If a location is out of the study area, users were instructed to enter just the name of the city. At the end of the survey, an average household entered 11.3 locations as its frequently visited locations. Among them, 7.8 were selected from the provided list, while 3.5 were recorded by users themselves. In addition to recording extra locations as frequently visited, locations that were visited only for some particular activities during the week might also be recorded with the same methods. An average household recorded 1.7 activity locations that were not indicated as frequently visited during the surveying week. It should be noted that six households selected locations entirely from the provided list. They did not record locations on their own. Overall, 242 locations were recorded by users themselves: 59 (24%) of them were entered with full addresses (26 are located outside of the study

area); 111 (46%) were entered by closest streets, land marks, and/or city name (30 were out of the study area and entered with city names); and 72 (30%) were entered with the GIS component. It is important to note that the method used to record a location was chosen by respondents themselves. They had the options of selecting one of the three methods that matched their knowledge of the locations (i.e., complete address, closest streets, land mark, or pinpointing it on a map).

4.3.1.3 Geo-Referencing Activity Locations

Records of these locations were all geo-coded in a GIS with various precisions (Figure 27 and 28). It clearly shows that throughout the surveying weeks most events were done within the study area. During weekend, several respondents traveled out of the study area for substantial distance. No precise geo-coding was intended for the locations out of the study area. Centroids of the cities were used to represent these locations. Locations recorded by the GIS components appeared in the database as pairs of longitude and latitude that can be directly managed and analyzed in a GIS. Among the 59 locations with full addresses, 33 of them were located in the vicinity of study area and address-matching was performed for these records. An address-matching program reads the address of a record and automatically finds the matching street segment in the reference street network (e.g., U. S. Census's TIGER/Line file). The geo-reference of this record is then created right next to this segment to represent the location. Although address-matching can create geo-references with satisfactory degree of precision (i.e., depends on the precision of the reference street database), it has certain limitations. A match-able address needs to have six elements: street number, street name, street type (e.g., Blvd.,

St., and Cir.), city name, state, and ZIP code. If any one of the address elements does not match records in the reference database, the matching would fail and human interaction is required to find the location.

Figure 27 Spatial Distribution of Event Sites

Among the 33 full addresses gone through address-matching, only 7 (21%) of them were automatically matched with reference to the 1995 Tiger/line files. Examination of the unmatched records showed that addresses entered by respondents often failed to meet the requirements of an address-matching procedure. For example, directional prefixes of streets (i.e., North or South), street types, and/or ZIP codes were

often missing. The names of the streets may also be misspelled. Extensive time and labor was required to handle the unmatched records. Geo-referencing of records identified by closest streets or landmarks also presented substantial difficulty. Majority of locations in this category were entered with two crossing streets. Similar to records entered with full address, missing elements or misspelling also demanded special attention.

Figure 28 Geo-coded Event Sites (Centered on Study Area)

No post-processing is needed to create geo-references for event sites recorded with the GIS component. Each of these records was in the form of a longitude and latitude pair that was written to the database when respondents pointed and clicked at an

event site. Note that the base map of the GIS component was also based on the 1995 TIGER/Line files. The precision of a GIS recorded location with respect to its true position on the ground cannot be accurately assessed, because it depends on two factors: the precision of the base map, and the scale at which a location was positioned on the map (i.e., respondents can freely zoom in the map). However, comparison can be made between a GIS-recorded location and one geo-coded by address-matching, which is also based on the same TIGER/Line files. The minimum scale at which a location can be recorded with the REACT! GIS is approximately 1:333 (i.e., one inch on the map window represents 333 inches on the earth's surface). It can be considered that address-matching procedure operates on the 1:1 scale, since the procedure locate the record based directly on the latitudes and longitudes of the end points of the matched reference street segment. If a point is well positioned on the REACT! map, the location is anywhere within 333 inches (28 feet) of the one located by address-matching. If respondents zoomed in one scale closer (1:118), the difference between the two would be within 10 ground feet.

The experience of geo-referencing locations can be summarized with the followings. First, address information reported by individuals is often insufficient for address-matching procedures, hence post-processing is almost always needed to handle the unmatched records. Second, allowing respondents to enter locations by approximate information such as closest streets or landmarks would downgrade the data resolution and also create the necessity for labor-intensive data processing. Third, locational information collected with the GIS component does not require geo-coding, since it is already in the form of longitude and latitude. The amount of time saved for geo-referencing records is

considerable even for a small record set like this. The precision of the GIS records is only slightly less than perfectly matched address records. However, the perfect match rate for reported addresses can be very low. Based on the experience of geo-coding various location records, the GIS component appears to be an efficient tool for collecting activity locations in a computerized activity diary.

4.3.1.4 Activity Program Characteristics

The activity program selected in the Initial Interview was mainly used to accelerate (i.e., point and click without typing) the data entry process in Weekly and Daily Calendar. However, additional questions were asked in the interview process to explore attributes of certain activities. Participating adults selected a total of 2099 activities, or an average 26 activities per person, as their typical activities (i.e., perform at least once per month). Only six persons ever added activities (a total of 7 activities) on their own. According to the results of user evaluation, most respondents indicated that activities in the pre-defined list were sufficient for them to describe their typical activities (see User Evaluation).

4.3.1.5 Interview Time

During the interview, the first person to run the program would enter household and vehicle information for the entire family. The other adult only needs to fill out personal information and activity program forms. The average time to complete the self-administrative interview is 26 minutes for the first adult and 13 minutes for the second

person. It has to be noted that actual interview time from 4 persons was not available for this analysis, because they exited (i.e., there is a button built on the user interface for this purpose) the interview midway before finishing it then resumed a day later. When filling out the interview for children, parents dealt with a small set of activities when describing children's activity programs. Consequently, the average interview time is only 6 minutes. Overall, comparing to the face-to-face up-front interview employed in the CHASE survey (i.e., lasted 1 to 2 hours), the average time for the computerized initial interview is satisfactory.

4.3.2 Weekly Activity Diaries

The weekly activity diaries were designed to record the process of activity scheduling throughout the surveying week. This part of the survey is more difficult for respondents to follow than the initial interview. Respondents were asked to enter not only what they did throughout the day but also the plans that preceded the action. Knowing the complexity of the diary, detailed instructions on the required tasks were given to respondents through the automatic slide show (see program design) and other supplemental materials (e.g., user manual). Generally, most respondents were aware of the required tasks (see user evaluation) and completed each 24-hour diary for the entire week, since REACT! internally examined and mandated completeness of the schedules. However, the resultant data show that a small portion of the respondents did not seem to follow the instruction as closely as others. Diaries of nine adults (from six households) contain significantly less details than others'. For example, some of these diaries consist of three to four long events (e.g., sleep, work, study) per day, without specifying short

events such as meals in between activities. In addition, five individuals (out of the nine) did not enter travel events on Daily Calendars, although it was clearly stressed in all the instructional materials that traveling between activities (at least 5 minutes) needed to be recorded as individual events. Data from these individual respondents represent both administrative and technical issues demanding further investigation. In this section, characteristics of the entire sample would be described first to demonstrate the impact of the questionable diaries on the complexion of overall data. The questionable dairies would be then examined separately, and potential causes for the inefficiency would also be discussed.

4.3.2.1 Resultant Diaries of the Entire Sample

During the pilot, the program recorded 12766 scheduling steps from the 81 adults, including 9210 addition (1205 were repeated events), 818 deletion, and 2738 modification. Average data entry steps per adult per day is illustrated in Figure 29. On Sunday, users performed the most data entry steps when entering known activities for the entire week. This is followed by a sudden drop on Monday. It is noted that on Monday users only updated their schedules from 12 midnight till the evening when they ran the program, as opposed to other days in the week they needed to update almost a full day (i.e., from previous evening till the current one) every night. Comparing to other days in the week, the peak on Tuesday seems abnormal. After examining the data, it was discovered that several respondents encountered errors and performed extra steps to correct them, when they tried to finalize the remainder of Monday (i.e., Monday's schedule should be completed without time gaps and conflicts). This represents an issue

for improvement in program design. No obvious fluctuation is observed for remainder of the week, except on the ending Sunday when some respondents entered the skipped Friday and/or Saturday. Overall, no consistent decline in entry steps is observed throughout the week. This suggests the amount of daily entry load did not cause evident fatigue effect.

Figure 29 Data Entry Steps per Adult (All Diaries)

At the end of the survey, 6738 activities and 1602 trips were entered by 81 adults. 5099 (76%) activities were in-home, while 1639 (24%) were out-of-homes. Note that the number of resultant activities and trips do not equal the numbers of addition minus deletion, because five households did not finish the ending Sunday's schedule. The activities and trips per adult per day are shown in Figure 30 and 31.

Figure 30 Activities Per Adult Per Day (All Diaries)

Figure 31 Trips Per Adult by Mode (All Diaries)

In Figure 30, no obvious fluctuation exists over the course of the week, except for the decrease of work/school activities over the weekend and the increase of shopping activities on Saturday. On Sunday, the overall average number of activities decreases, because respondents only needed to finish their schedules up to the time they ran the program. In Figure 31, the most notable fluctuations are the increase of car trips on Saturday and the total trips decrease on Sunday.

During the pilot study, REACT! also collected from the 81 adults 6155 responses as to why they made certain schedule changes. Changes made to basic activities (e.g., night sleep, shower, regular meals) were not questioned. The purpose was to keep the length of each data entry session short. If changes to all activities were questioned, the excessive number of dialogs may make respondents impatient thus the quality of the data obtained could be affected. These responses will be analyzed in conjunction with the entire scheduling steps. It is expected that answers to these questions can provide information about decision rules of activity scheduling.

4.3.2.2 Diaries with Insufficient Details

Diaries of nine individuals (from six households) are of questionable quality because they contain significantly less details than others. The insufficiencies of these diaries are of three major types:

- (1). Failure to separating travel from activities: Six out of the nine respondents in the questionable group did not record travel events for the entire week, although the program clearly instructed users that traveling needs to be

recorded as individual events. These respondents indicated, in the post-survey user evaluation, that travel time to an activity was included in the duration of the activity.

- (2). Overly simplified schedules: Two individuals rarely entered short events such as meals. According to their diaries, each of their days often consisted of only three to four major events. For example, an overly simplified schedule might start with sleep from midnight to 9 AM, followed by work from 9 AM to 5 PM then an in-home activity that continued all the way to midnight. Individuals who failed to report travel also tend to simplify their diaries.
- (3). Reluctance of responding to the decision tracing dialogs: Two adults of a same household selected almost exclusively “I don’t know” or “I was not thinking about anything” whenever the decision tracing dialogs appeared. However, their diaries are not subject to the first two types of inefficiency.

Table 4 shows the difference in data entry steps of the two data quality groups. It reveals that the questionable group performed substantially less addition and modification steps than the valid group. Figure 32 shows the difference in overall data entry steps of the two groups. It clearly shows that the two curves fluctuated with a similar pattern. Aside from Monday, the questionable group performed approximately 10 to 15 steps less than the valid group. Because the daily entry steps did not decline consistently day by day, the insufficiency is not likely due to fatigue. Moreover, the similar number of steps on the first Sunday suggests that respondents who produced the questionable data were not necessarily avoiding the required tasks and ignoring the program’s instruction. Otherwise, they would have had entered much less steps on the first Sunday as well.

Data quality group	Number of individuals	Addition	Addition of repeated events	Cancellation	Modification	Total steps
Valid	72	7547 (14.97)*	1068 (2.12)	724 (1.44)	2517 (5.00)	11856 (23.52)
Questionable	9	458 (7.30)	137 (2.17)	94 (1.49)	221 (0.43)	910 (14.44)
Total	81	8005 (14.11)	1205 (2.13)	818 (1.44)	2738 (4.83)	12766 (22.51)

* Number in each parenthesis is the average steps per person, per day in this group.

Table 4 Comparison of Data Entry Steps (between Valid and Questionable Groups)

Figure 32 Comparison of Total Data Entry Steps (between Valid and Questionable Groups)

The average number of activities per adult is shown in Figure 33 and Figure 34. for the questionable group and valid group respectively. The tendency for the questionable group to simplify their diaries is clearly demonstrated with the figures.

Figure 33 Activities per Adult (Questionable Diaries)

Especially, note that the questionable group entered approximately three basic activities (including meals, showers, and sleep) a day, two less than the valid group. It could be argued that such difference is valid simply because some people regularly skip breakfast or lunch. However, two of the respondents were believed to have simplified their schedules because they entered no meal activities for the entire week. The oversimplification is not likely caused by fatigue or entry load because the average number of total events fluctuated randomly across the week.

Figure 34 Activities per Adult (Valid Diaries)

The average number of trips derived from valid diaries is illustrated in Figure 35. This figure is almost identical to that of the entire sample (see Figure 31), because the questionable group altogether entered only 41 car trips. Six persons (from four households) in this group included the travel time in the duration of the corresponding activity.

Figure 35 Trips per Adult (Valid Diaries)

Table 5 shows the number of times respondents answered decision tracing questions. Although a person in the valid group performed nine more entry steps than one in the questionable group, the difference of the average number of answers per person per day is approximately four. Note that many of the missing events were basic activities that would not activate the Decision Tracing Dialogs. Data from two respondents of a same household were listed as questionable because they responded to every Decision Tracing Dialog with the same answer "I don't know". It is believed that their way of answering questions was not an attempt of avoiding the required tasks, because their diaries actually contain sufficient details. In the post-survey evaluation, they indicated that they never thought about anything or reasoned in anyway when they carry out their everyday activities.

Data quality group	Number of individuals	Total number of Answers	Average number of answers per person per day
Valid	72	5699	11.31
Questionable	9	456	7.24
Total	81	6155	10.86

Table 5 Number of Decision Tracing Questions Answered

4.3.2.3 Potential Causes of the Insufficient Data

As elaborated in the previous section, it is believed the insufficient data were not a direct result of fatigue or data entry load. In addition, it is not likely that these respondents were intentionally avoiding the required tasks. It seems more likely that they were entering their daily schedules with their own interpretation rather than the instruction given to them. There is a common characteristic existing in many of the respondents who did so: six out of the eight respondents who did not have enough details in their diaries speak English as a second language. It is likely that they may not have comprehended the instruction as well as others. Especially, the data entry tasks of the Daily Calendar are not as straightforward as those of the Initial Interview or Weekly Calendar. The instruction of separating travel from activities is likely to be accidentally overlooked in the process of learning how to use the program. Another potential reason for the oversimplification is due to the program design that allowed respondents to enter just one activity whenever they did more than one at a same time. This may explain why some of them did not insert lunch into a work event that lasted from 9 AM to 5 PM.

