SCHEDULING THROUGH ICT: WHAT ARE THE TRAVEL IMPLICATIONS?

by

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1 Introduction

Information and communication technologies (ICT) have substantially altered the processes of production, distribution and consumption at the global level. It has also made immeasurable impacts on the everyday life of urban residents in industrialized countries. The Internet has made a wide range of information available irrespective of its source location, and cellular technologies have enhanced the telecommunications capabilities enjoyed by urban residents. The travel behavior literature shows that ICT has affected urban residents' travel patterns as well (see, e.g., Mokhatarian and Meenakshisundaram, 1999, and Senbil and Kitamura, 2003). Similar impacts can also be expected in urban areas of developing countries.

Deregulation was one of the major issues in telecommunications market during the last two decades. Many economies in the developed countries deregulated the telecommunications the sector by easing the market entrance conditions in order to increase competition and hence efficiency in the market (Cairncross, 1997; for a discussion see Crandall, 1997). Services increased while prices decreased and different products powered by new technologies emerged and diffused in the market with increasing paces. Urban dwellers are now using not only home phones but also other telecommunications devices in their daily lives intensively (see Graham and Marvin, 1996; especially the figure given on page 16 in Graham and Marvin, 1996 is quite illustrative about this). The implications of deregulation in the market and the emerging technologies on the individual's daily activity engagement stand as an interesting subject for research. In this study, we consider scheduling of activities through ICT and their implications on individuals' trip making.

Scheduling is an important element of activity-based studies of travel demand. In the literature, it is often the case that a schedule is regarded as part of personal logistics that are addressed by using either heuristics, discrete choice analysis, or combinatorics. But on many instances, the fact that schedule is an iterative and interactive process and has a history has not given the right emphasis. Thus, in this study we address these points in an effort to fill the gap by considering ICT devices and applications[1], which generally support interactive scheduling. We will consider how individuals schedule, reschedule, or cancel activities by using different ICT applications in a conceptual framework that we propose, and attempt to link these decisions to travel demand.

Schedules emerge through personal discretion or interactions among people. ICT is an important element that facilitate interactions among people, through which people schedule, update, or cancel activities. Conventional telephone, cellular telephone, e-mail and the Internet are representative ICT devices and applications that are often used to schedule activities. These ICT devices and applications offer different communications capabilities, which interact with they way people schedule activities through them.

In this study we first elaborate on the properties of ICT devices and applications and indicate why individuals use different devices or applications in scheduling. Then data from a survey conducted in late 2003 are used to find evidence for scheduling and travel demand. We will also examine different types of ICT users and compare their activity engagements and trips in a day.

2 Motivation: Communications via ICT

In the activity-based literature, an activity schedule is an organization of activities, which is determined by interdependent decisions concerning spatial, temporal and travel choices. The process of arranging activities both in time and space, in relation to other activities, is referred to as scheduling. Scheduling is a logistic problem of locating activities by trading travel time and activity duration, access to activity locations, while considering

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[1] Note that ICT technologies do not define just devices such as the stationary telephone or cellular phones, but applications that are device independent within a proper environment. For example, almost all cellular phones support email applications, though in restricted manners when compared to personal computers. Added services such as caller identification, call rerouting can also be considered as applications that are device free. (see Muller, 2000)

time budgets and opportunities available. Scheduling, which often assumes an iterative process of scheduling and rescheduling, thus directly influences travel behavior.

The activity scheduling literature includes two streams of research: (i) satisfaction, and (ii) maximization of utility. The first stream of researches assumes that individuals use heuristics to solve problems, e.g., rule-based "if…then" problem solving models (see Newell and Simon, 1972; Tverksy and Kahneman, 1974). Alternatives are developed by individuals and evaluation of these alternatives is achieved with errors and biases, which are generally assumed to be part of human decision making processes (see Gärling, 1994). Hayes-Roth and Hayes-Roth (1979), Gärling et al (1986) and Gärling et al (1998) are typical examples of this group of studies.

The second stream of researches use the maximization principle applied to the individual's utility. The basic assumption of this line of research is that all possible activity and travel patterns available to an individual are taken into consideration. The utility of any schedule available is evaluated with respect to observed attributes of the schedule and the individual and the household (e.g., see Ben-Akiva et al; 1996, Kitamura and Fujii, 1998). It should be noted that the concern in this study is not on the modeling effort. Instead, the focus is to relate scheduling and ICT use. Thus the problem in this study is how individuals utilize ICT in order to make schedules and how they are related to travel demand. We define the very properties of ICT devices and applications, which individuals might consider important in scheduling and might be helpful understanding why individuals use particular devices for particular purposes.

