# Supporting Appropriate Communication Media Selection Through Context-Awareness

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***Abstract***

*Communicating with someone via the right communication media seems to be difficult nowadays as people use various mode of communication media and senders do not have any knowledge about receivers' current communication media, especially in ubiquitous environment. Thus, we propose the method how the most appropriate media to reach the receiver can be selected based on the effective measures. In the paper, a preliminary evaluation of the proposed method is also described to show its effectiveness. We are developing a research prototype system to support the sender with the information of the best reachable media to the receiver.*

## 1. Introduction

The most important problem for a person who wants to communicate with someone is how to best reach that person. As people can use variety of communication media such as mobile phone, office phone, home phone, email and instant messaging, it is difficult for a sender to communicate the receiver with the right communication media. With the advent of mobile phones the communication seems to be easier without knowing the receivers' current activity e.g. home, work or school [1]. However, the modern communication technologies can also bring burdens to the users such as unnecessary calls during meeting [8] and missing the important calls [14].

The recent researches [1], [4], [5] has been tried to realize a person's availability for communication with sufficient contextual awareness. Although these works can give the knowledge about the availability of receiver, most of works leave the final decision to the users to select the best media to reach the receiver. In our research, we develop a method how the most appropriate communication media can be selected so that user does not need to make any effort to reach the recipient. To realize the method, three effective measures- availability, user preference and stability for the media selection are defined [9]. By applying these measures, the best media to reach a person can be determined effectively. The paper proposes a simple algorithm to select which communication media is the best to reach the receiver. We also conduct the user studies to show how much accurate the system can select the most appropriate media to reach the receiver.

The rest of the paper is organized as follows. The next section describes the motivation of our paper and intended use of the system by briefly reviewing some related works on user availability. This is followed by description of proposed measures for media selection of our system. Next, the system architecture and a typical use case of the system are described. Then we present some preliminary evaluations with user studies, the result and discussion over this user studies. Finally, we conclude our work with some future works.

## 2. Problem definition and motivation of the work

We main motivation of our research is to reduce the burden from communication initiator by selecting the most appropriate communication media to reach the receiver without letting user in too much information. We describe the problem finding in section 2.1 as the example usage and scenario of our system deployment.

### 2.1. Example usage and scenario

A simple example scenario of our system deployment is described in Figure 1.
Suppose that user A wants to contact with user B as he wants to inform that the emergency meeting will be started in 10 minutes. User A usually connects with user B office phone during office hours. However user B cannot be reachable via office phone at that time because he is currently in a conference room and using his computer.

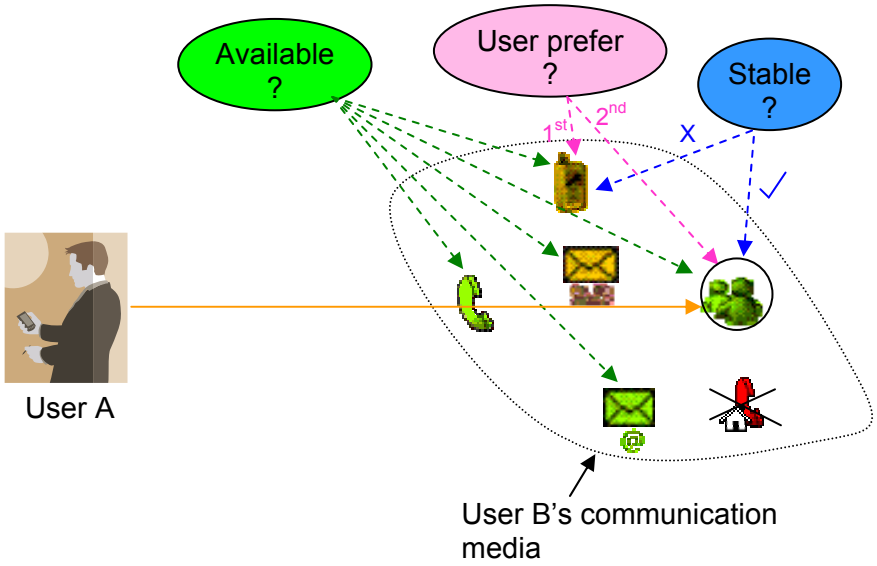


**Figure 1. Example usage and scenario of the system**

There is a simple solution which is that user A will call to user B's mobile phone if he cannot reach user B via the office phone. But what if the mobile phone is switch-off as user B is in conference. As he is now using computer and IM, user A can send IM or email to him. How user A can know he is now currently using IM. It would be helpful for user A if he knows that user B is currently using IM and sending IM is the best way to reach user B. Our system will solve that kind of problem technically. To realize the method, the effective measures- availability, user preference and stability are proposed.