4.3.2.5 Children's Diaries

The purpose of asking parents to enter children's diaries was to investigate how children's schedules affect parents' without substantially increasing entry load for parents. The pilot sample contains sixteen children (from fourteen households). Ten of the children are under three years old and six of them are between six and sixteen. During the survey their parents recorded a total of 787 activities for them. Note that a category of activities was used for parents to record children's diaries (see Table 2). These events are not directly comparable to those of the adults. The resultant data show that activities in this category are suitable for children under six years old as parents were able to select events exclusively from this category to describe children's diaries. Their diaries consisted of exclusively basic activities and "with parents" events that represent scheduling constraints of their parents. The same procedure appears to be insufficient for school-aged children as activities in adult's category (e.g., recreation and social events) were used for children over eight years old. These children had done more activities without parents' immediate presence. School events were also important elements of their diaries. Ideally, these children should enter data by themselves using a set of specially defined activities. However, the pilot study was not authorized to have minors access the survey on their own.

4.3.2.4 Daily Entry Time

The average data entry time separating by data quality groups is presented in Table 6. It has to be noted that the entry time considers only the time spent keying in

Data group	Data item	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total
Questionable adults	Average entry time	0:20	0:21	0:14	0:14	0:15	0:08	0:11	0:10	1:53
	Number of persons skipped the day	0	1	2	1	1	0	2	0	7
Valid adults	Average entry time	0:19	0:26	0:22	0:20	0:17	0:18	0:18	0:18	2:38
	Number of persons skipped the day	0	3	7	6	6	18	8	4	52
Children	Average entry time	0:06	0:04	0:07	0:07	0:06	0:04	0:05	0:03	0:42
	Number of persons skipped the day	0	3	2	3	4	5	6	2	25

Table 6 Daily Entry Time

data. On Sunday and Monday respondents would spend extra minutes reading instructions. The average difference between the two groups is approximately six minutes per day, but the time use pattern across days of the week is very similar in both groups. On the beginning Sunday, although respondents were asked to look ahead of the entire week and record activities they know they would do, the entry time on this day was not the longest in the week. The main reason is that users could copy and paste activity records that repeated on other days of the week. This feature accelerated the entry process on the Weekly Calendar. Monday was the most intensive session when users learned to use the Daily Calendar to update activities. After that, daily entry time gradually decreased, as respondents became familiar with the program, until a slight surge during weekends. This small increase can be explained by the fact that a certain number of people ran a longer session to make up what they skipped on Friday and/or Saturday. Among couples, the second person to enter data usually spent less time than the first person. This may be an indication that couples learned from each other how to run the program. For the time parents spent for their children, it reveals the same pattern as that

of adults but with a much shorter duration each day. This is because the activity information requested for children was not as much as adults'. In addition, Decision Tracing Dialogs were suppressed whenever parents entered for their children.

The number of skipped days were also tabulated in Table 6. Overall, 59 of the 648 (9%) adult data entry sessions and 25 of the 128 (19%) children data entry days were skipped. No one skipped the beginning Sunday since if a household missed the day they would be instructed to begin the process next Sunday (i.e., data from the Initial Interview remained valid in the database). Friday and Saturday were the days that were skipped the most. It has to be noted that the program always asked respondents to first finish entering the skipped days then continue with the current day. Therefore, activities on these days were all collected later. Five households did not finish the survey on the ending Sunday due to various reasons. These data could not be recovered, since these respondents were not available to run the program later.

4.3.3 User Evaluation

At the end of the surveying week, a set of eleven questions (see Table 7) was sent to each participating household by email. These questions were intended to assess, from users' viewpoints, if the program design achieved its goals. Answers to these questions were provided by the persons who acted as the correspondent to the survey administrator. Since couples were allowed to learn how to run the program from each other, the opinions of the second person were not sought. Responses from 33 households were

Questions	Number of Yes	Number of No	Missing
Part I Initial Interview			
1. Did the survey questions provide clear instructions on what and how to enter your responses?	33 (71%)	0	14 (29%)
2. Did you ever click on the [Help] button?	10 (22%)	23 (49%)	14 (29%)
If yes, did you find answers to your questions?	8 (80%)	2 (20%)	0
3. When you were asked to enter your frequently visited locations, were you able to select most of the locations you often visit from the list provided?	30 (64%)	3 (7%)	14 (29%)
4. When you were asked to select your typical activities, were you able to select most of the activities you often do from the list provided?	31 (67%)	2 (4%)	14 (29%)
Part II. Weekly Calendar			
5. On the first Sunday: (a) Were you aware that you should not intentionally plan and enter more activities than you had already planned prior to beginning the program?	31 (67%)	2 (4%)	14 (29%)
(b) Do you think you follow this principle reasonably well?	31 (67%)	2 (4%)	14 (29%)
6. Were you aware that if there were any details about an activity that you did not know you should leave the field as a [I don't know] response?	31 (67%)	2 (4%)	14 (29%)
7. Were you aware that if there was an activity you know you would do in the survey week but the exact date had yet to be determined you should enter the activity in the [Any Day] column?	31 (67%)	2 (4%)	14 (29%)
Part III. Daily Calendar			
8. Were you aware that, if you ever walked, rode a bicycle, took a bus, or drove a car for over 5 minutes to get to your next activity, you should enter this travel time between activities to your Final Schedule ?	29 (62%)	4 (9%)	14 (29%)
9. When there were boxes popping up to ask you for reasons, were you aware that you can select "No specific reasons" or "I was not thinking about anything", if indeed that was the case?	32 (68%)	0	15 (32%)
10. Did you find the Daily Calendar easy to use when you saw it for the first time? If not, could you tell us what we can do to improve it?	29 (62%)	4 (9%)	14 (29%)
11. Do you have any comments on any aspect of the survey research process?	NA	NA	NA

Table 7 User Evaluation

received. In Table 7, households that did not send in their responses are listed as missing. According to the results, majority of the respondents indicated that the program features did convey the survey designer's instructions. Although it remains to be examined, most interviewees indicated that they were aware and followed the principle of not intentionally plan activities. Note the households that failed to separate travel from activities were reflected in the results of question 8. However, only one of them was among the households who thought the interface of Daily Calendar is hard to use (see question 9).

4.4 Summary and Measures for Improvements

This chapter described the results of the REACT! pilot study in Irvine, California. In general, the pilot testing validated the program's capability of guiding participants to complete data entry tasks on their own, thus the design objective of reducing cost and human resource of a computerized survey is achieved. Other positive results regarding objectives of reducing instrumental biases and expanding program capabilities were also obtained. The GIS component proved to be an efficient way of recording activity locations, since no post-processing is required to geo-code the locations. The pilot study also identified several areas for improvement. Most important of all, the oversimplified diaries represent important technical and administrative issues that need to be addressed immediately. To summarize, the following program design and survey administrative changes could be considered for improvement of overall survey efficiency and data quality:

- (1). The use of the GIS component for location indication can be prioritized. Other entry methods could be used only after respondents fail to indicate the locations with the GIS.
- (2). The design of Daily Calendar should be more user-friendly: Although it is not going to lessen the required level of language efficiency, a more intelligent graphical user interface may help ease the reliance on written instructions.
- (3). The program should be capable of letting respondents report two activities at a same time period. Many respondents commented that they often did more than one activities at a time and thus were confused about which activity to report. Relaxing the constraint on concurrency would enable researchers to observe activity schedules close to their natural forms. This capability may also reduce the chance of collecting diaries that lack essential details.
- (4). The practice of separating travel from activities needs to be re-evaluated. Although for some people recording travel as individual events may be more intuitive than including them in activities, there are definitely other people who perceive it in the opposite way. In addition, an immediate disadvantage of separating travel from activities is the increased number of entries per day. A more comprehensive evaluation should be made to determine if travel should be treated as individual events.
- (5). The program should internally check for the validity of a schedule. For example, if travel is going to be treated as an individual event, the program should check for a travel event preceding an out-of-home activity. If travel is

not entered, warning should be issued. Similarly, the program could also check for the existence of meals and other basic activities.

- (6). The coordination between a couple's schedules should be improved. For example, it might be beneficial to list husband's and wife's schedules side by side in the Daily Calendar to enable copy and paste activities that were done together.
- (7). A set of activity classification tailored for middle and high school children should be used. In addition, their direct access to the program should also be considered.
- (8). Technical support can be provided actively to ensure that respondents are performing the required tasks correctly.
- (9). Finally, the full potential of the Internet has yet to be explored. Currently, the program performs one-way interaction through the Internet by loading its data to survey server. Although the administrators can examine the data on the server side, human intervention such as emails and phone calls are used to notify participants about errors in previous entry sessions. To automate the correction process, the program can be adapted to actively retrieve corrected data and instructions from server.

CHAPTER 5 DATA ANALYSIS: ON THE STRUCTURE OF WEEKLY ACTIVITY/TRAVEL PATTERNS

5.1 Introduction

Although various theories and models of activity scheduling behavior had been proposed (see literature review), they were mostly hypotheses describing revealed behavioral patterns. No data derived from the behavioral process was used in the formation and validation of these theories. A notable exception is the aforementioned Cullen and Godson (1975). They formulated and tested the important activity-peg principle by carrying out a special survey. The data collected from the REACT! pilot study contain information similar to those in Cullen and Godson's, such as spatial and temporal structures (i.e., execution time and location), type of participants (i.e., involved persons), and degree of pre-arrangement (i.e., time horizon when the decision of carrying out a particular event was determined). However, the REACT! data set is richer in that it was collected in a weekly period and respondents were also asked to record their advance knowledge about upcoming events. With this data, analyses extending Cullen and Godson's can be pursued. In addition, it has been postulated and tested that human plans are often partially elaborated prior to execution (Meyer and Rebok, 1985). Our understanding of the household activity scheduling process will certainly benefit from investigation of what elements of an activity plan are elaborated and how they are

elaborated. There has yet to be a study in the field of activity-based analysis examining activity plans and their realization in time and space. By asking respondents to enter just known details (i.e., date, time, and location) of an activity plan, REACT! captured the advance knowledge of activity plans and preserved the elaboration levels of these plans close to their natural forms.

The analysis presented here begins with statistical description of the overall manner in which survey respondents allocated their time to different activities. For events other than basic activities (i.e., decision timing as to when meals, shower, and sleep was not questioned), a variable indexing how far ahead in time an event was scheduled is derived from the data. With this scheduling horizon index, the analysis proceeds to investigate the inter-relationship among an activity's scheduling horizon, attributes (e.g., duration, location, involved person, and day of the week), and the actor's social-demographic background. After the investigation, the focal point of the analysis is then shifted to activity plans prior to their execution. Composition of these plans is analyzed to reveal plan elements that are more likely to be left open for scheduling flexibility. Finally, tours (i.e., trip chains) were identified and the mechanism of tour formation is dissected by analyzing the scheduling horizon of each tour stop.

5.2 Time Allocation Analysis

As background to subsequent analysis of scheduling behavior, statistics of how respondents partitioned their time budgets are presented. This mode of analysis allows one to establish an overall picture of survey participants' activity programs and

behavioral patterns that are results of the scheduling process. Weekly diaries of 72 adults (i.e., the valid group, see the chapter on pilot study for details) are included in the analysis. 12 of them are single adults (one with a child). There are also 19 couples without children and 11 couples with one to two children. The average age of the respondents is 28.54 (the oldest is 55 while the youngest is 20). There are 34 male and 38 female respondents. Although the sample was derived from student communities, not all of the respondents were students. There were 27 student spouses who were not students (i.e., 10 employed and 17 unemployed). Among the 45 students, 31 of them were employed and 14 were unemployed.

For analytical tractability, individual activities are aggregated to five functional classes. Table 8 lists the activity classes and the corresponding lists of activities. Table 9 summarizes respondents' time allocation on different functional classes of activities. Note that number in each cell pertains to an average adult respondent (this applies to all the time allocation tables). In this table it is clearly demonstrated that, except for sleep, work and maintenance activities were allocated with a large proportion of time budgets on both daily and weekly levels. However, there is a significant difference in the average duration of these two groups of activities. In terms of average duration, work is the second longest class next to sleep while maintenance is the shortest overall. The difference in duration reflects that domestic chores and personal activities may be easily fitted into schedules that are anchored by work or other more constraining events. Recreation and entertainment is the second most frequent activity class (i.e., judged by daily average number of events). It also occupied a substantial portion of the time budgets. Shopping and social activities were performed at similar daily and weekly frequencies, but social

events tend to be longer. An average respondent spent approximately twice as much time on social events as shopping.

Class	Activities	Class	Activities
Work School	Work School (only if you are a student)	Recreation/ Entertainment	Jogging, biking, roller-skating Fitness center Golf Spectator sports Bars Movies in theaters Watching videos Regular TV programs Browsing Web sites Relaxation/Rest Hobbies at home (crafts, gardening, and others) Pleasure driving
Maintenance	Meals Meal preparation Shower/dress Cleaning/Maintenance (at home) Pick-up/drop-off kids Pick-up/drop off others Attending to children (at home)		
Shopping Services	Major Grocery (10+ items) Minor Grocery (<10 items) House wares/clothing/personal items Drug Store Mostly browsing Convenience store Medical care Personal services (Hair, nails ...) Professional services (dry clean, auto repair...) Banking/ATM Post office/Shipping Library Gas station Video rental store	Social	Visiting Hosting visitors Phone/email (over 10 minutes) Church and other religious events Volunteer work

Table 8 Activity Functional Classes

Activity Class	Daily average events ¹	Daily average time (min) ²	Weekly percent of events ³	Weekly percent of time ⁴	Average duration (min) ⁵
Maintenance (excluding sleep)	5.7	253.0	36.8%	17.7%	44.2
Work/School	1.8	320.9	11.7%	22.5%	183.1
Shopping/Services	0.6	36.2	4.0%	2.5%	58
Recreation/Entertainment	2.3	190.1	15.1%	13.3%	81.3
Social	0.7	76.6	4.4%	5.4%	114.8
Sleep	1.0	485.9	6.9%	34.0%	479.1
¹ Number of activities in this group per person per day ² Minutes spent on activities in this group per person per day ³ Percent of events (per person) in this group over total number of events done in the entire week ⁴ Percent of time (per person) spent on activities in this group in the entire week ⁵ Average duration per event in this group (Daily average time / average number)					

Table 9 Time Allocation on Different Functional Classes of Activities

Table 10 shows the allocation of time by types of participants. Here the participants are those persons who directly interacted with the actors during activities. At the first glance, it seems surprising that 'alone' activities constituted such a great proportion of one's time budget yet the average duration of each event was not the greatest among all types. This is because majority of work/school activities were recorded as 'alone'. Rest of the 'alone' activities were mostly short and frequent maintenance activities. Activities performed with people outside of households (i.e., others and both) were longer in average duration but less frequent than those done alone or with family members exclusively. Majority of the activities performed exclusively with others were work/school-related, whereas most of those done with both family members and other people were social events. This explains their long average duration

and low frequency. Activities done exclusively with family members were the shortest in average duration yet they were fairly frequent. Maintenance and recreation/entertainment activities constituted the major proportion of this category.