People use ICT devices and applications to communicate in order to attain an objective or satisfaction (see Pool, 1982 for detailed discussions). Communications is basically information exchange. Typically one party has some information that the other does not, and communication results in the equalization of information between the parties. If communication is related to activity engagement at different locations, there are three possible relations between activity and ICT use, i.e., substitution, complementation and modification (see Salomon, 1985, 1986; Mokhtarian, 1990):

i. a decrease of activities either in the duration or frequency by the use of ICT $\Rightarrow$ **S**ubstitution

ii. an increase of activities either in the duration or frequency by the use of ICT $\Rightarrow$ **C**omplementation

iii. the change in some aspects of activities apart from the duration or frequency of activities, e.g., timing, location and etc. $\Rightarrow$ **M**odification

The cancellation of an activity might result in adding another activity; hence a different pattern of daily activities and a different chaining of trips might result. Similarly, an addition of any activity might result in shortening or even cancelling some other activities, which might call for logistic solutions in response to the changes in activity agenda. On the other hand, an activity on future days might be cancelled, modified or a new activity might emerge as a result of information exchange. The repercussions of these changes will be seen in many activities and trips that may be only remotely related to the initial changes. Moreover other activities not similar to the activities affected are also subject to change as result of logistic reorganization. ICT devices and applications should change considerably depending on the properties of activities, such as timing, location and fixities, as different technologies have different characteristics.

Three characteristics of ICT are relevant here:

i. Simultaneity
ii. Time Lag
iii. Availability

As the word indicates, simultaneity refers to any communication that is conducted simultaneously. Any communication device or application, which can be used for simultaneous voice transmission possesses simultaneity. Simultaneous voice transmission enables the each party of communication to evaluate the psychology of the other, which might render a joint activity of the parties unwanted, or might trigger a joint activity for face-to-face communication with full senses, i.e., visual and sensual. Also simultaneous communication is a two-way communication, where information that must be conveyed immediately can be communicated (see Claisse and Rowe, 1993). The conventional stationary telephone and the cellular phone both possess simultaneity.

Let the elapsed time between the time of communication and the realization of the information content of the communication, e.g., a meeting, be the time lag. Time lag affects the way communications is done, such as the selection of communication mode and the timing of communication. Suppose information about a joint activity a week later is sent to friends by email; with the time lag of one week, the information contained in the email can be acquired well before the event. If time lag is small, then chances are large that information sent by email is not acquired on time.

Lastly, availability refers to the ability to use ICT continuously, in both space and time. If an ICT device is fixed to a location, then being away from that location means no immediate poor accessibility; if the device has no storage capabilities, then no accessibility results during absence. Conventional telephone and email are two typical examples in this context. For example, an individual is accessible by the conventional telephone only when he is in the vicinity of his telephone. In case of email, messages can be read at any time after it is received when the receiver has access to his email.

3 Data

The data set is compiled from a weeklong activity survey that is conducted in late 2003 with students enrolled in five different universities in Japan. The survey was handed out to students in class. The survey has parts pertaining to communications incidents over conventional telephone, cellular phone, email and Internet use on a weekend day (Sunday) or a weekday (Monday). Of interest were what kind of information is conveyed with whom and what kinds of implic ations are caused for the activities of the respondents.

3.1 ICT Devices and Applications

The students who answered question properly in the survey are 169 and the ICT devices owned by these students are shown in Figure X.

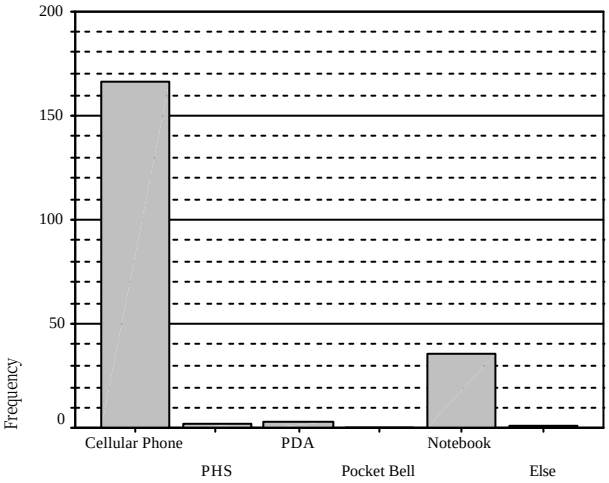


Figure 1 ICT Devices Ownership

Almost all of the students own a cellular phone; this well represents the current status of cellular phone ownership among younger generations. Second to the cellular phone, at a level corresponding to approximately a quarter of cellular phone frequency is the notebook, which has growing popularity among university students.

The ICT arsenal owned by the students supply them applications such as emailing, visual and text data transmission, fax, banking etc. Within all of these applications, the dominant application is email; second to email comes the internet surfing (Figure 2).

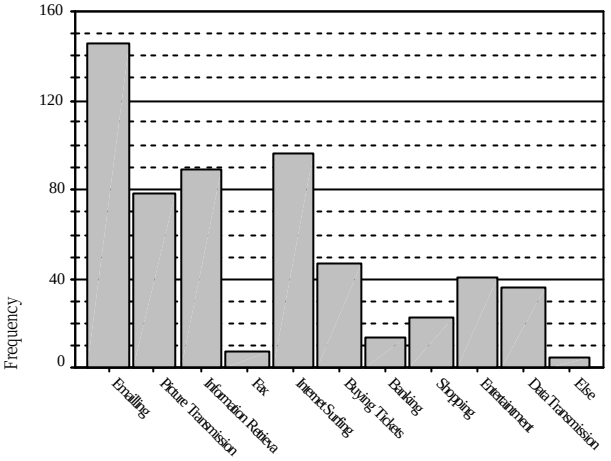
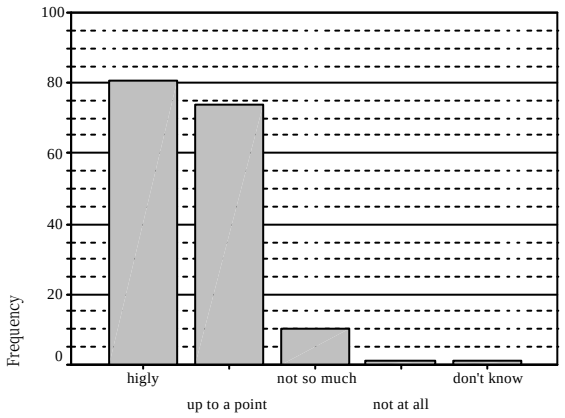


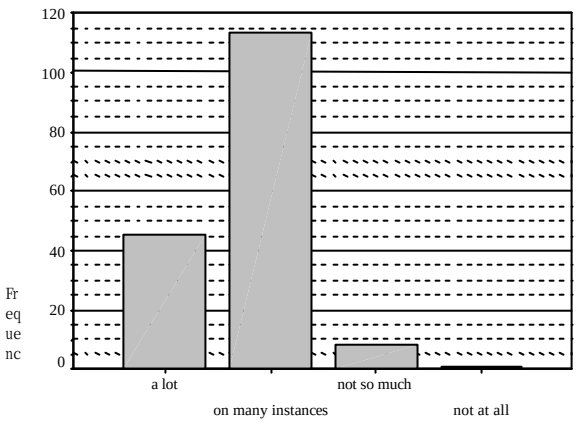
Figure 2 Applications supplied by ICT Arsenal

Having the above devices and functions in ones ICT arsenal, the students answer questions about the necessity and benefits of ICT as in Figure 3 a and b.



Are Mobile Communciations necessary for a living?

a



Does Mobile Communciations change your life?

b

Figure 3 Necessity of Mobile Communications and Effects on Individual Lives

We can conclude based on these responses that generally students regard mobile communications as necessity and they believe that ICT changes the way they live.

The communications over different ICT devices or applications show that the distribution of the use frequencies is skewed to the left for all of the devices or applications. The use of telephones and the Internet differs from email application in the frequency of non-users. The distribution indicates most of the students used email at least once a day (see Figures 4, 5, 6). On the far right of the scale where extreme uses of ICT devices or applications exist, emails far exceeds telephones and the Internet. These results are mostly due to the fact that email is the cheapest way of communic ation

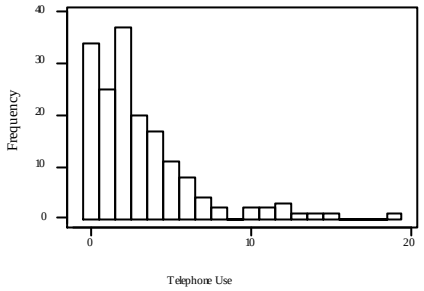


Figure 4 Telephone Traffic

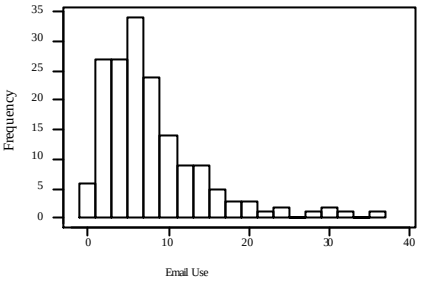


Figure 5 Email Traffic

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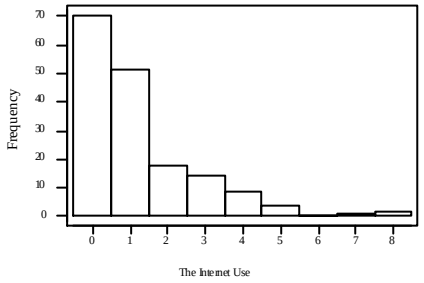
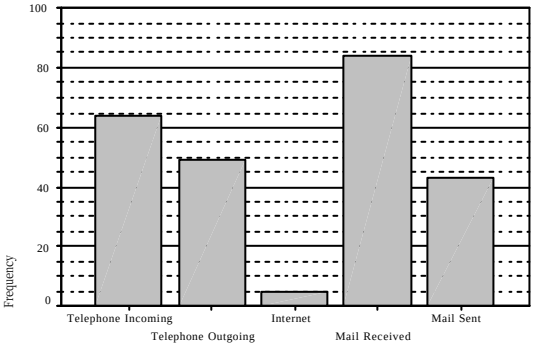


Figure 6 Internet Use

130 Turning to scheduling by the ICT devices, Figure 7 shows the frequency of any communication direction by
131 ICT device or application used. We have email as the dominant mode of scheduling (note that most of the cel-
132 lular phones enable emailing at service rates that are very inexpensive). Second to email, we have telephone
133 calls of which almost all are conducted by cellular phones (Figure 7).



134

135 Figure 4

136 The scheduling effects are mostly seen as complementation (addition of activity), modification is the second
137 mode of effect on activities by the use of ICT devices.