Participant type	Daily average events	Daily average time (min)	Weekly percent of events	Weekly percent of time	Average duration (min)
Alone	8.1	551.2	53.4%	38.6%	67.9
Others	0.7	81.9	4.5%	5.7%	125.3
Members	4.9	252.2	30.9%	17.7%	51.0
Both	0.6	56.6	4.4%	4.0%	88.6

Table 10 Time Allocation on Activities with Different Participants

Table 11 summarizes time allocated on activities occurring at different locations. Activities occurring at home were short yet they occupied a large proportion of time. The substantial amount of time spent at home is likely a special feature of the sample, which consists of students living very close to campus. There were many short journeys back home for lunch or dinner throughout weekdays. Moreover, most of the students also worked at home. An average adult spent approximately eight hours at home per day (i.e., excluding sleep) but each event lasted for only about an hour. This reflects the fact that in-home activities can be easily fragmented to adjust for constraints imposed by other events. On the contrary, out-of-home activities had longer average duration but were much less frequent than in-home activities. They are often the constraints in scheduling of activities.

Locations	Daily average events	Daily average time (min)	Weekly percent of events	Weekly percent of time	Average duration (min)
Home (excluding sleep)	8.2	500.3	52.7%	35.1%	61.1
Out-of-home (excluding travel)	2.9	377.5	19.5%	26.4%	130.2

Table 11 Time Allocation on In-home and Out-of-home Activities

Table 12 shows the functional allocation of time on different days of the surveying week. Each cell contains the average minutes each respondent spent on that category of activities. There is no dramatic increase or decrease in participation level for all types of activities during weekdays. The only notable exception is work/school activities on Tuesday and Thursday, on which most classes were scheduled. The surge in minutes happened on Friday and/or Saturday for all types of activities, except for work/school that declined as expected. Maintenance and recreation/entertainment remained at a consistent participation level during weekdays and increased only marginally during weekend. However, on weekend, time spent on social event increased more than twice the weekday level and peaked on Sunday when most religious events took place. Note that the group containing shopping activities also includes services and errands. This helps to explain the small number of minutes spent on this category on Sunday, because services are generally not available on the day.

Activity class	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Maintenance (excluding sleep)	234.7	247.6	256.6	252.5	241.2	279.0	264.6
Work/School	381.1	422.8	388.9	392.9	327.8	175.1	129.0
Shopping/ Services	30.0	16.9	30.6	25.1	32.5	88.4	26.7
Recreation Entertainment	183.8	160.7	169.0	186.1	199.3	211.9	221.3
Social	47.4	38.7	45.5	33.7	94.7	109.2	184.8

Table 12 Time Allocation on Different Days of the Week

5.3 Structure of Activity Patterns

After examining respondents' time allocation, activity classes accounting for major portion of individuals' time budgets can be generally divided into two groups: (1) short and frequent (i.e., 3 to 5 times a day) and (2) long and consistent (i.e., once to twice a day). Maintenance, recreation, with-family, and in-home activities belong in the former group, while work/school, with-others, and out-of-home fall into the latter. It can be hypothesized that short events might have shorter planning period, or ultimately spontaneous. For example, they could be left unscheduled before a day began and later opportunistically fitted into a schedule pre-arranged with other constraining events (e.g., events with long duration) as the day evolved. Reasoning behind this hypothesis is that, since if it requires only a small amount of time to complete, there usually would be several free time windows available for such activities. Individuals can wait for the opportunities when they are free from other engagement. In addition, it could also be that some activities are just naturally spontaneous in a specific time and locations. For example, while at home, it is very natural for someone to turn on television and watch for

half an hour without thinking about it. It is reasonable to expect that short events are of this nature, because it is not likely that someone would spontaneously do something for a few hours without being broken by other constraints, unless there is a long, continuous period of free time available (e.g., in the evening or weekend). The presence and type of participants may also be factors affecting an event's duration and scheduling horizon. For example, it has been found in time allocation analysis that average duration of events with family members was shorter than those with others. When family members were present, the number of constraints needed to be coordinated increased. This may have directly resulted in more short events throughout the days of couples.

The above hypotheses and propositions can be tested by directly examining the relationships between characteristics of an activity and the time horizon when decision of undertaking it was made. To achieve this goal, a variable identifying the scheduling horizon is needed.

5.3.1 Index of Scheduling Horizon

Data collected in the REACT! pilot study contains essential information for identification of activity scheduling horizon. In this empirical analysis of scheduling structure, an ordinal variable with four levels, indexing how far ahead the decisions of participating in activities were made, was extracted from the pilot data:

- (1). Spur of the moment
- (2). Within day planning
- (3). Within week planning

(4). Before the week planning

Explanation of each level is described in descending order, which is also the temporal order by which activity records were entered. First, events labeled as "Before the week planning" are those entered on the beginning Sunday. These activities were likely being repeated every week. It is reasonable to treat them as having the most distant scheduling horizon for they had been recognized and structured before other events. Events counted as "Within week planning" were those known at least one day before they were performed, but not necessarily as early as the first Sunday. The above two levels correspond to activities that were entered in the Weekly Calendar (i.e., they were known at least a day before). When an activity was entered on the Daily Calendar after it was done (i.e., it was never entered in the Weekly Calendar before), the respondents were asked about the short-term decision timing of undertaking this activity (see Figure 23 for details). "Within Day planning" level corresponds to decision timing of "earlier in the day", while "Spur-of-the-moment" level contains those of "right before the activity", "right after the previous activity", or "during previous activity". Although these two levels of planning were both performed within the same day, the difference is that one is largely spontaneous and the other might have minimal level of planning involved.

It is important to note that the terms 'planning horizon' and 'scheduling horizon' used in this analysis* do not necessarily suggest that people at all time consciously think about when to do each activity. They were merely used to denote the advance horizon at which the occurrence of each activity was known and expected. Underlying the categorization of the planning levels is a continuous variable measuring time interval

* The terms "schedule" and "plan" are used interchangeably in this chapter. Neither suggests whether an activity was consciously planned or not.

between an event's first entering the overall scheduling flow and its finally execution. The higher the order is the earlier it enters the structure. Interpretation of each level should not be strictly based on the literal meanings of its label. For example, "before the week" event is not necessarily planned a week ahead of other events. However, it was earlier than events of other levels. In general, activities with more distant horizons constitute the constraints around which other activities were arranged in time and space. For example, people would not necessarily think about that they have to go to work on weekdays. However, the occurrence of work activities is always expected and other activities seem to be structured around work activities.

5.3.3 Contingency Tables of Scheduling Horizon

The scheduling horizon variable is used to examine the overall scheduling structure in terms of which activities anchored the schedules and which ones were opportunistically filled in. Here the units of analysis are activities. Because that the variables under examination are mostly categories (e.g., planning levels, type of involved persons, and location in terms of in-home or out-of-home), contingency tables are used to explore the relationship between an activity's planning horizon and its characteristics. Two-way contingency tables are used first to directly examine the relationship between an event's scheduling horizon and other attributes. Three-way tables are then used to extend the analysis and ensure that the revealed two-way relationships are not entirely due to either a single factor (e.g., the activity being work/school), or a third factor such as demographic status of the actor. It is noted that basic activities and travel are not included in the analysis. In addition, sometimes respondents indicated that they did not know or

remember the decision timing of certain activities. The scheduling horizons of these activities were labeled as 'missing'.

5.3.3.1 Two-Way Contingency Tables

Table 13 tabulates the number of activities (of various functional classes) that fall into each planning category. For each activity class, there are two numbers presented under each planning category. The one on the left is the number of events in that category. On the right is the proportion of events, of the same activity type, planned within this horizon. The proportion is derived by dividing the cell count with the corresponding row sum. The row order of this table is arranged so that proportion of “spur-of-the-moment” increases and that of before-week decreases, except for social events whose spur-of-the-moment ratio is not in order. The Pearson goodness-of-fit statistics (χ^2) is large enough to reject the null hypothesis that the observed cell counts are the same as those produced by chance (see Wickens, 1989 for details), which essentially indicates the two factors (activity type vs. planning horizon) in this table are not independent of each other.

Activity Class	Spur		Within day		Within week		Before week		Missing		Total
Work School	200*	23.09%*	65	7.51%	182	21.02%	376	43.42%	43	4.97%	866
Social	129	38.74%	32	9.61%	42	12.61%	116	34.83%	14	4.20%	333
Shopping Services	113	36.81%	40	13.03%	32	10.42%	100	32.57%	22	7.17%	307
Maintenance	304	36.85%	50	6.06%	168	20.36%	196	23.76%	107	12.97%	825
Recreation/ Entertainment	689	59.50%	47	4.06%	140	12.09%	202	17.44%	80	6.91%	1158
Total	1435	41.13%	234	6.71%	564	16.17%	990	28.37%	266	7.62%	3489
Goodness of fit statistics											
Null Hypothesis				Pearson χ^2			Degree of Freedom (DF)		Significance (Sig)		
Complete independence				369.422			12		0.00		

*

Number of events In the category (N)	Row total
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Note: The same cell arrangement applies to all of the following tables.

Table 13 Two-way Table of Activity Class and Scheduling Horizon

Overall, approximately 41 percent of all events were spur-of-the-moment. Together with within-day planning, events entered on the execution days accounted for 47 % of all events. Events known before the execution day (i.e., before-week and within-week) accounted for 45% of all events (i.e., another 8% were missing). Work/school activities were mostly (43.42%) planned on the first Sunday evening or at least a day before (21.02%). It is surprising to see that a certain portion of work/school events (23.09%) was spontaneous. Note that this functional class includes school activities. School-related events, such as studying, usually happen whenever students have time available. Except for work, most activities were relatively impulsive. However, the

overall frequency distribution does not seem to contradict one's expectation. For example, approximately half of the social events were known before the day (i.e., including before-week and within-week). It is reasonable to expect such distribution, since church and religious events were within this functional class. When comparing with other activity classes, shopping/services class contains a relatively higher proportion of within-day planning events. This tendency can be expected, since most activities within this class require out-of-home trips. People might have to wait for a suitable time window to carry out the events. Recreation and entertainment events had the highest degree of impulsiveness among all types of activities. Majority of activities within this class such as watching TV, browsing the Web, and relaxation/rest are naturally spontaneous.

The following series of tables examine the relationships between an activity's scheduling horizon and other attributes. Tables 14 shows how planning horizon varies across events with different duration. Events over 180 minutes were deliberately separated as a group to show that long events did have higher chance of being planned early.

Duration (t)	Spur		Within day		Within week		Before week		Missing		Total
t ≤ 60 min	857	47.06	100	5.49%	264	14.50	438	24.05	162	8.90	1821
60 min < t ≤ 180 min	485	39.92	99	8.15%	206	16.95	339	27.90	86	7.08	1215
t > 180 min	93	20.53	35	7.73%	94	20.75	213	47.02	18	3.97	453
Total	1435	41.13	234	6.71%	564	16.17	990	28.37	266	7.62	3489
Goodness of fit statistics											
Null Hypothesis		Pearson χ^2			DF			Sig.			
Complete independence		143.6365			6			0			

Table 14 Two-way Table of Activity Duration and Scheduling Horizon

Table 14 clearly demonstrates that activity with longer duration was usually planned within a more distant horizon. As duration of an event increased, the chance for it to be planned before week or within week increased, and that of being spur-of-the-moment decreased. This supports the earlier hypothesis stipulating that events with short duration are more likely to be impulsive. Table 15 crosses involved persons with planning horizon. Whenever people other than household members were involved in an event, the event would be categorized as "Others", regardless if family members were involved. Activities done with family members were most likely to be impulsive, since these activities are mostly maintenance or recreation oriented. This is consistent with the findings in time allocation analysis where this type of events was found to be short and frequent, a pattern that has been shown to have higher chance of being spontaneous.

Participant	Spur		Within day		Within week		Before week		Missing		Total
Alone	840	41.92%	131	6.54%	296	14.77%	587	29.29%	150	7.49%	2004
Household Members only	485	44.25%	74	6.75%	192	17.52%	258	23.54%	87	7.94%	1096
Others	110	28.28%	29	7.46%	76	19.54%	145	37.28%	29	7.46%	389
Grand Total	1435	41.13%	234	6.71%	564	16.17%	990	28.37%	266	7.62%	3489
Goodness of fit statistics											
Null Hypothesis			Pearson χ^2			DF			Sig.		
Complete independence			45.77385			6			3.283866e-008		

Table 15 Two-way Table of Activity Participant and Scheduling Horizon

“Alone” events also have strong tendency of being impulsive. However, alone events contain work/school activities. They have a slightly higher proportion of before-week planning than those with family members. Events done with others are the most likely being planned in advance. This is also consistent with the previous finding that “Others” tend to be long and consistent. Table 16 tests if being in-home increased or decreased the chance of doing spur-of-the-moment events. It should not be surprised to see that most in-home activities were spontaneous and out-of-home events often entered the scheduling structure early. To see if people tend to improvise when they have large time window available, frequency counts of planning horizon against weekend and weekdays were generated (Table 17). As expected, events carried out on weekends contain a higher proportion of spur-of-the-moment and less before-week planning than those done in weekdays.

Location	Spur		Within day		Within week		Before week		Missing		Total
In-Home	1168	52.45%	121	5.43%	323	14.50	414	18.59%	201	9.03%	2227
Out-of-home	267	21.85%	113	9.25%	241	19.72	576	47.14%	65	5.32%	1262
Total	1435	41.13%	234	6.7%	564	16.16	990	28.37%	266	7.62%	3489
Goodness of fit statistics											
Null Hypothesis				Pearson χ^2			DF		Sig.		
Complete independence				418.9036			3		0		

Table 16 Two-way Table of Activity Location and Scheduling Horizon

Location	Spur		Within Day		Within week		Before week		Missing		Total
Weekday	1016	39.03%	159	6.11%	422	16.21	808	31.04%	198	7.61%	2603
Weekend	419	47.29%	75	8.47%	142	16.03	182	20.54%	68	7.67%	886
Total	1435	41.13%	234	6.71%	564	16.17	990	28.37%	266	7.62%	3489
Goodness of fit statistics											
Null Hypothesis				Pearson χ^2			DF		Sig.		
Complete independence				42.14632			3		3.735284e-009		

Table 17 Two-way Table of Day of the Week and Scheduling Horizon

In next three tables, the association between event actors' demographics on scheduling structure is examined. First, planning horizons of events were categorized by gender of the actors (Table 18). The table shows that female tend to be more organized than male by laying out more events in advance and being less impulsive throughout the week. Although the goodness-of-fit statistics is not as large as those in previous tables, it still rejects the null hypothesis (i.e., factors are independent) at 5% significance level. Table 19 shows how marital status of the actors related to events' planning horizon. Couples with no children tend to act more impulsive than others while single persons

tend to know what they were going to do in advance. Couples with children did not have the luxury of acting freely, however, they seemed to leave longer term plans open and operate their days within middle-ranged planning horizon. The pattern shown in this table is very similar to the relationship between involved persons and planning horizon (see Table 15). Finally, Table 20 tests if the employment status of a person affected how events were planned. The table shows that employed persons tend to be less impulsive. The proportion of before-week events is almost identical for both groups, but employed persons showed more structure in within-week category.