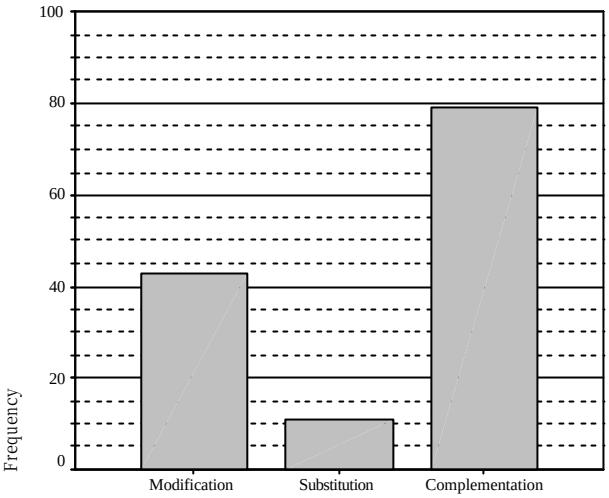


Figure 5

Students reported in the survey their activity scheduling through ICT use either on the day or on the next day of the communication, by indicating the way of communication viz. incoming or outgoing and the device utilized. Overall 26% of the incoming telephone calls and also 26% of outgoing calls resulted in a commitment on the day of communication. Commitments for the next day decrease a little but are roughly at the same rates of 20% and 22 % for incoming and outgoing telephone calls, respectively.

The levels for email communication are generally lower than those of telephone with 15% on the day of communication, both for incoming and outgoing email communications. On the other hand, commitments on the next day are higher than those on the day of communication with email (24% and 21% on the next day of incoming and outgoing communication incidents, respectively). These might be due to the time lag involved in email communication, even though most of the email exchanges were done by cellular phones. Email communication is not simultaneous; hence there is always a time lag between the time of information transmission and the acquisition of the information by the receiving party.

The Internet is different from both telephone and email because Internet communication involves only one party in most cases. Because of this, the fraction of commitments for the same day reduces to 4%, which is much lower than the other two devices. On the other hand, the figure rises to 17% for commitments on the next day of communication.

3.2 Activities and Trip Making

The survey had a weeklong duration, which began from Sunday and ended on Saturday. Figures 9 and 10 show how respondents used time on Sundays and Wednesdays, by time of day and by location (home, out-of home, or traveling).

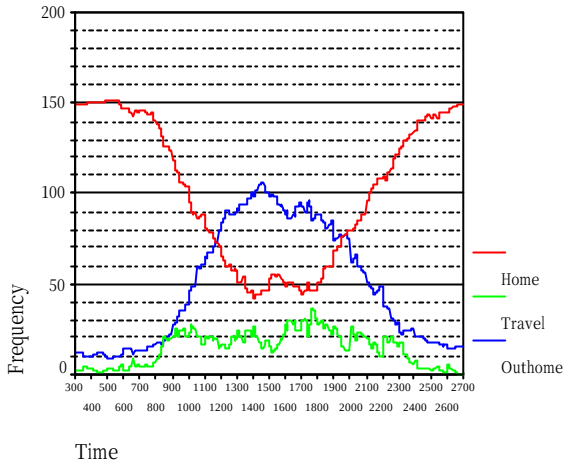


Figure 6 Distribution of In-Home, Out-Home and Travel Activities by Time: Sundays, 3:00AM to 27:00 AM (3:00 AM next day)

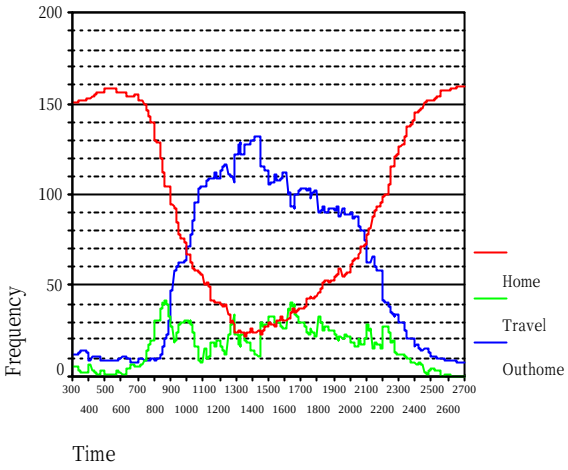


Figure 7 Distribution of In-Home, Out-Home and Travel Activities by Time: Wednesdays, 3:00AM to 27:00 AM (3:00 AM next day)

On the weekend, students were more relaxed to participate in out-home activities as shown by the slow and smooth increase in the morning of the curve showing the number of students participating in out-of-home activities. On weekdays, on the other hand, the curve rises sharply within a short period after 9:00 AM. The Anatomy of Scheduling via ICT

In this section we will elaborate on how schedules are built up into daily itineraries by ICT. For this purpose, we will delve into communications in detail. besides we will evaluate the schedules with respect to the characteristics of the ICT devices given in Section 2. For each ICT device or application we have data on:

i. time of communication
ii. communication mode
iii. type of communication
    scheduling events for the day of communication
    scheduling events for the next day of communication
    chatting
    emergency contact
iv. the other party of the communication

Also for each device, data are available on

1. number of contacts made (email and internet communications only)
2. transportation related site (for internet communications only)

The first two items under iii directly refer to scheduling by individuals. We also have data on scheduling outcomes as:

i. a new schedule is added
ii. a scheduled activity is changed
iii. a scheduled activity is cancelled
iv. a schedule is confirmed mutually

In the following sections, we will examine the respective ICT devices and their use with respect to scheduling.

3.3 The Use of Telephone

Students frequently use their cellular phones for voice communication (around 90% of voice communication); very few of them use home phones (around 6%). The rest of the communication is achieved by the messaging functions/applications of either the cellular phones or home telephones.

Students communicated with family members, friends and others with approximately the same frequencies, both incoming or outgoing calls. Approximately a half of all telephone calls have involved scheduling for either the day of communication or the next day. Scheduling for the same day was mostly with friends. Although friends are still a dominant category when we consider scheduling for the next day, the percentage of friends falls significantly.

Table 1 Incoming Telephone Call

	Family		Friend		Other		Subtotal	
	Row %	Column %	Row %	Column %	Row %	Column %	Row %	Column %
Schedule on The Day of Communication	2,8%	6,9%	91,7%	29,3%	5,6%	16,0%	100,0%	25,8%
Schedule on The Next Day of Communication	10,7%	20,7%	69,6%	17,3%	19,6%	44,0%	100,0%	20,1%
Chat	13,0%	55,2%	81,3%	44,4%	5,7%	28,0%	100,0%	44,1%
Emergency Call	17,9%	17,2%	71,4%	8,9%	10,7%	12,0%	100,0%	10,0%
Subtotal	10,4%	100,0%	80,6%	100,0%	9,0%	100,0%	100,0%	100,0%

The percentage of the friends category does not change much between incoming and outgoing telephone calls. Regarding the direction of communication, friends become active (i.e., placing outgoing calls) and passive (receiving incoming calls) equally. For immediate schedules students become active with respect to family members. Schedules on the next day of communication, on the other hand, family members become active.

Table 2 Outgoing Telephone Call

	Family		Friend		Other		Subtotal	
	Row %	Column %	Row %	Column %	Row %	Column %	Row %	Column %
Schedule on The Day of Communication	5,6%	16,7%	92,6%	29,6%	1,9%	4,3%	100,0%	25,7%
Schedule on The Next Day of Communication	6,5%	16,7%	71,7%	19,5%	21,7%	43,5%	100,0%	21,9%
Chat	11,4%	50,0%	82,3%	38,5%	6,3%	21,7%	100,0%	37,6%
Emergency Call	9,7%	16,7%	67,7%	12,4%	22,6%	30,4%	100,0%	14,8%
Subtotal	8,6%	100,0%	80,5%	100,0%	11,0%	100,0%	100,0%	100,0%

3.4 The Use of Email

Cellular phone is the dominant device when students exchange email messages (around 90%). A very small fraction of them uses email via personal computers. It is evident by examining Table X that scheduling for the next day is much larger with email (except for the communications with family members). Scheduling for the second day is more frequent than scheduling for the same day in case of incoming email messages with others. For outgoing email messages, the same pattern observed for incoming messages can be observed except the outgoing emails to others.

Table 3 Incoming Email

	Family		Friend		Other		Subtotal	
	Row %	Column %	Row %	Column %	Row %	Column %	Row %	Column %
Schedule on The Day of Communication	7.9%	16.0%	90.1%	15.3%	2.0%	3.8%	100.0%	14.5%
Schedule on The Next Day of Communication	3.6%	12.0%	83.1%	23.3%	13.3%	41.5%	100.0%	23.9%
Chat	8.1%	64.0%	85.9%	57.5%	6.0%	45.3%	100.0%	57.0%
Emergency Call	12.5%	8.0%	71.9%	3.9%	15.6%	9.4%	100.0%	4.6%
Subtotal	7.2%	100.0%	85.2%	100.0%	7.6%	100.0%	100.0%	100.0%

Table 4 Outgoing Email

	Family		Friend		Other		Subtotal	
	Row %	Column %	Row %	Column %	Row %	Column %	Row %	Column %
Schedule on The Day of Communication	8,1%	20,0%	86,5%	14,1%	5,4%	22,2%	100,0%	14,7%
Schedule on The Next Day of Communication	4,7%	16,7%	93,4%	21,8%	1,9%	11,1%	100,0%	21,1%
Chat	5,8%	56,7%	90,8%	59,0%	3,4%	55,6%	100,0%	58,8%
Emergency Call	7,4%	6,7%	85,2%	5,1%	7,4%	11,1%	100,0%	5,4%
Subtotal	6,0%	100,0%	90,4%	100,0%	3,6%	100,0%	100,0%	100,0%

3.5 The Use of the Internet

The use of the Internet does not facilitate simultaneous communication except for the chat activity. The Internet use pertains to one-way communication for most instances. One either collects information or surfs the Internet for information seeking or for pleasure.