Gender	Spur		Within Day		Within week		Before week		Missing		Total
Male	670	43.3%	123	7.9%	266	17.2%	416	26.9%	73	4.7%	1548
Female	765	39.4%	111	5.7%	298	15.4%	574	29.6%	193	9.9%	1941
Total	1435	41.14%	234	6.71%	564	16.17%	990	28.37%	266	7.62%	3489
Goodness of fit statistics											
Null Hypothesis			Pearson χ^2			DF			Sig.		
Complete independence			10.89038			3			0.01233367		

Table 18 Two-way Table of Gender and Scheduling Horizon

Marital Status	Spur		Within Day		Within week		Before week		Missing		Total
Single	161	37.88%	19	4.47%	29	6.82%	186	43.76%	30	7.06%	425
Married no children	866	47.04%	114	6.19%	302	16.4%	465	25.26%	94	5.11%	1841
Married with children	408	33.36%	101	8.26%	233	19.05%	339	27.72%	142	11.61%	1223
Total	1435	41.14%	234	6.71%	564	16.17%	990	28.37%	266	7.62%	3489
Goodness of fit statistics											
Null Hypothesis			Pearson χ^2			DF			Sig.		
Complete independence			111.1041			6			0		

Table 19 Two-way Table of Marital Status and Scheduling Horizon

Employment Status	Spur		Within Day		Within week		Before week		Missing		Total
Employed	831	38.10%	167	7.66%	371	17.01%	618	28.34%	194	8.90%	2181
Unemployed	604	46.18%	67	5.12%	193	14.76%	372	28.44%	72	5.5%	1308
Total	1435	41.14%	234	6.71%	564	16.17%	990	28.37%	266	7.62%	3489
Goodness of fit statistics											
Null Hypothesis			Pearson χ^2			DF			Sig.		
Complete independence			22.15889			3			0.00006044898		

Table 20 Two-way Table of Employment Status and Scheduling Horizon

5.3.3.2 Three-Way Contingency Tables

The analysis of two-way tables verified the hypothesis of activities with shorter duration were more likely to be opportunistically filled in a schedule already anchored by their longer duration counterparts. It has also been found that the situation (e.g., location, involved person, and day of the week) under which the activity occurred was related to its scheduling horizon. Especially, two factors seemed to influence the overall scheduling structure more than other factors. One is whether the activity is work/school-related and

the other is whether it is in-home. Comparing to other activity classes, work/school is the only activity type that has a significant higher proportion of structured events than opportunistic events. There is a concern regarding if the patterns observed in the two-way tables would still hold, when work/school activities were isolated from the analysis. The same concern is applied to the location factor of being in-home or not, because in-home activities were so predominantly impulsive. If in-home activities were to be separated from out-of-home activities, would the patterns revealed in the two-way tables be observed in both groups? More importantly, would the original two factors turn out to be independent when location is presented in the analysis as a third factor? To answer these questions, three-way contingency tables were used to verify the two-way relationships in the presence of a significant third factor. A dichotomous location or activity type variable (i.e., in-home vs. out-of-home, and work/school vs. non-work/school) is to be included in contingency tables as the third factor. For example, events will be further classified into groups of in-home and out-of-home. Attempts will be made to assess if duration, involved persons, and day of the week still relate, in the same way, to planning horizon in both groups. Moreover, actors' employment and marital status will also enter the three-way tables to verify that the patterns are not entirely attributed to the actors' background.

In a two-way table, there is only one way to describe the relationship: either the rows and columns of the table are associated or they are not. A three-way table offers multiple ways (each is referred to as a model) of describing the inter-relationship among the three factors:

- (1). Complete independence: The three factors classified in the table are completely dissociated. The classification of any factor has no effect on the classification of any other factor or combinations of any other two factors.
- (2). One-factor independence: One of the factors in the table is independent from the other two. Hypothesis testing of one-factor independence can be performed for any one of the three factors.
- (3). Conditional independence: Two factors in the table are conditionally independent from the third. For example, A is associated with B and B is associated with C, but A and C have no association. In this example, the pair of A and C is said to be conditionally independent from B. Testing of conditional independence also allows for three sub models, with any pair of factors being tested against the third.
- (4). Homogeneous association: This model hypothesizes that there is a relationship between every pair of factors in the table that does not interact with the remaining factor. Simply put, every two factors of the three are related, but they do not interact all together.
- (5). Three-way association (Saturated model): A three-way association takes one step beyond the homogeneous one by assuming additionally every pair of factors interacts with the remaining one. A saturated model has no degree of freedom thus its test statistics are always zero (i.e., the model fits data perfectly). It is the default model with which other models are compared for goodness-of-fit measures (i.e., testing the null hypothesis that the target model is not significantly different from the saturated one).

Hypothesis testing of the three way models are usually accomplished with log-linear models, which hypothesize that the logarithm of the expected frequency of a particular cell is a linear combination of the associated row and column terms. Except for the saturated, each of the above models can be represented as such a linear combination that is subsequently compared to the saturated one (i.e., a perfect fit that in reality does not exist) for goodness-of-fit statistics*.

The following series of tables present the analysis results. These tables can be divided into four groups each with a different variable as the third factor, including dichotomous location, dichotomous activity type, actors' employment status, and marital status, respectively. Test statistics of all models are summarized on the bottom half of each table.

5.3.3.2.1 In-home vs. Out-of-home

Table 21 summarized the three-way relationship among location, activity class, and planning horizon. Overall, the two-way pattern between activity class and scheduling horizon (see Table 13) can not be observed in the in-home group. Majority of the in-home events were improvised during the day. Only a small portion of in-home work events were recognized at the beginning of the week. Specifically, intention of working at home was mostly formed and realized throughout the week with a high proportion of

* A complete presentation of the formulation of log-linear models requires extensive elaboration and formal mathematical notations. See Wickens (1989) for such a presentation.

Location	Activity Class	Spur		Within Day		Within week		Before week		Missing		Total
In-Home	Work School	150	40.98%	35	9.56%	76	20.77%	79	21.58%	26	7.10%	366
	Social	100	55.87%	14	7.82%	8	4.47%	49	27.37%	8	4.47%	179
	Maintenance	299	41.07%	41	5.63%	134	18.41%	158	21.70%	96	13.19%	728
	Recreation/ Entertainment	614	65.25%	31	3.29%	104	11.05%	123	13.07%	69	7.33%	941
In-Home Total		1168	52.45%	121	5.43%	323	14.50%	414	18.59%	201	9.03%	2227
Out-of-Home	Work School	50	10.00%	30	6.00%	106	21.20%	297	59.40%	17	3.40%	500
	Social	29	18.83%	18	11.69%	34	22.08%	67	43.51%	6	3.90%	154
	Shop/Services	113	36.8%	40	13.03%	32	10.42%	100	32.57%	22	7.17%	307
	Maintenance	5	5.15%	9	9.28%	34	35.05%	38	39.18%	11	11.34%	97
	Recreation/ Entertainment	75	34.56%	16	7.37%	36	16.59%	79	36.41%	11	5.07%	217
Out-of-Home Total		267	21.16%	113	8.95%	241	19.10%	576	45.64%	65	5.15%	1262
Grand Total		1435	41.13%	234	6.71%	564	16.17%	990	28.37%	266	7.62%	3489
Goodness of fit statistics												
Models*		Independent factor				Pearson χ^2		DF	Sig.			
Complete independence		NA				1896.8088		31	.0000			
Independence of one factor		Activity type				1379.1327		28	4.-273			
		Location				1260.2005		19	1.-255			
		Planning horizon				711.4841		27	1.-132			
Conditional independence		Activity type – Location				1006.2102		16	5.-204			
		Planning horizon – Location				367.6989		15	4.E-69			
		Activity type – planning horizon				318.1183		24	4.E-53			
Homogeneous association		NA				59.4892		12	3.E-08			

*Saturated model is not listed, since its test statistics is always 0.

Table 21 Three-way Table of Location, Activity Class, and Scheduling Horizon

spontaneity. In-home social events were polarized at either spur-of-the-moment improvisation or before-week planning. Phone calls (over 10 minutes) were the major component of the former, while events like hosting visitors were expected early in the week. In the out-of-home group, the overall frequency distribution resembles the structure of the corresponding two-way table (see Table 13), with the exception that both out-of-home maintenance and recreation events have a slightly higher structural (within-

week and before-week) proportion than shopping activities. Out-of-home maintenance events were exclusively pick-up/drop-off passengers. This should explain its high planning proportion. Log-linear analysis of this table indicates that none of the three factors is expected to be independent from the other two. Although no significant model is found, a fitted model is likely one between the homogeneous association and the saturated, which also indicates the highly inter-related bound among the three factors.

The two-way structure of duration and scheduling horizon (see Table 14) is consistent with pattern shown in the out-of-home group of the corresponding three-way table (Table 22). Out-of-home activities with longer duration do have higher tendency of being thought about early and less chance of being improvised through the day. The same pattern is not as distinct in the in-home group. While the proportions of spur-of-the-moment and within-day events did decrease as duration increased, it's the within-week column, rather than the before-week one, that ascends consistently. It can be postulated, based on the findings, that the hypothesized structure between activity duration and planning horizon is also valid for in-home activities, however, the structure operates in a shorter horizon. There is no distinct pattern for longer term planning of in-home events. Test statistics suggested that all three factors are mutually dependent.

Location	Duration	Spur		Within Day		Within Week		Before Week		Missing		Total
In-Home	t ≤ 60 min	693	53.93%	50	3.89%	171	13.31%	246	19.14%	125	9.73%	1285
	60 min < t ≤ 180 min	410	51.96%	56	7.10%	119	15.08%	137	17.36%	67	8.49%	789
	t > 180 min	65	42.48%	15	9.80%	33	21.57%	31	20.26%	9	5.88%	153
In-Home Total		1168	52.45%	121	5.43%	323	14.50%	414	18.59%	201	9.03%	2227
Out-of-Home	t ≤ 60 min	164	30.60%	50	9.33%	93	17.35%	192	35.82%	37	6.90%	536
	60 min < t ≤ 180 min	75	17.61%	43	10.1%	87	20.42%	202	47.42%	19	4.46%	426
	t > 180 min	28	9.33%	20	6.67%	61	20.33%	182	60.67%	9	3.00%	300
Out-of-Home Total		267	21.16%	113	8.95%	241	19.10%	576	45.64%	65	5.15%	1262
Grand Total		1435	41.13%	234	6.71%	564	16.17%	990	28.37%	266	7.62%	3489
Goodness of fit statistics												
Models		Independent factor				Pearson χ^2		DF		Sig.		
Complete independence		NA				850.5558		17		8.-170		
Independence of one factor		Duration				317.9108		14		2.E-59		
		Location				561.5123		11		2.-113		
		Planning horizon				506.7803		15		2.E-98		
Conditional independence		Planning horizon – Location				378.3833		9		6.E-76		
		Duration – Location				140.9578		8		1.E-26		
		Planning horizon – Duration				100.4238		12		5.E-16		
Homogeneous association		NA				37.5084		6		1.E-06		

Table 22 Three-way Table of Location, Duration, and Scheduling Horizon

The three-way scheduling structure of weekday/weekend is presented in Table 23. The pattern is consistent in both in-home and out-of-home groups, with more improvisation and less planning on weekends. Test statistics for one factor independence shows that there is not a single factor can be completely isolated from the other two. However, the relationship between location and day of week is a weak one. Goodness of fit index for the conditional independence of this linkage is significant. This suggests that during the survey respondents did not necessarily do more activities at home on weekends or vice versa. The test for homogeneous association is also highly significant.

The choice of the best-fitted model depends on how one values the lost of one degree of freedom (i.e., from the conditional independence model to the homogeneous one). One might choose the conditional independence model over homogeneous one for parsimonious reason. However, it is noted that the key of the log-linear analysis here is to validate the relationship between planning horizon and event attributes. It clearly demonstrates that both location and day of week are not independent of scheduling horizon.

Location	Day of Week	Spur		Within Day		Within Week		Before Week		Missing		Total
In-Home	Weekday	817	50.84%	78	4.85%	236	14.69%	323	20.10%	153	9.52%	1607
	Weekend	351	56.61%	43	6.94%	87	14.03%	91	14.68%	48	7.74%	620
In-Home Total		1168	52.45%	121	5.43%	323	14.50%	414	18.59%	201	9.03%	2227
Out-of-Home	Weekday	199	19.98%	81	8.13%	186	18.67%	485	48.69%	45	4.52%	996
	Weekend	68	25.56%	32	12.03%	55	20.68%	91	34.21%	20	7.52%	266
Out-of-Home Total		267	21.16%	113	8.95%	241	19.10%	576	45.64%	65	5.15%	1262
Grand Total		1435	41.13%	234	6.71%	564	16.17%	990	28.37%	266	7.62%	3489
Goodness of fit statistics												
Models		Independent factor		Pearson χ^2		DF		Sig.				
Complete independence		NA		489.1774		10		9.E-99				
Independence of one factor		Location		429.5249		7		1.E-88				
		Day of week		52.2583		7		5.E-09				
		Planning horizon		450.3189		9		2.E-91				
Conditional independence		Location – Day of week		10.9813		4		.0268				
		Planning horizon – Location		406.5837		6		1.E-84				
		Planning horizon – Day of week		30.2058		6		4.E-05				
Homogeneous association		NA		.8013		3		.8491				

Table 23 Three-way Table of Location, Day of the week, and Scheduling Horizon

As for the three-way relationship among location, participants, and scheduling horizon (Table 24), the observed frequencies of the out-of-home group are consistent with those of its two-way equivalent, with events done with family members being the most spontaneous and the least planned. There is no significant structure in the in-home group. Only notable feature is the slightly higher proportion of before-week planning for “alone” events, which were basically work or study at home. Events done with family members have an almost identical makeup as those done with “others”. It suggests that while at home respondents did not necessarily structure events differently with regards to who was involved, unless it was work or school related.