Table 5 Internet

	PC Site		Cellular Site		Else Site		Subtotal	
	Row %	Column %	Row %	Column %	Row %	Column %	Row %	Column %
Appointment on The Same Day	100,0%	2,0%	,0%	,0%	,0%	,0%	100,0%	1,5%
Appointment on The Next Day	60,0%	3,9%	40,0%	8,5%	,0%	,0%	100,0%	5,0%
Information on Transportation	31,3%	3,3%	68,8%	23,4%	,0%	,0%	100,0%	7,9%
Emergency Call	75,4%	56,2%	24,6%	59,6%	,0%	,0%	100,0%	56,4%
Information about University	97,6%	26,8%	2,4%	2,1%	,0%	,0%	100,0%	20,8%
Chat	70,6%	7,8%	17,6%	6,4%	11,8%	100,0%	100,0%	8,4%
Subtotal	75,7%	100,0%	23,3%	100,0%	1,0%	100,0%	100,0%	100,0%

3.6 Scheduling by Devise Use Frequencies

In this section we will investigate scheduling by individuals who use ICT devices and applications with different frequencies (see Appendix A about how users are classified and the respective descriptive statistics). There are four (from Level 0 to Level 3) levels of users classified based on the use of ICT:

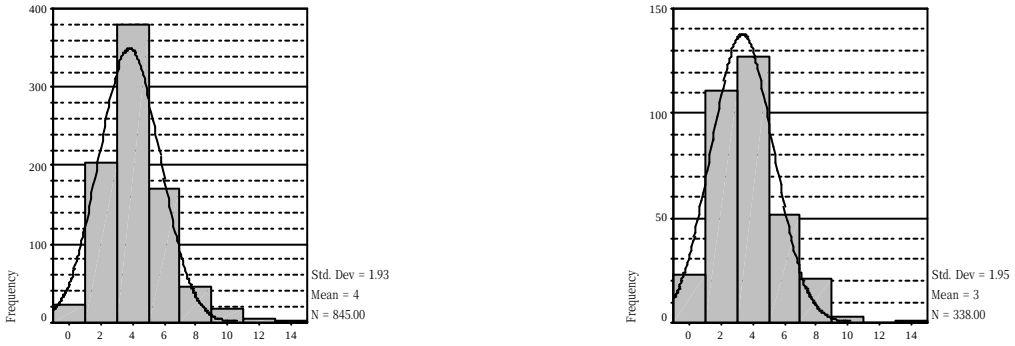
1. Nonusers
2. Light users
3. Moderate Users

4. Intense Users

We purport a basic hypothesis that with increasing use of ICT devices or applications, activities (either in the form of new schedules, changes in the schedules, or cancellations of schedules) affected by the communication increases. We test this hypothesis by using one-way ANOVA using the user classes for respective ICT devices. It is evident from the ANOVA tables given in Appendix B that the intense telephone users significantly differ from the rest of the users and have the largest number of activities in their agenda. The moderate and intense email users also have the highest numbers of activities in their agenda that significantly differs from the rest of the email users. On the other hand, all classes of Internet users show similar numbers of activities (approx. 1,3 to 1,6). When we compare the different ICT devices and applications, ANOVA analysis suggests that telephone use or more truly voice transmission is more effective than the other modes. This is apparent when we compare the F-scores obtained by different ANOVA analysis.

4 Trip Demand

In this section we offer evidence obtained by random-effect Poisson regression analyses (see APPENDIX C for a brief description of Poisson regression analysis) about the relations between the trips students have taken on weekdays and weekend days and the ICT uses along with other independent dummy variables pertaining to sex, car ownership and living in the family house. As indicated in the Data section above, the data consist of the activity engagements for a whole week. The mean number of trips is different between these two different day groups (see APENDIX D). The distributions of the number of trips are shown for weekdays and weekend days in Figure 8 a and b.



a. Trips in Weekdays (from Monday to Friday) b. Trips in Weekend Days (Saturday and Sunday)

Figure 8 Frequencies of The Number of Trips

We have already defined and supplied information about ICT devices and applications uses and user groups in the above sections. The males constitute the 81% of the entire sample, and 59% of all students live in their family house, the rest of them live either in student dormitories or apartments. Lastly, 27% of all students own cars for their excusive use. The basic statistics are as follows:

Table 6 Descriptive Statistics of Independent Variables Other than ICT Use and User Classes

Independent Variables other than ICT Use and User Classes	Mean	Standard Deviation
SEX	0.81	0.39
Living in FAMILY House	0.59	0.49
CAR	0.27	0.45

The first Poisson regression analysis takes the number of trips taken by students as the dependent variable and the number of all ICT communication incidents as the independent variable. The second analysis takes the

number of trips taken on weekend days as the dependent variable regressed on total number of ICT communication incidents.

The results of regression analyses are shown in Table 7 and suggest that on both weekdays and weekend days, trips generally increases with increasing telecommunications. In addition, the coefficient estimates indicate that a telecommunication incident induces more trips on weekdays than on weekend days.

Table 7 The Random Effects Poisson Regression

Dependent Variable : The Number of Trips by Days			
Time of Trips	**Variable**	**Estimate**	**t-score**
Weekdays (reperated measurements of 5 days per student)	Constant	1.34	19.07
	Total Number of ICT Communications*100	0.72	2.34
	SEX	-0.00	-0.00
	FAMILY	-0.28	-5.40
	CAR	0.21	3.61
	α	0.08	6.14
Weekend (repeated measurements of 2 days Sunday and Saturday per individuals)	Constant	1.07	10.67
	Total Number of ICT Communications*100	0.62	1.92
	SEX	0.18	1.99
	FAMILY	-0.26	-3.68
	CAR	0.16	2.22
	α	0.03	1.53

It is evident that when we take the communications incidents over the three days (Sunday, Monday and Tuesday) when students reported their ICT use, the effect of total ICT communications increases with improving t-score, and the coefficient, α, of the variance of the error component decreases.