Location	Participant	Spur		Within Day		Within Week		Before Week		Missing		Total
In-Home	Alone	707	51.68%	77	5.63%	165	12.06%	298	21.78%	121	8.85%	1368
	Family Members	383	53.72%	35	4.91%	131	18.37%	96	13.46%	68	9.54%	713
	Others	78	53.42%	9	6.16%	27	18.49%	20	13.70%	12	8.22%	146
In-Home Total		1168	52.45%	121	5.43%	323	14.50%	414	18.59%	201	9.03%	2227
Out-of-Home	Alone	133	20.91%	54	8.49%	131	20.60%	289	45.44%	29	4.56%	636
	Family Members	102	26.63%	39	10.18%	61	15.93%	162	42.30%	19	4.96%	383
	Others	32	13.17%	20	8.23%	49	20.16%	125	51.44%	17	7.00%	243
Out-of-Home Total		267	21.16%	113	8.95%	241	19.10%	576	45.64%	65	5.15%	1262
Grand Total		1435	41.13%	234	6.71%	564	16.17%	990	28.37%	266	7.62%	3489
Goodness of fit statistics												
Models		Independent factor		Pearson χ^2		DF		Sig.				
Complete independence		NA		627.1967		17		2.-122				
Independence of one factor		Location		533.6275		11		2.-107				
		Planning horizon		462.3634		15		5.E-89				
		Party		177.6499		14		2.E-30				
Conditional independence		Party – Planning horizon		54.4642		12		2.E-07				
		Planning horizon – Location		429.5691		9		7.E-87				
		Party – Location		115.0613		8		3.E-21				
Homogeneous association		NA		31.3872		6		2.E-05				

Table 24 Three-way Table of Location, Participant, and Scheduling Horizon

5.3.3.2.2 Work vs. Non-work

The following tables (Tables 25, 26, 27, and 28) divide the two-way tables into groups of work and non-work. Table 25 presents the three-way structure of work, dichotomous location, and planning horizon. Consistent structures are observed in both groups of work and non-work. A small variation is found in the within-day column: whereas out-of-home events have higher proportion of within-day planning in the non-work group, in-home events had the higher proportion in work group. This variation is meaningful in that people would think about going out to do some non-work activities or

bring unfinished work back home later in the day. The reverse is usually not true. Not many people would go out to work in the later part of the day. In addition, unless there is a special occasion, most of the time people probably would not think about what they are going to do when they go home. Hypothesis testing validates the dependence of each factor in the overall structure. No factor is statistically independent.

Activity Type	Location	Spur		Within Day		Within Week		Before Week		Missing		Total
Non-work	In-Home	1018	54.70%	86	4.62%	247	13.27%	335	18.00%	175	9.40%	1861
	Out-of-Home	217	28.48%	83	10.89%	135	17.72%	279	36.61%	48	6.30%	762
Non-work Total		1235	47.08%	169	6.44%	382	14.56%	614	23.41%	223	8.50%	2623
Work	In-Home	150	40.98%	35	9.56%	76	20.77%	79	21.58%	26	7.10%	366
	Out-of-Home	50	10.00%	30	6.00%	106	21.20%	297	59.40%	17	3.40%	500
Work Total		200	23.09%	65	7.51%	182	21.02%	376	43.42%	43	4.97%	866
Grand Total		1435	41.13%	234	6.71%	564	16.17%	990	28.37%	266	7.62%	3489
Goodness of fit statistics												
Models		Independent factor		Pearson χ^2		DF		Sig.				
Complete independence		NA		928.7384		10		4.-193				
Independence of one factor		Planning horizon		543.1189		9		3.-111				
		Location		563.2720		7		2.-117				
		Work		364.3541		7		1.E-74				
Conditional independence		Planning horizon – Location		357.7628		6		3.E-74				
		Planning horizon – Work		130.0742		6		1.E-25				
		Location – Work		140.7375		4		2.E-29				
Homogeneous association		NA		35.5660		3		9.E-08				

Table 25 Three-way Table of Work, Location, and Scheduling Horizon

The frequency distribution of duration versus planning horizon (Table 26) in the work groups reveals the expected structure (i.e., the longer the duration the earlier the scheduling horizon). In non-work group, although the structure is not as distinct, the pattern can still be recognized. Events with the longest duration are indeed the least impulsive and the most planned, but the difference between the other two duration categories is marginal. In addition, the before-week proportion of the middle category is slightly less than the shortest one. This suggests that non-work events were mostly improvised during the day. People do not intentionally schedule non-work event unless the duration is of certain length. The homogeneous association formed by the three factors is the most significant model among all.

Table 27 shows how the planning structures of work and non-work events vary across the week. Expected structures are observed in both groups of work and non-work: on weekend there is higher proportion of spur-of-the-moment events and less before-week events. Most of non-work activities were determined during the day, regardless it was weekday or weekend. If there was need for work in the weekend, it was usually recognized within the week, rather than being planned before the week began.

Activity Type	Duration	Spur		Within Day		Within Week		Before Week		Missing		Total
Non-work	t ≤ 60 min	782	47.83%	88	5.38%	231	14.13%	381	23.30%	153	9.36%	1635
	60 min < t ≤ 180 min	391	46.83%	70	8.38%	129	15.45%	183	21.92%	62	7.43%	835
	t > 180 min	62	40.52%	11	7.19%	22	14.38%	50	32.68%	8	5.23%	153
Non-work total		1235	47.08%	169	6.44%	382	14.56%	614	23.41%	223	8.50%	2623
Work	t ≤ 60 min	75	40.32%	12	6.45%	33	17.74%	57	30.65%	9	4.84%	186
	60 min < t ≤ 180 min	94	24.74%	29	7.63%	77	20.26%	156	41.05%	24	6.32%	380
	t > 180 min	31	10.33%	24	8.00%	72	24.00%	163	54.33%	10	3.33%	300
Work Total		200	23.09%	65	7.51%	182	21.02%	376	43.42%	43	4.97%	866
Grand Total		1435	41.13%	234	6.71%	564	16.17%	990	28.37%	266	7.62%	3489
Goodness of fit statistics												
Models		Independent factor				Pearson χ^2		DF		Sig.		
Complete independence		NA				1113.2524		17		5.-226		
Independence of one factor		Work				753.8926		11		1.-154		
		Planning horizon				260.9230		15		7.E-47		
		Duration				706.8397		14		9.-142		
Conditional independence		Work – Planning horizon				136.5977		9		5.E-25		
		Planning horizon – Duration				79.0710		12		6.E-12		
		Duration – Work				495.6480		8		6.-102		
Homogeneous association		NA				27.1544		6		.0001		

Table 26 Three-way Table of Work, Duration, and Scheduling Horizon

Activity Type	Day of Week	Spur		Within Day		Within Week		Before Week		Missing		Total
Non-work	Weekday	853	46.16%	103	5.57%	273	14.77%	456	24.68%	163	8.82%	1848
	Weekend	382	49.29%	66	8.52%	109	14.06%	158	20.39%	60	7.74%	775
Non-work total		1235	47.08%	169	6.44%	382	14.56%	614	23.41%	223	8.50%	2623
Work	Weekday	163	21.59%	56	7.42%	149	19.74%	352	46.62%	35	4.64%	755
	Weekend	37	33.33%	9	8.11%	33	29.73%	24	21.62%	8	7.21%	111
Work total		200	23.09%	65	7.51%	182	21.02%	376	43.42%	43	4.97%	866
Grand Total		1435	41.13%	234	6.71%	564	16.17%	990	28.37%	266	7.62%	3489
Goodness of fit statistics												
Models		Independent factor		Pearson χ^2		DF		Sig.				
Complete independence		NA		358.1225		10		8.E-71				
Independence of one factor		Day of week		125.0876		7		7.E-24				
		Planning horizon		237.6334		9		4.E-46				
		Work		299.0087		7		1.E-60				
Conditional independence		Work – Day of week		91.8359		4		5.E-19				
		Work – Planning horizon		193.0556		6		6.E-39				
		Planning horizon – Day of week		37.6277		6		1.E-06				
Homogeneous association		NA		14.8469		3		.0020				

Table 27 Three-way Table of Work, Day of the week, and Scheduling Horizon

Intuitively one would assume 'alone' events are the most impulsive, since no other persons would constrain the decisions and action. This supposition has not been supported in the previous tables because the category of alone events included work. Table 28 demonstrates that the supposition is indeed a valid one for non-work activities. In the non-work group, the proportion of spur-of-the-moment decreases from top to bottom, which can be considered an increasing order of coupling constraint. The before-week column does not increase in this order, but within-week does show such tendency. Work events with other people involved mostly long term planning, while working along

showed more flexibility in that spur-of-the-moment events constituted a substantial proportion overall.

Activity Type	Participant	Spur		Within Day		Within Week		Before Week		Missing		Total
Non-work	Alone	654	51.01%	74	5.77%	137	10.69%	305	23.79%	112	8.74%	1282
	Family Members	473	44.45%	69	6.48%	190	17.86%	248	23.31%	84	7.89%	1064
	Others	108	38.99%	26	9.39%	55	19.86%	61	22.02%	27	9.75%	277
Non-work total		1235	47.08%	169	6.44%	382	14.56%	614	23.41%	223	8.50%	2623
Work	Alone	186	25.76%	57	7.89%	159	22.02%	282	39.06%	38	5.26%	722
	Family Members	12	37.50%	5	15.63%	2	6.25%	10	31.25%	3	9.38%	32
	Others	2	1.79%	3	2.68%	21	18.75%	84	75.00%	2	1.79%	112
Work total		200	23.09%	65	7.51%	182	21.02%	376	43.42%	43	4.97%	866
Grand Total		1435	41.13%	234	6.71%	564	16.17%	990	28.37%	266	7.62%	3489
Goodness of fit statistics												
Models		Independent factor		Pearson χ^2		DF		Sig.				
Complete independence		NA		757.1295		17		6.-150				
Independence of one factor		Party		512.4965		14		2.-100				
		Planning horizon		303.8909		15		9.E-56				
		Work		697.2015		11		2.-142				
Conditional independence		Work – Party		476.4366		8		8.E-98				
		Planning horizon – Party		107.2373		12		2.E-17				
		Work – Planning horizon		255.6985		9		6.E-50				
Homogeneous association		NA		63.4119		6		9.E-12				

Table 28 Three-way Table of Work, Participants, and Scheduling Horizon

5.3.3.2.3 Employment Status

In addition to the dichotomies of in-home/out-of-home and work/non-work, it is expected that grouping by the actors' demographics such as employment and marital status may also result in meaningful patterns of cell frequencies. The purpose of incorporating demographic status as the third factor in contingency table analysis is to

explore the change in scheduling structure due to characteristics of the actors, particularly constraints inherent to the person's role. The first set of three-way tables incorporates the binary factor of employed/unemployed. Among respondents, 41 of them were employed and 31 were unemployed. The unemployed category contains students who did not hold any sort of work appointments. The decision of keeping them in the unemployed group was based on the observation that most of the employed persons, either student employees or non-students, usually remained at work or school for at least eight hours a day (which was often divided into halves by lunch), while unemployed students did not face time window constraints of this size and thus had more flexibility in terms of scheduling.

The followings four tables (Tables 29, 30, 31, and 32) show the three-way structures with employment status as the third factor. Overall, unemployed persons did show a higher propensity of making impulsive decisions. However, due to the unemployed students in the group, they did not necessarily have fewer constraints than the employed. The participant table (Table 31) shows a sudden drop in the proportion of the before-week events done with family members, because that work events were mostly done alone or with other persons. Test statistics show no one-factor independence is expected in any table, but several of the factor pairs are subject to conditional independence. The linkage between employment status and planning horizon is weak in both duration (Table 29) and location (Table 30) tables. Employment status and day of week (Table 32) is another independent pair.

Employment Status	Duration (t)	Spur		Within Day		Within Week		Before Week		Missing		Total
Not Employed	t <= 60 min	363	50.21%	37	5.12%	93	12.86%	186	25.73%	44	6.09%	723
	60 min < t <= 180 min	210	44.97%	23	4.93%	80	17.13%	129	27.62%	25	5.35%	467
	t > 180 min	31	26.27%	7	5.93%	20	16.95%	57	48.31%	3	2.54%	118
Not Employed Total		604	46.18%	67	5.12%	193	14.76%	372	28.44%	72	5.50%	1308
Employed	t <= 60 min	494	44.99%	63	5.74%	171	15.57%	252	22.95%	118	10.75%	1098
	60 min < t <= 180 min	275	36.76%	76	10.16%	126	16.84%	210	28.07%	61	8.16%	748
	t > 180 min	62	18.51%	28	8.36%	74	22.09%	156	46.57%	15	4.48%	335
Employed Total		831	38.10%	167	7.66%	371	17.01%	618	28.34%	194	8.90%	2181
Grand Total		1435	41.13%	234	6.71%	564	16.17%	990	28.37%	266	7.62%	3489
Goodness of fit statistics												
Models		Independent factor				Pearson χ^2		DF		Sig.		
Complete independence		NA				210.1804		17		3.E-35		
Independence of one factor		Planning horizon				168.4021		15		5.E-28		
		Duration				182.8978		14		2.E-31		
		Employment Status				54.4168		11		1.E-07		
Conditional independence		Employment status – Duration				33.5408		8		5.E-05		
		Employment status – Planning horizon				23.8715		9		.0045		
		Duration – Planning horizon				146.5705		12		3.E-25		
Homogeneous association		NA				7.5880		6		.2699		

Table 29 Three-way Table of Employment Status, Duration, and Scheduling Horizon

Employment Status	Location	Spur		Within Day		Within Week		Before Week		Missing		Total
Not Employed	In-Home	514	56.48	33	3.63%	117	12.86%	182	20.00%	64	7.03%	910
	Out-of-Home	90	22.61	34	8.54%	76	19.10%	190	47.74%	8	2.01%	398
Not Employed Total		604	46.18	67	5.12%	193	14.76%	372	28.44%	72	5.50%	1308
Employed	In-Home	654	49.66	88	6.68%	206	15.64%	232	17.62%	137	10.40	1317
	Out-of-Home	177	20.49	79	9.14%	165	19.10%	386	44.68%	57	6.60%	864
Employed Total		831	38.10	167	7.66%	371	17.01%	618	28.34%	194	8.90%	2181
Grand Total		1435	41.13	234	6.71%	564	16.17%	990	28.37%	266	7.62%	3489
Goodness of fit statistics												
Models		Independent factor		Pearson χ^2		DF		Sig.				
Complete independence		NA		470.6583		10		8.E-95				
Independence of one factor		Employment status		45.6596		7		1.E-07				
		Planning horizon		435.5915		9		3.E-88				
		Location		439.5843		7		8.E-91				
Conditional independence		Planning horizon – Location		416.2986		6		9.E-87				
		Employment status – Location		23.4007		4		.0001				
		Employment status – Planning horizon		18.4002		6		.0053				
Homogeneous association		NA		4.5909		3		.2043				

Table 30 Three-way Table of Employment Status, Location, and Scheduling Horizon

Employment Status	Participant	Spur		Within Day		Within Week		Before Week		Missing		Total
Not Employed	Alone	371	46.73	33	4.16%	127	15.99%	210	26.45%	53	6.68%	794
	Family Members	199	48.07	25	6.04%	49	11.84%	125	30.19%	16	3.86%	414
	Others	34	34.00	9	9.00%	17	17.00%	37	37.00%	3	3.00%	100
Not Employed Total		604	46.18	67	5.12%	193	14.76%	372	28.44%	72	5.50%	1308
Employed	Alone	469	38.76	98	8.10%	169	13.97%	377	31.16%	97	8.02%	1210
	Family Members	286	41.94	49	7.18%	143	20.97%	133	19.50%	71	10.41%	682
	Others	76	26.30	20	6.92%	59	20.42%	108	37.37%	26	9.00%	289
Employed Total		831	38.10	167	7.66%	371	17.01%	618	28.34%	19	8.90%	2181
Grand Total		1435	41.13	234	6.71%	564	16.17%	990	28.37%	26	7.62%	3489
Goodness of fit statistics												
Models		Independent factor		Pearson χ^2		DF		Sig.				
Complete independence		NA		123.1060		17		4.E-18				
Independence of one factor		Party		98.4388		14		9.E-15				
		Planning horizon		96.9016		15		5.E-14				
		Employment status		74.0262		11		2.E-11				
Conditional independence		Employment status – Planning horizon		51.3891		9		6.E-08				
		Employment status – Party		53.0757		8		1.E-08				
		Party – Planning horizon		75.2957		12		3.E-11				
Homogeneous association		NA		33.2810		6		9.E-06				

Table 31 Three-way Table of Employment Status, Participant, and Scheduling Horizon

Employment Status	Day of Week	Spur		Within Day		Within Week		Before Week		Missing		Total
Not Employed	Weekday	446	44.91%	47	4.73%	150	15.11%	294	29.61%	56	5.64%	993
	Weekend	158	50.16%	20	6.35%	43	13.65%	78	24.76%	16	5.08%	315
Not Employed Total		604	46.18%	67	5.12%	193	14.76%	372	28.44%	72	5.50%	1308
Employed	Weekday	570	35.40%	112	6.96%	272	16.89%	514	31.93%	142	8.82%	1610
	Weekend	261	45.71%	55	9.63%	99	17.34%	104	18.21%	52	9.11%	571
Employed Total		831	38.10%	167	7.66%	371	17.01%	618	28.34%	194	8.90%	2181
Grand Total		1435	41.13%	234	6.71%	564	16.17%	990	28.37%	266	7.62%	3489
Goodness of fit statistics												
Models		Independent factor			Pearson χ^2		DF		Sig.			
Complete independence		NA			72.8397		10		1.E-11			
Independence of one factor		Employment status			31.0210		7		6.E-05			
		Day of week			50.8764		7		1.E-08			
		Planning horizon			70.8632		9		1.E-11			
Conditional independence		Day of week – Planning horizon			48.7067		6		9.E-09			
		Employment status – Planning horizon			29.5733		6		5.E-05			
		Employment status – Day of week			8.8297		4		.0655			
Homogeneous association		NA			7.1721		3		.0666			

Table 32 Three-way Table of Employment Status, Day of Week, and Scheduling Horizon

5.3.3.2.4 Marital Status

The following tables (Tables 33, 34, 35, and 36) further separate the two-way tables into three marital status groups: single, married with no children, and married with children. Similar to employment status groups, the structure of each table is consistent with previous tables. Only notable exception is the duration table (Table 36), in which the middle duration group contains a smaller proportion of before-week events and a larger spur-of-the-moment than the group with the shortest duration. A similar pattern also appears in the non-work group presented before (see Table 26). The similarity is likely due to the unemployed homemakers in the married-with-children group. No

independence of any form is found when marital status is presented as the third factor. It suggests marital status is indeed an important role factor of the overall scheduling structure.

Marital Status	Activity Type	Spur		Within Day		Within Week		Before Week		Missing		Total
Single	Non-work	119	42.35	10	3.56%	16	5.69%	113	40.21%	23	8.19%	281
	work	42	29.17	9	6.25%	13	9.03%	73	50.69%	7	4.86%	144
Single Total		161	37.88	19	4.47%	29	6.82%	186	43.76%	30	7.06%	425
Married No Children	Non-work	757	55.74	87	6.41%	170	12.52%	272	20.03%	72	5.30%	1358
	work	109	22.57	27	5.59%	132	27.33%	193	39.96%	22	4.55%	483
MNC Total		866	47.04	114	6.19%	302	16.40%	465	25.26%	94	5.11%	1841
Married With Children	Non-work	359	36.48	72	7.32%	196	19.92%	229	23.27%	128	13.01	984
	work	49	20.50	29	12.13	37	15.48%	110	46.03%	14	5.86%	239
MWC Total		408	33.36	101	8.26%	233	19.05%	339	27.72%	142	11.61	1223
Grand Total		1435	41.13	234	6.71%	564	16.17%	990	28.37%	266	7.62%	3489
Goodness of fit statistics												
Models		Independent factor		Pearson χ^2		DF		Sig.				
Complete independence		NA		392.6610		17		6.E-73				
Independence of one factor		Work		279.9835		11		1.E-53				
		Planning horizon		362.2428		15		6.E-68				
		Marital status		195.9284		14		4.E-34				
Conditional independence		Marital status – Work		82.8191		8		1.E-14				
		Marital status – Planning horizon		165.9744		12		3.E-29				
		Work – Planning horizon		250.6215		9		7.E-49				
Homogeneous association		NA		44.1575		6		7.E-08				

Table 33 Three-way Table of Marital Status, Work, and Scheduling Horizon

Marital Status	Location	Spur		Within Day		Within Week		Before Week		Missing		Total
Single	In-Home	131	45.49%	8	2.78%	15	5.21%	111	38.54%	23	7.99%	288
	Out-of-Home	30	21.90%	11	8.03%	14	10.22%	75	54.74%	7	5.11%	137
Single Total		161	37.88%	19	4.47%	29	6.82%	186	43.76%	30	7.06%	425
Married No Children	In-Home	715	62.01%	59	5.12%	153	13.27%	150	13.01%	76	6.59%	1153
	Out-of-Home	151	21.95%	55	7.99%	149	21.66%	315	45.78%	18	2.62%	688
MNC Total		866	47.04%	114	6.19%	302	16.40%	465	25.26%	94	5.11%	1841
Married With Children	In-Home	322	40.97%	54	6.87%	155	19.72%	153	19.47%	102	12.98%	786
	Out-of-Home	86	19.68%	47	10.76%	78	17.85%	186	42.56%	40	9.15%	437
MWC Total		408	33.36%	101	8.26%	233	19.05%	339	27.72%	142	11.61%	1223
Grand Total		1435	41.13%	234	6.71%	564	16.17%	990	28.37%	266	7.62%	3489
Goodness of fit statistics												
Models		Independent factor		Pearson χ^2		DF		Sig.				
Complete independence		NA		574.6897		17		3.-111				
Independence of one factor		Planning horizon		573.8804		15		1.-112				
		Location		481.1501		11		3.E-96				
		Marital status		183.5927		14		1.E-31				
Conditional independence		Marital status – Location		60.5425		8		4.E-10				
		Marital status – Planning horizon		175.1122		12		4.E-31				
		Planning horizon – Location		474.4526		9		2.E-96				
Homogeneous association		NA		38.6544		6		8.E-07				

Table 34 Three-way Table of Marital Status, Location, and Scheduling Horizon

Marital Status	Day of Week	Spur		Within Day		Within Week		Before Week		Missing		Total
Single	Weekday	111	35.24%	15	4.76%	24	7.62%	139	44.13%	26	8.25%	315
	Weekend	50	45.45%	4	3.64%	5	4.55%	47	42.73%	4	3.64%	110
Single Total		161	37.88%	19	4.47%	29	6.82%	186	43.76%	30	7.06%	425
Married No Children	Weekday	620	45.06%	75	5.45%	222	16.13%	385	27.98%	74	5.38%	1376
	Weekend	246	52.90%	39	8.39%	80	17.20%	80	17.20%	20	4.30%	465
MNC Total		866	47.04%	114	6.19%	302	16.40%	465	25.26%	94	5.11%	1841
Married With Children	Weekday	285	31.25%	69	7.57%	176	19.30%	284	31.14%	98	10.75%	912
	Weekend	123	39.55%	32	10.29%	57	18.33%	55	17.68%	44	14.15%	311
MWC Total		408	33.36%	101	8.26%	233	19.05%	339	27.72%	142	11.61%	1223
Grand Total		1435	41.13%	234	6.71%	564	16.17%	990	28.37%	266	7.62%	3489
Goodness of fit statistics												
Models		Independent factor				Pearson χ^2		DF		Sig.		
Complete independence		NA				159.7840		17		3.E-25		
Independence of one factor		Planning horizon				159.0508		15		4.E-26		
		Day of week				51.5557		11		3.E-07		
		Marital status				123.9350		14		1.E-19		
Conditional independence		Marital status – Planning horizon				121.7499		12		3.E-20		
		Marital status – Day of week				10.6848		8		.2202		
		Planning horizon – Day of week				51.0562		9		7.E-08		
Homogeneous association		NA				8.0804		6		.2323		

Table 35 Three-way Table of Marital Status, Day of the Week, and Scheduling Horizon

Marital Status	Duration	Spur		Within Day		Within Week		Before Week		Missing		Total
Single	t <= 60 min	98	44.55%	10	4.55%	10	4.55%	85	38.64%	17	7.73%	220
	60 min < t <= 180 min	47	32.64%	4	2.78%	13	9.03%	71	49.31%	9	6.25%	144
	t > 180 min	16	26.23%	5	8.20%	6	9.84%	30	49.18%	4	6.56%	61
	Single Total	161	37.88%	19	4.47%	29	6.82%	186	43.76%	30	7.06%	425
Married No Children	t <= 60 min	528	56.71%	49	5.26%	114	12.24%	184	19.76%	56	6.02%	931
	60 min < t <= 180 min	285	42.60%	51	7.62%	129	19.28%	173	25.86%	31	4.63%	669
	t > 180 min	53	21.99%	14	5.81%	59	24.48%	108	44.81%	7	2.90%	241
	MNC Total	866	47.04%	114	6.19%	302	16.40%	465	25.26%	94	5.11%	1841
Married With Children	t <= 60 min	231	34.48%	41	6.12%	140	20.90%	169	25.22%	89	13.28%	670
	60 min < t <= 180 min	153	38.06%	44	10.95%	64	15.92%	95	23.63%	46	11.44%	402
	t > 180 min	24	15.89%	16	10.60%	29	19.21%	75	49.67%	7	4.64%	151
	MNC Total	408	33.36%	101	8.26%	233	19.05%	339	27.72%	142	11.61%	1223
Grand Total		143	41.13%	234	6.71%	564	16.17%	990	28.37%	266	7.62%	3489
Goodness of fit statistics												
Models		Independent factor				Pearson χ^2		DF		Sig.		
Complete independence		NA				306.1209		28		1.E-48		
Independence of one factor		Marital status				167.3769		22		2.E-24		
		Planning horizon				304.6883		24		2.E-50		
		Duration				197.9036		22		3.E-30		
Conditional independence		Duration – Planning horizon				195.2256		18		9.E-32		
		Duration – Marital status				54.2417		16		5.E-06		
		Planning horizon – Marital status				162.5285		18		3.E-25		
Homogeneous association		NA				46.4868		12		6.E-06		

Table 36 Three-way Table of Marital Status, Duration, and Scheduling Horizon

5.4 Structure of Initial Activity Plans

According to Meyer and Rebok (1985), everyday problem solving requires both planning and acting in a continuous, dynamic fashion. Prior to execution, initial plans are only partially elaborated. Problem solvers would later dynamically fill in all the details and even modified the initial plans based on the constraints and feedback derived from action. Such a dynamic process also applies to everyday activity scheduling. Each daily activity schedule, viewed as an instance of an everyday problem, is the result of the dynamic decision-making process that involves planning and improvisation in a domain with spatial and temporal constraints. This supposition is supported by the findings of the planning horizon analysis that shows the planned and opportunistic portions of activity patterns. However, if the execution of each event is viewed as a specific problem to be solved, certain attributes of a planned event might be only partially elaborated prior to execution. It is reasonable to expect people would left certain details of an activity plan open for flexibility in scheduling and also as a means of reducing cognitive planning effort. There are also the cases in which the certain details were simply unknown at the time. Investigating what elements of the initial activity plans were unspecified would dramatically enhance our understanding of the dynamic scheduling process. For each planned event (i.e., before-week and within-week), REACT! retained its original elaboration, as well as all the modification steps, in addition to its final outcome. The following series of tables show what elements of activity plans were undetermined before execution. 1432 initial activity plans entered before and within the surveying week by the 72 respondents were recorded. Initial plans of 122 events were missing, because

respondents indicated that they knew these activities before the day but they forgot to entered. Table 37 shows that almost half (46%) of the initial plans do not contain execution time or date (Any Day). Especially, shopping/services activities were the most often left unspecified among all types of activities. Contrarily, whenever respondents put down an activity plan, the location was usually known (Table 38). Less than 10 % of activity plans lack locational information, with shopping and recreation activities being the only activity type with over 10% of un-determination rate. Among the 1316 events with known locations, only 42 of them were eventually carried out at a different location than that of the initial plans. A general structure of the dynamic scheduling process can be inferred by summarizing these findings: individuals are more likely to adjust timing of events so they could do activities at the intended locations, which could be required or simply preferred.

Activity Class	Time Undetermined		Time Determined		Total
Maintenance	179	56.11%	140	43.89%	319
Work school	109	22.47%	376	77.53%	485
Shop Services	116	72.96%	43	27.04%	159
Recreation Entertainment	170	54.66%	141	45.34%	311
Social	78	49.37%	80	50.63%	158
Total	652	45.53%	780	54.47%	1432

Table 37 Elaboration of Execution Time Plans

Activity Class	Location Undetermined		Location Determined		Total
Maintenance	13	4.08%	306	95.92%	319
School/Work	20	4.12%	465	95.88%	485
Shop/Services	28	17.61%	131	82.39%	159
Recreation/Entertainment	42	13.50%	269	86.50%	311
Social	13	8.23%	145	91.77%	158
Total	116	8.10%	1316	91.90%	1432

Table 38 Elaboration of Location Plans

Table 39 shows the distribution of activity plans with respect to participants. Overall, there were more 'alone' plans than 'with company'. Work/school plans are the main reason for the higher proportion in the alone column. Other than this, the entire table is close to evenly distributed, suggesting no significant structure with regards to plans and involved persons.

Activity Class	Alone		With companies		Total
Maintenance	156	48.90%	163	51.10%	319
School/Work	401	82.68%	84	17.32%	485
Shop/Services	64	40.25%	95	59.75%	159
Recreation/Entertainment	160	51.45%	151	48.55%	311
Social	74	46.84%	84	53.16%	158
Total	855	59.71%	577	40.29%	1432

Table 39 Planned Participants

A unique feature of REACT! is the capability of recording plans with undetermined date. If respondents knew they would do certain activities during the surveying week, but the exact date has yet to be determined, they would indicate these

activities as "Any Day". Table 40 shows the distribution of plans across the intended days of the week. The distribution is very similar to the one that summarizes time allocation of final events (see Table 12). Planning rate of each activity class usually zigzags throughout weekdays with major fluctuation occurring on weekends. Shopping and recreation were more likely to be left on the "Any Day" column than other activity types, suggesting their lower priority in general scheduling scenarios.