Table 8 The Random Effects Poisson Regression

Dependent Variable : The Number of Trips by Days			
Time of Trips	**Variable**	**Estimate**	**t-score**
Survey Days Of ICT Use (repeated measurements of 3 days Sunday, Monday and Tuesday per individuals)	Constant	1.26	15.71
	Total Number of ICT Communications*100	0.82	2.40
	SEX	0.03	0.40
	FAMILY	-0.24	-4.46
	CAR	0.17	2.77
	α	0.03	2.43

When we introduce our user classification (see Section 3.6 above; the values of 0 through 3 are assigned to Level 0 through Level 3, respectively, as a crude approximation for this initial analysis.) as independent variables instead of the total number of telecommunication incidents, we arrive at results that only telephone users have significant positive effects on the number of trips, on both weekdays and weekend days. The effects of telephone use on the number of trips on both weekdays and weekends are approximately same.

Table 9 The Random Effects Poisson Regression

Dependent Variable : The Number of Trips by Days			
Time of Trips	**Variable**	**Estimate**	**t-score**
Weekdays (reperated measurements of 5 days per student)	Constant	1.12	13.03
	Telephone User Class	0.07	1.85
	Email User Class	0.05	1.65
	Internet User Class	0.06	1.66
	SEX	-0.07	-1.53
	FAMILY	-0.00	-0.10
	CAR	0.08	1.67
	α	0.69	5.50
Weekend (repeated measurements of 2 days Sunday and Saturday per individuals)	Constant	1.04	7.89
	Telephone User Class	0.06	1.69
	Email User Class	-0.00	-0.10
	Internet User Class	0.06	1.45
	SEX	0.15	1.68
	FAMILY	-0.24	-3.49
	CAR	0.18	2.20
	α	0.27	1.37

The same analysis is conducted for the three days collectively and the same effects are observed as above, i.e., the effect of telephone user class increases while that of email user class diminishes.

Table 10 The Random Effects Poisson Regression

Dependent Variable : The Number of Trips by Days			
Time of Trips	**Variable**	**Estimate**	**t-score**
Survey Days Of ICT Use (repeated measurements of 3 days Sunday, Monday and Tuesday per individuals)	Constant	1.16	10.71
	Telephone User Class	0.09	1.91
	Email User Class	0.03	1.13
	Internet User Class	0.07	1.99
	SEX	0.00	0.12
	FAMILY	-0.24	-4.24
	CAR	0.18	3.07
	α	0.03	2.22

5 Conclusions

It is evident from the analyses introduced by this study that activity scheduling is significantly associated with the use of most of the ICT devices and applications. The more one utilizes means of communication the more he will be involved in activity scheduling. Also it is evident that, although the generic concepts related to ICT effects on scheduling, i.e., simultaneity, time lag and availability, have not been addressed fully, some evidence is obtained in their support. When the cellular phone (note that most of the communications are achieved by cellular phones either by voice or email) is used for voice communication, it has more effects on scheduling in the short time horizon than when they are used for emailing. For the trip demands, we also see significant positive effects of telephone calls and email exchanges on trip demands of individuals. Though we observe complementary effects on weekend trips, the magnitude of the effects is smaller than the effects observed on week-

284 days. This result can be seen visually when Figures 9 and 10 are examined once more with this conclusion in
285 mind. On weekends individuals are more apt to stay at home than weekdays.

286 The range of devices and applications are diversifying with unprecedented paces and applications tend to con-
287 verge and fused into single devices (see Figure 2 above), and the cellular phones are the typical hosting device
288 of all these converging applications. As cellular phones are portable devices, the interactions with others, espe-
289 cially with the members of one's social network (see Tables 1-5) would become more up-to-the minute and the
290 effects can be more prominent on activity scheduling.

291

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APPENDIX A

We differentiate users with respect to the frequency of both incoming and outgoing traffic of communication contacts made by students as shown in Table A-1. The first class of user refers to the individuals who have not used the devices or applications within the time period for which they reported their use. The other classes are formed by examining the frequencies of use of the devices or applications respectively (see histograms given by Figures 4-6).

Table A 1 The User Classes and Descriptive Statistics

	User→ [frequency range]	**Mean**	**Standard Deviation**
Telephone	0→[0]	0,00	0,00
	1→[1-3]	1,93	0,74
	2→[4-6]	4,75	0,80
	3→[7→]	10,76	3,34
Email	0→[0]	0,00	0,00
	1→[1-3]	1,91	0,71
	2→[4-6]	4,92	0,82
	3→[7→]	12,54	6,46
The Internet	0→[0]	0,00	0,00
	1→[1-2]	1,46	0,44
	2→[3-4]	3,39	0,49
	3→[5→]	6,14	1,46