Activity Class	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Any Day	Total
Maintenance	42 13.2	35 11.0%	42 13.2%	50 15.7	45 14.1%	40 12.5	40 12.5	25 7.8%	319
School Work	82 16.9	92 19.0%	92 19.0%	88 18.1	80 16.5%	28 5.8%	12 2.5%	11 2.3%	485
Shop Services	25 5.7	8 5.0%	15 9.4%	6 3.8%	11 6.9%	35 22.0	6 3.8%	53 33.3	159
Recreation									
Entertainment	45 14.5	37 11.9%	40 12.9%	40 12.9	49 15.8%	35 11.3	29 9.3%	36 11.6	311
Social	14 8.9%	16 10.1%	19 12.0%	13 8.2%	24 15.2%	20 12.7	38 24.1	14 8.9%	158
Total	208 14.5	18 13.1%	208 14.5%	197 13.8	209 14.6%	158 11.0	125 8.7%	139 9.7%	1432

Table 40 Intended Day of the Week

5.5 Structure of Travel Patterns

The lack of treatment for multi-sojourn travel (i.e., trip-chain) in trip-distribution models has been regarded as one of the most serious drawback of the conventional travel demand models. Various theoretical and analytic methods have been proposed to tackle trip-chaining behavior. Most of these models (e.g., Adler and Ben-Akiva, 1979; Kitamura, 1984) rely on utility theory to produce "optimum" travel patterns as results of individuals' utility maximization. The most often cited critique of utility-based models is their strong assumption on individuals' capability of making perfect decision that optimizes their internal utility, usually represented by a function of expenditure for

activity participation and travel. When applied to analysis of trip-chaining behavior, utility approach is subject to another strong assumption: elements of a trip-chain (tour), such as the number of sojourns (stops), the type of activity at each stop, and sequencing of the stops, are determined simultaneously. Although this assumption results in practical models, its deviation from real behavior has never been investigated. In this section, all out-of-home activities are grouped into tours to investigate the mechanism of trip-chain formation. By examining the planning horizon of the event at each stop of a tour can help identify if stops in a tour were determined simultaneously or sequentially. If a tour was not determined simultaneously, following the transactional opportunistic planning model, it can be hypothesized that stops in the later part of a tour were more likely to be opportunistically determined. In addition, it is reasonable to expect that if one of the stop in a tour requires a longer travel time, the event occurring at the stop is likely to be considered earlier. Similarly, in a tour a spur-of-the-moment stop is more likely to occur if it is close to the current location.

5.5.1 Tour Structure

A tour is composed of a sequence of out-of-home stops (activity locations). If more than one activities occurred at the same location consecutively, the location is counted as one single stop. Stop sequence increases only when the person went to another location for a different event. 802 tours are identified from all out-of-home activities, except for jogging and recreational biking that started and ended at home and did not serve for purposes other than exercises. Table 41 shows the structure of tours in terms of when event on each stop was planned. Out-of-home meals are also included in the table.

since they accounted for a small portion of the overall out-of-home activities. The lower portion of the table contains mostly empty cells, since there were very few tours containing more than three stops. The analysis will be focused on two-stop and three - stop tours, which clearly demonstrate that the proportion of opportunistic stops increased as stop sequence increased. For two-stop tours, approximately 60% of the events occurring at the first stop were planned (before-week and within-week), but only 19% were determined opportunistically (spur and within-day). The planned and opportunistic proportions are almost identical at the second stop. Among three-stop tours, the cell counts of the first two stops are similar to those of the two-stop tours. However, at the second and third stop, the opportunistic portions are higher than the planned. Hypothesis testing of independence was performed separately for two and three stop tours only, since there are not enough records of tours with more than three stops. The testing results verify that the relationship between stop sequence and scheduling horizon is not due to chance (i.e., the hypothesis of independence is rejected).

Number of stops in tour	Stop Sequence	Spur		Within day		Within week		Before week		Missing		Meals		Total
One	1st	142	17.44%	48	5.90%	143	17.57%	374	45.95%	32	3.93%	75	9.21%	814
One stop total		142	17.44%	48	5.90%	143	17.57%	374	45.95%	32	3.93%	75	9.21%	814
Two*	1st	20	12.66%	11	6.96%	33	20.89%	64	40.51%	10	6.33%	20	12.66%	158
	2nd	43	29.25%	16	10.88%	14	9.52%	44	29.93%	11	7.48%	19	12.93%	147
Two stop total		63	20.66%	27	8.85%	47	15.41%	108	35.41%	21	6.89%	39	12.79%	305
Three **	1st	10	14.71%	3	4.41%	10	14.71%	35	51.47%	5	7.35%	5	7.35%	68
	2nd	12	22.64%	10	18.87%	5	9.43%	13	24.53%	2	3.77%	11	20.75%	53
	3rd	12	25.00%	10	20.83%	8	16.67%	7	14.58%	6	12.50%	5	10.42%	48
Three stop total		34	20.12%	23	13.61%	23	13.61%	55	32.54%	13	7.69%	21	12.43%	169
Four	1st	1	11.11%	0	0.00%	3	33.33%	4	44.44%	0	0.00%	1	11.11%	9
	2nd	2	22.22%	3	33.33%	1	11.11%	1	11.11%	0	0.00%	2	22.22%	9
	3rd	2	18.18%	2	18.18%	3	27.27%	1	9.09%	1	9.09%	2	18.18%	11
	4th	3	27.27%	0	0.00%	4	36.36%	4	36.36%	0	0.00%	0	0.00%	11
Four stop total		8	20.00%	5	12.50%	11	27.50%	10	25.00%	1	2.50%	5	12.50%	40
Five	1st	1	25.00%		0.00%	1	25.00%	2	50.00%	0	0.00%	0	0.00%	4
	2nd	1	20.00%	1	20.00%	0	0.00%	3	60.00%	0	0.00%	0	0.00%	5
	3rd	0	0.00%	1	25.00%	0	0.00%	3	75.00%	0	0.00%	0	0.00%	4
	4th	0	0.00%		0.00%	1	25.00%	1	25.00%	0	0.00%	2	50.00%	4
	5th	1	20.00%	1	20.00%	0	0.00%	3	60.00%	0	0.00%	0	0.00%	5
Five stop total		3	13.64%	3	13.64%	2	9.09%	12	54.55%	0	0.00%	2	9.09%	22
Six	1st	0	0.00%	0	0.00%	0	0.00%	1	100.00%	0	0.00%	0	0.00%	1
	2nd	0	0.00%	1	100.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1
	3rd	0	0.00%	0	0.00%	1	100.00%	0	0.00%	0	0.00%	0	0.00%	1
	4th	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	100.00%	1
	5th	1	100.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1
	6th	0	0.00%	1	100.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1
Six stop total		1	16.67%	2	33.33%	1	16.67%	1	16.67%	0	0.00%	1	16.67%	6
Grand Total		251	18.51%	108	7.96%	224	16.52%	560	41.30%	67	4.94%	143	10.55%	1356

* Test for independence of all factors of two-stop tours: $\chi^2 = 20.26208$ d.f. = 4 (p=0.0004432829) (missing records omitted, but meals included)

** Test for independence of all factors of three-stop tours: $\chi^2 = 27.66633$ d.f. = 8 (p=0.0005420354) (missing records omitted, but meals included)

Table 41 Scheduling Structure of Tours

Based on the above findings, it can be inferred that the decisions of visiting stops in tours are not necessarily pre-determined at the same time. There are definitely a certain number of tours that are opportunistically formed. While engaging in planned activities, individuals may see opportunities of carrying out certain activities at different locations coming up later in the day. The decision of undertaking these activities or not would be based on their evaluation (i.e., not necessarily conscious) of feasibility. It is reasonable to expect that travel time required to reach the activity locations would come to one's mind as an evaluation criterion. For example, a spur-of-the-moment event is likely to occur if it is close to one's current position. Table 42 shows the three-way cross table of event type (work/non-work), travel time used to reach the event location, and the event's planning horizon. The spur-of-the-moment proportion clearly descended as travel time increased in both groups. Within work group, the proportion of before-week also increases in this order. Note that in this analysis attention should also be directed to the within-day column. Proportion on this column increase as travel time increases in both groups. This suggests that if one suddenly comes up with the idea of doing something, it might be undertaken immediately if the location is very close. If it is of some distance, the chance for it to be scheduled on the later part of the day would increase. Test statistics indicate that observed relationships are valid, since no independence between duration and scheduling horizon can be concluded. Consistent with conventional wisdom, the conditional independence between work and travel time is significant, indicating the weak association between them.

Event Type	Travel time (t)	Spur		Within day		Within week		Before week		Missing		Meals		Total
Non - Work	t < 10min	70	24.05%	11	3.78%	38	13.06%	78	26.80%	16	5.50%	78	26.80%	291
	10 <= t < 30 min	90	23.32%	44	11.40%	55	14.25%	128	33.16%	26	6.74%	43	11.14%	386
	t >= 30	22	17.19%	21	16.41%	21	16.41%	40	31.25%	7	5.47%	17	13.28%	128
	Missing	21	35.59%	2	3.39%	8	13.56%	22	37.29%	1	1.69%	5	8.47%	59
Work total		203	23.50%	78	9.03%	122	14.12%	268	31.02%	50	5.79%	143	16.55%	864
Work	t < 10min	28	17.50%	5	3.13%	41	25.63%	76	47.50%	10	6.25%	0	0.00%	160
	10 <= t < 30 min	18	7.00%	19	7.39%	46	17.90%	168	65.37%	6	2.33%	0	0.00%	257
	t >= 30 min	1	1.54%	5	7.69%	13	20.00%	45	69.23%	1	1.54%	0	0.00%	65
	Missing	1	10.00%	1	10.00%	5	50.00%	3	30.00%	0	0.00%	0	0.00%	10
Non work total		48	9.76%	30	6.10%	105	21.34%	292	59.35%	17	3.46%	0	0.00%	492
Grand total		251	18.51%	108	7.96%	227	16.74%	560	41.30%	67	4.94%	143	10.55%	1356
Goodness of fit statistics*														
Models		Independent factor			Pearson χ^2			DF		Sig.				
Complete independence		NA			131.4291			17		1.E-19				
Independence of one factor		Planning horizon			129.5230			15		3.E-20				
		Work			96.0158			11		1.E-15				
		Travel time			49.9316			14		6.E-06				
Conditional independence		Work – Planning horizon			94.4929			9		2.E-16				
		Work – Travel time			13.9641			8		.0827				
		Planning horizon – Travel time			47.7102			12		4.E-06				
Homogeneous association		NA			11.4516			6		.0754				

*The logliner analysis omitted missing and meals

Table 42 Three-way Table of Work, Travel Time, and Scheduling Horizon

Table 43 crosses the mode used to get to the event location with its planning horizon. The “No travel” category contains successive events that occurred at the same locations. It should not be surprising to see that these events were relatively impulsive. The “Non car” category contains walk, bicycle, car pool, and bus, but majority of them were walk trips to school. This directly explains its high proportion of before-week planning. It seems that if a person could use a car, the propensity of opportunistically participating in activities elsewhere would increase. However, the difference between the opportunistic proportion of car and non-car categories is not significant, because most

respondents live in an apartment complex where a variety of activities could be reached within 10 minutes of walking distance.

Mode used	Spur		Earlier in the day		Within Day		Before Week		Missing		Eat		Total
No Travel	64	22.46%	6	2.11%	45	15.79%	92	32.28%	14	4.91%	64	22.46%	285
Non Car	53	15.54%	23	6.74%	70	20.53%	178	52.20%	5	1.47%	12	3.52%	341
Car (as driver)	112	16.94%	76	11.50%	99	14.98%	265	40.09%	47	7.11%	62	9.38%	661
Missing	22	31.88%	3	4.35%	13	18.84%	25	36.23%	1	1.45%	5	7.25%	69
Total	251	18.51%	108	7.96%	227	16.74%	560	41.30%	67	4.94%	143	10.55%	1356
Goodness of fit statistics*													
Null Hypothesis			Pearson χ^2			DF			Sig.				
Complete independence			99.68604			8			0.00				

*Missing records omitted, but meals included

Table 43 Two-way Table of Mode and Scheduling Horizon

5.5.2 Opportunistic Trip-chaining

In the previous section it was found that some tours were opportunistically formed throughout the day. To understand the fraction of tours that were determined simultaneously or opportunistically, tours themselves are used as the units of analysis here. Among the 802 tours, 616 are single-stop trips and 186 multi-stop tours (Table 44). The high percentage of single-stop trips is likely a special feature of the sample. Most student respondents lived within 10 minutes of walking distance to school. After work many would go directly back home before they would go out again for other activities. As a result, there were substantially more single-stop work trips than mixed multi-stop tours.

Tour Purpose	Single-Stop Tour		Multi-Stop Tour		Total
Work only	204	98.55%	3	1.45%	207
Work/Non work mixed	76	48.10%	82	51.90%	158
Non work only	336	76.89%	101	23.11%	437
Total	616	76.81%	186	23.19%	802

Table 44 Tour Purposes and Tour Types

Table 45 summarizes the planning horizon of single-stop trips. The planned category combined events with scheduling horizons of “before-week” and “within-week”. If there were more than one events occurring at the stop, the planning horizon for the trip is based on the event with the most distant horizon among these events. For example, if an individual went out and did one planned event and one spur-of-the-moment event at the stop, the trip is counted as planned. Out-of-home meal trips were separated, because respondents were not questioned about the planning horizon for meal activities. Work/school trips were mostly known before the day. Especially, when there were other activities happening at the work places, the multi-purpose trips were all planned before the day. Non-work or non-school trips were more likely to be spontaneous or planned within the day. Overall, single-stop trips were often planned before the day. The propensity for the respondents to impulsively go out was pretty low.

Single-stop trip purpose	Spur		Earlier in the day		Planned		Meals		Missing		Total
Work school only	12	5.88%	13	6.37%	174	85.29%	0	0.00%	5	2.45%	204
Multi-purposed (mixed)	0	0.00%	0	0.00%	76	100.00%	0	0.00%	0	0.00%	76
Non-work school only	71	21.13%	27	8.04%	194	57.74%	27	8.04%	17	5.06%	336
Total	83	13.47%	40	6.49%	444	72.08%	27	4.38%	22	3.57%	616

Table 45 Scheduling Horizon of Single-stop Tours

For multi-stop tours, a stop is counted as planned if there was at least one event at the stop being decided either before-week or within-week. Because the decision horizons for meal activities were not questioned, two separate tables were created: one counts meals as planned events (Table 46) and the other counts them as not planned (Table 47). A planned tour is one in which all the stops were planned at least a day before. A "pure opportunistic" tour contains no planned stops. That is, decision of visiting each stop is either made spur-of-the-moment or within-day. A transactional opportunistic tour is between pure opportunistic and planned. It contains at least one planned stop but not all of them were planned. The definition of transactional opportunistic follows Meyer and Rebok, reflecting the fact that a daily activity/travel schedule often contain only a few determined events before the day unfolds. The executed schedules are the results of transaction between these initial plans and actions.