APPENDIX B

One-way ANOVA: number of total scheduled activities affected versus Telephone Users

```
Analysis of Variance for number o
Source     DF        SS        MS        F        P
teluser     3     88,14     29,38     9,90    0,000
Error     165    489,68      2,97
Total     168    577,82

                                    Individual 95% CONFIDENCE INTERVALS For Mean
                                    Based on Pooled StDev
Level       N      Mean     StDev  --------+---------+---------+--------
0          34     0,853     1,158  (----*----)
1          82     1,195     1,383       (--*--)
2          36     1,639     2,140         (----*---)
3          17     3,471     2,853                      (------*------)
                                    --------+---------+---------+--------
Pooled StDev =    1,723                 1,2       2,4       3,6
```

One-way ANOVA: number of total scheduled activities affected versus Email Users

```
Analysis of Variance for number o
Source     DF        SS        MS        F        P
emailuse    3     62,22     20,74     6,64    0,000
Error     165    515,60      3,12
Total     168    577,82

                                    Individual 95% CONFIDENCE INTERVALS For Mean
                                    Based on Pooled StDev
Level       N      Mean     StDev  -+---------+---------+---------+-----
0           6     0,333     0,816  (-------------*--------------)
1          34     0,382     0,652          (-----*-----)
2          54     1,648     2,057                       (---*----)
3          75     1,880     1,924                          (---*---)
                                    -+---------+---------+---------+-----
Pooled StDev =    1,768          -1,0       0,0       1,0       2,0
```

One-way ANOVA: number of total scheduled activities affected versus The Internet Users

```
Analysis of Variance for number o
Source     DF        SS        MS        F        P
intuser     3      1,32      0,44     0,13    0,945
Error     165    576,50      3,49
Total     168    577,82

                                    Individual 95% CONFIDENCE INTERVALS For Mean
                                    Based on Pooled StDev
User        N      Mean     StDev  ----------+---------+---------+------
0          70     1,514     1,932              (-----*----)
1          69     1,348     1,838            (-----*----)
2          23     1,565     1,927           (---------*--------)
3           7     1,429     1,134  (-----------------*----------------)
                                    ----------+---------+---------+------
Pooled StDev =    1,869                 0,80      1,60      2,40
```

APPENDIX C

The Poisson regression belongs to the class of count-data models. Fully parametric Poisson regression (see Greene 2000 and Cameron and Trivedi, 1998) assumes that the conditional frequency of activities, y_i, given independent variables, $\mathbf{x_i}$, is independently and identically distributed with the probability mass function

$$f\left(y_i|\mathbf{x_i}\right)=\frac{e^{-m_i}m_i^{y_i}}{y_i!} \quad ,y_i=0,1,2,3,\ldots. \tag{1}$$

The Poisson probability mass function is characterized solely by the mean parameter, μ_I, which is assumed to be (Cameron and Trivedi, 1998, p. 61),

$$E\left(y_i|x_i\right)=m_i=\exp\left(\mathbf{x_i'}\boldsymbol{ß}\right) \tag{2}$$

where

$\boldsymbol{ß}$ = kX1 parameter vector.

The maximum likelihood estimation is the standard method for Poisson regression. The log-likelihood function is,

$$\ln L\left(\boldsymbol{ß}\right)=\sum_{i=1}^{n}\left\{y_i\mathbf{x_i'}\boldsymbol{ß}-\exp\left(\mathbf{x_i'}\boldsymbol{ß}\right)-\ln\left(y_i!\right)\right\} \tag{3}$$

Interpretation of the coefficients in Poisson regression is based on the conditional mean function $E\left(y_i|x_i\right)=\mu_i=\exp\left(\mathbf{x_i'}\boldsymbol{ß}\right)$. When we take the first derivative of this conditional function, the result indicates marginal effects of any independent variable on the conditional mean function. This is shown for independent variable x_j as

$$\frac{\partial E\left(y_i|x_j\right)}{\partial x_j}=b_j\exp\left(\mathbf{x_i}\boldsymbol{ß}\right) \tag{4}$$

When we introduce random effects into the model, the mean parameter is assumed to be in the form (Cameron and Trivedi, 1998, p. 287)

$$E\left(y_i|x_i\right)=m_i=u_i\exp\left(\mathbf{x_i'}\boldsymbol{ß}\right)\equiv\exp\left(\mathbf{x_i'}\boldsymbol{ß}+u_i\right) \tag{5}$$

where u_i is the group effects and $\exp\left(u_i\right)$ is assumed to have a Gamma Distribution with parameters $\left(d,d\right)$thus the $E\left[\exp\left(u_i\right)\right]$ becomes 1 and variance $V\left[\exp\left(u_i\right)\right]$ becomes $1/d$ which is estimated as a in the models. In the regression analysis d is assumed to be equal to 2.

APPENDIX D

One-way ANOVA: WEEKEND versus WEEKDAY

```
Analysis of Variance for TRIPS
Source     DF        SS        MS        F        P
DAY         1     52.49     52.49    14.02    0.000
Error    1181   4420.51      3.74
Total    1182   4473.00
                                    Individual 95% CONFIDENCE INTERVALS For Mean
                                    Based on Pooled StDev
Level       N      Mean     StDev  -----+---------+---------+---------+-
Weekend   338     3.343     1.951  (--------*-------)
Weekdays  845     3.809     1.928                       (----*-----)
                                    -----+---------+---------+---------+-
Pooled StDev =    1.935              3.25      3.50      3.75      4.00
```