Multi-stop tour purposes	Pure opportunistic		Transactional opportunistic		Planned		Missing		Total
Work Only	0	0.00%	1	33.33%	2	66.67%	0	0.00%	3
Work/Non work (mixed)	4	4.88%	51	62.20%	20	24.39%	7	8.54%	82
Non Work Only	21	20.79%	44	43.56%	25	24.75%	11	10.89%	101
Grand Total	25	13.44%	96	51.61%	47	25.27%	18	9.68%	186

Table 46 Scheduling Horizon of Multi-stop Tour (Meals Counted as Unplanned)

Type	Pure opportunistic		Transactional opportunistic		Planned		Missing		Total
Work Only	0	0.00%	1	33.33%	2	66.67%	0	0.00%	3
Work Non Wor	4	4.88%	37	45.12%	34	41.46%	7	8.54%	82
Non Work Only	8	7.92%	44	43.56%	38	37.62%	11	10.89%	101
Grand Total	12	6.45%	82	44.09%	74	39.78%	18	9.68%	186

Table 47 Scheduling Horizon of Multi-stop Tour (Meals Counted as Planned)

Depending on if meals are counted as planned or not, it can be expected that approximately 25% to 40% of all tours made by survey respondents were planned. Decision timing for these tours complies with the aforementioned utility-based trip-chaining models. That is, participation in all the events in these tours was determined simultaneously prior to departure. However, there is a substantial portion of tours that were not chained together at the same time horizon. 44% to 51% of all tours were combinations of plans and improvisation and 6% to 13% of them were completely formed throughout the day. Overall, 50% to 60% of trip-chains made by the respondents do not comply with the behavioral assumption of utility theory. These tours were made progressively as intention and opportunities of activity participation occasionally being evaluated and realized throughout the day.

5.5 Analysis Summary and the Implications on Travel Demand Modeling

Data collected with REACT! were used to examine the structure of activity and travel patterns. Two-way contingency tables show that activities with shorter duration were more likely to be opportunistically filled in a schedule already anchored by their longer duration counterparts. It has also been found that the situation (e.g., location, involved person, and day of the week) under which the activity occurred was related to its scheduling horizon. Three-way contingency tables were used to verify the two-way relationships in the presence of a third factor. Dichotomous location and activity type variable (i.e., in-home vs. out-of-home, and work/school vs. non-work/school) are each included in contingency tables as the third factor. In general, results of the three-way tables proved that the structures revealed in two-way tables are still valid in the presence of the third factor.

The analyses of tour structure show that the proportion of opportunistic stops increased as stop sequence increased. In addition, the opportunistic proportion also decreased as travel time increased. Overall, these results demonstrate that a certain portion of trip-chains was opportunistically formed, rather than the simultaneous chaining suggested by conventional models.

The analysis presented in this chapter point out two potential directions to improve practical travel demand models. First, in terms of data collection, the conventional activity/travel diary approach needs to be augmented. It is found that a certain portion of out-of-home activities actually occurred spontaneously. Thus, taking “snapshots” of the revealed activity patterns for a day or two does not necessarily capture the consistent patterns. Asking questions related to individuals’ typical activity program

seems to be a way of addressing this dilemma. For example, based on the finding that individuals tend to adjust timing of events rather than the locations, it may be worthwhile to consider adding questions such as frequently visited locations to the conventional travel diaries. If the set of alternative locations were known, there could be better chances to deduce the decision strategies that resulted in the revealed patterns. Second, this analysis clearly demonstrated that the behavioral strategy behind everyday activity scheduling is close to the viewpoint of transactional opportunistic rather than utility-maximization. Instead of contemplating the optimal choices before action, individuals are often improvising in an environment with certain spatial and temporal constraints.

Combining the above two arguments, an agent-based simulation system of activity scheduling may be designed in a way that agents spontaneously improvise within the set of alternative locations while observing spatial and temporal constraints. These constraints correspond to the structural events in activity schedules (i.e., the typical activity programs). Models of these events could have higher predictability than those derived from "snapshot" patterns, since the latter may contain more unreliable random components. As for the improvisation strategies, a few common-sense rules can be implemented for observation of emergent patterns. Furthermore, the data collected by REACT! contain the entire scheduling processes and the stated-responses as to why certain decisions were made. Inferences of decision strategies can be made with such data. The resultant simulation system would produce a distribution of daily patterns, rather than a representative one, that closely resemble how individuals live in this complex world.

CHAPTER 6 CONCLUSIONS

6.1 Summary

A new computer program, REACT!, has been developed to collect data on household activity scheduling process. The program was tested in a pilot study in Irvine, California. Hypotheses formed at the beginning of the research have been tested and verified. Provision of financial compensation indeed created incentives for respondents to install REACT! in their computers. Experience from survey administration and empirical analysis of the resultant data also validated the program's capability of guiding participants to complete data entry tasks on their own, thus the objective of reducing the cost and human resource of such a computerized survey is achieved. Other positive results regarding objectives of reducing instrumental biases and expanding program capabilities were also obtained, especially, the GIS component proved to be an efficient way for recording activity locations, since no post-processing is required to geo-code the locations. The pilot study also identified several areas for improvement. Most important of all, the oversimplified diaries represent important technical and administrative issues to be addressed urgently.

Data collected with REACT! were used to examine the structure of activity and travel patterns. The hypothesis of transactional opportunistic scheduling behavior is indeed a valid one, since a certain portion of respondent's plans were only partially

elaborated prior to the execution. In addition, the series of analyses validated that 'activity-peg' phenomenon does exist, although it is not exactly that of Cullen and Godson. In this study, activities with shorter duration were found more likely to be opportunistically filled in a schedule already anchored by their longer duration counterparts. In addition, the situations (e.g., location, involved person, and day of the week) under which an activity occurred were related to its scheduling horizon. Analyses were also performed to validate that the above findings hold in the presence of a third factor (i.e., in-home vs. out-of-home, and work/school vs. non-work/school). Additionally, analysis of tour structure reveals that a certain portion of trip-chains was formed opportunistically. The proportion of opportunistic stops tends to increase as stop sequence increase. Travel time required to reach an activity is also positively related to scheduling horizon of the activity, with distant stop being planned earlier.

The two expected contributions are both realized. First, REACT! and the survey approach represent a significant advancement in the methodologies of household travel survey. By surpassing CHASE, there has yet to be a travel survey application with the depth and efficiency as those demonstrated with REACT!. Furthermore, with identification of the scheduling structure as the fulfillment of the second contribution, the value of such a survey approach is further strengthened. Next important milestone for the proposed survey approach is to use REACT! in a survey with a scale larger than the pilot study.

6.2 Future Research

Following the lead of this study, three rather distinct yet interconnected research proposals can be pursued in the future. First, the same approach could be applied directly in a larger scale survey of 300 to 500 households. Building on the experience of the pilot study, Lawton's (1996) vision of a computerized household survey (see Chapter 1) can be fully realized. The Decision Tracing Dialogs can be easily adapted to various stated-response or stated-preference questions. In addition, the sample size of such a survey can be augmented by providing potential participants who do not have PCs laptops on which to complete the survey. The survey period can also be reduced to two to three days as a means of increasing sample size. Sampling issues, such as the restriction on computer literacy, can be addressed by combining computer-assisted with face-to-face interview approaches. For computer users, REACT! will automatically guide respondents to complete the survey. Field investigators can be assigned to carry the program and interview respondents who do not use a computer. Note that the practice of face-to-face interview can extend the reach of a household survey to the subgroup in the population that has long been neglected due to literacy and language issues.

Second, the survey approach can be integrated with Global Positioning Systems (GPS) for route choice data, a critical yet hard-to-capture element of travel and activity surveys. In a related research effort, an in-vehicle Global Positioning System (GPS) data collection system, TRACER, that is capable of continuously recording and transmitting vehicle position and movements, has been developed and is being implemented in a variety of projects (Marca et al., 2001). These units use GPS to record vehicle position, are equipped with a wireless two-way modem for broadcasting or receiving data, and

self-activate, therefore, obviating driver interaction. Used in conjunction with REACT!, TRACER can serve several purposes. First, it can serve as a memory jogger. When a respondent logs into REACT! after a day of travel, TRACER will have already processed and conveyed tracking data to the respondent PC where that day's routing and associated activity stops can be displayed. More importantly, REACT! can query as to why certain routes were selected. Second, the integration of REACT! with TRACER can be used to explore route choice dynamics. This scenario combines data on vehicle paths with contemporaneous data on traffic conditions along that path and also with information from respondents about why specific routes were selected. Finally, it can be used to study the evolution of travel behavior of people who move to a new residence. Not much is known about travel behavior during this transitional period, thus, a fundamental yet non-invasive examination of "learning behavior" could lead to interesting insights. Since no one knows when the travel behavior of people in a relocated household stabilizes, placing GPS units in all household vehicles would be a cost-efficient, laborsaving way of obtaining this information.

Third, empirical analysis based on the pilot data should be continued and extended. Two important aspects of the overall activity scheduling behavior have yet to be fully analyzed in this study: activity program and dynamic schedule changes. An activity program refers to a participant's typical activities with various attributes entered in the initial interview. This information should be included in the analysis of activity scheduling structure to see what role activity programs play in the process. Analysis should also be performed to examine the dynamics of rescheduling behavior. This type of analysis was not feasible with conventional outcome data. However, when a respondent

changed the original plans. REACT! questioned and recorded their responses as to why such changes were made. Comprehensive analysis on these data would help elicit principles and rules of the dynamics of scheduling behavior that are central to the computational process models and agent-based simulation.

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APPENDIX

RECRUITING ADVERTISEMENT

Participants wanted for research project

The Department of Civil and Environmental Engineering of UCI is conducting research aiming at collecting information of what activities people typically do on a weekly basis. This information is expected to help us to estimate the amount of daily traffic on streets. We are looking for single adults over 18 years of age or married couples with or without children who have a PC running Windows 95, 98, or NT at home with Internet connection. Participants will install a computer program and enter their weekly activities in this program. Each participant will typically spend approximately 20 to 30 minutes each day for 9 days (from a Sunday to the next Sunday, plus one day before the first Sunday). Participants will be financially compensated for participation in the study: single persons will receive \$25 dollars; married couples will receive \$50 dollars. If participants decide to withdraw from participation before the data collection is completed, partial compensation (i.e., proportional to the number of days participated) will be provided. Please contact Ming Lee at mingshel@uci.edu or (949) 824-6571 for detailed information, or visit survey administrative Web site at www.its.uci.edu/~react

GUIDELINES DISTRIBUTED WITH THE REACT! SURVEY PACKAGE

Thank you for taking part in the REACT! survey

Welcome to the **REACT!** survey. The survey has two parts: Initial Interview and Weekly Activity Diary. The recording of your Weekly Activity Diary begins on a Sunday and ends on the very next Sunday. The Initial Interview is proceeded the first time you run the program. It should be finished no later than the Sunday evening when the recording of Weekly Activity Diary begins. It is advised that you install and begin to run the Initial Interview before this Sunday so the amount of time you spend on entering data can be reduced.

The recording of the Weekly Activity Diary begins on a Sunday evening (you have to complete the Initial Interview). Each night, you should run the program anytime from 6PM to 12AM (midnight). If you prefer to run the program after midnight, you can do so from Monday to Saturday. But on both the beginning and ending Sundays, you must run the program before midnight. On the first Sunday evening, you will be asked to enter the activities for the upcoming week (from Monday to the next Sunday). On Monday evening, you will be asked to update what you have actually done throughout the day. Also, you will be asked to update changes you have made to your activity plans for the rest of the week (i.e.: Tuesday to Sunday). You will need to repeat this process for every evening of the surveying week.

Upon completion of the survey, you will receive your financial compensation of \$25 for a single person, or \$50 for married couples. Should you decide to terminate your participation in the study before completion, you will receive a partial compensation. This amount will be determined by the number of days you took part in the study.

Included in this envelop are a program CD, a brief program and installation guide, a step by step guide to tell you how to run the program on Monday, and two Consent to Act as a Human Research Subject forms. Please read this form before you sign and proceed with the survey. The consent forms are required by Institutional Review Board at UCI's Office of Research Administration. If you are single you only need to sign one. If you and your spouse will both participate in the survey, both of you should sign.

Please try to install the program before this coming Sunday and run it after installation to begin the Initial Interview. For instruction on how to install the program, please see the REACT! Installation Guide. If you encounter problem installing the program, please contact us as soon as possible. If you have any questions and/or problems with the REACT! program, please feel free to contact Ming Lee at (949) 824-6571 or (949) 233-6094 (cellular phone), or send email to mingshel@uci.edu.

Thank you very much for taking part in the REACT! survey.

SURVEY CONSENT FORM

CONSENT TO ACT AS A HUMAN RESEARCH SUBJECT UNIVERSITY OF CALIFORNIA IRVINE

A Computerized Survey of Household Weekly Activities

TITLE OF STUDY

Ming-Sheng Lee, Civil & Environmental Engineering, 824-6571.

NAME, DEPARTMENT AND TELEPHONE NUMBER OF INVESTIGATOR

You (and your spouse) have been asked to participate in a research study which is exempt from review by an Institutional Review Board. The purpose of the study, terms of your participation, as well as any expected risks and benefits, must be fully explained to you before you sign this form and give your consent to participate.

You should also know that participation in research is entirely voluntary. You may refuse to participate, or may withdraw from participation at any time without jeopardy to future medical care, education or employment status, or other entitlement.

You will be financially compensated for your participation: a single person will receive \$40 dollars; single with children will receive \$60 dollars; a married couple without children will receive \$80 dollars; and a married couple with children will receive \$100 dollars. If you decide to withdraw from participation before you complete the survey, partial compensation (i.e., proportional to the number of days participated) will be provided.

The investigator may withdraw you from participation at his/her professional discretion. Especially, if you fail to enter and send in data for two days, you will be withdrawn from the survey by the investigator. Upon withdrawal, partial compensation will be provided up to the day of withdrawal. However, if a participant fails to send in data for two days, partial compensation will only be provided up to the day when data are received for the last time.

Any information derived from this research project which personally identifies you will not be voluntarily released or disclosed without your separate consent, except as specifically required by law.

If at any time you have questions regarding this research or your participation in it, you should contact the investigator or his/her assistants who must answer your questions.

If, at any time, you have comments regarding the conduct of this research or if you wish to discuss your rights as a research subject, you may contact the Office of Research Administration at (949) 824-6068 or (949) 824-2125.

You will be given a copy of this consent form to keep.

I consent to participate in this study.

SIGNATURE OF SUBJECT (Age 18 and older)

DATE

SIGNATURE OF INVESTIGATOR

DATE