### 2.2. Intended use of the system

Our system is intended for supporting the works in the ubiquitous environment. The works done in context-aware and ubiquitous technologies help people to make decisions about when and how to communicate with colleagues with the automatically sensed context and availability information. Prior works on user availability [1], [2], [4] provided the users with information about the context of the parties to select the best media to reach the recipient. MyConnector [4], a computer service research prototype, can intelligently connect people both at the right time and at the right place with the best possible medium for society appropriate communication by learning the availability of users by tracking computer activity, location

and calendar entries. MyVine [1] uses speech detection, location information, computer activity and calendar information to model a person's availability. As these works give the user about the information of the all available media of the recipient, users have to decide to select the best media. Users have to check all status of the media of their colleagues by themselves. Letting the user in too many of decisions will burden the user.

Therefore, our work intends to reduce the burden from the users by selecting the most appropriate media to reach the receiver. The main motivation of our approach is to automatically select the best possible media based on the three measures- availability, user preference and stability. The more reliable services can be provided to the users by applying these measures in the existing systems of the ubiquitous environment.

## 3. Proposed method for media selection

In this section, a media selection function based on the following three measurements [10] and a simple algorithm for selecting the most appropriate communication media is proposed.

### 3.1. Proposed measures for media selection

First we define the availability measure to guess which media is currently being used by the user. Secondly, we define the user preference measure to specify the available media as there may be more than one available media for the recipient. Finally, we define the stability measures to know whether the media which can be considered as available and preferred by user is stable or not.

**3.1.1 Availability (A):** availability *A* can be defined how much the media of the receiver is currently in active i.e. which device is currently being used by the receiver. Based on the user's schedule, logs or call history, it can be traced that which media is mostly used in the certain period of time and location. We define the availability measure as follows. If the media is available, the availability value of this media, *A*, is equal to "1" otherwise the value is "0". By applying this measure, the system can know that which media are currently available for the recipient.

**3.1.2. User Preference (P):** user preference *P* can be defined as the particular media which is frequently used by the user. To calculate user preference we need to maintain user's call history such as how many calls are made by each media, how frequently the media is used and computer activities such as how often a user account is logging in and how long the account is being online. User preference can be calculated as follows.

$$P = \frac{\text{No. of usage for each media}}{\text{No. of total usage for all available media}} \quad (1)$$

As there are various kinds of media for a user, the current media may be different depending on the user preference. Therefore user preference should be taken into account for selecting the appropriate media.

**3.1.3. Stability (S): s**tability *S* can be defined as a measure that describes how many calls are connected during the certain period of time *T* (e.g. T=10 minutes). We can say that the

media is stable if 50% of incoming calls are reachable within *T*. We can calculate the stability value as follows.

$$S = \frac{\text{No. of connected calls within time T}}{\text{No. of total incoming calls within Time T}} \quad (2)$$

Therefore, the system can select the most appropriate media based on these three measures to reach the receiver via the stable media which is available and most preferable by the user. This stability equation would be considered for the synchronous communication media. For the asynchronous communication media such as email and IM, the stability measure would not be calculated.

### 3.2. Media Selection Algorithm

An algorithm for selecting the most suitable communication media is presented in this section. We proposed a simple communication media selection algorithm as follows.

**[Communication media selection algorithm]**

```
/Initial setting of available media
Let Location = { L1, L2,…, Ln}
Let Media = { M1, M2,…, Mm}
Set sumofAvailability =0
For each Li ∈Location
        If isAvailable(Mj) then Availability(Mj)=1
        Else Availability (Mj)= 0
        sumofAvailability + = 1
End For
// Finding preferable media among available media
If sumofAvailability > 1 then
        Calculate Preference(Mj)
        Store Mj in PreferenceList by descending order of Preference(Mj)
        Mprefer ← M(0)
Else
        Mbest ← Mj
End If
// Checking preferable media from the stability point
If Mprefer = Msync
   MediaStability is initially set to NULL
   While MediaStability is not ENDOFSELECTION
      Calculate Stability(Mprefer)
    If Stability > δ
           MediaStability is set to ENDOFSELECTION
       Else
     Change Mprefer to the next of the PreferenceListEnd While
          Mstable ← Mprefer
   Mbest ← Mstable
   Else
          Mbest ← Mprefer
   End If
```

## 4. Research prototype

We are currently developing a research prototype by realizing the system as shown in Figure 2.

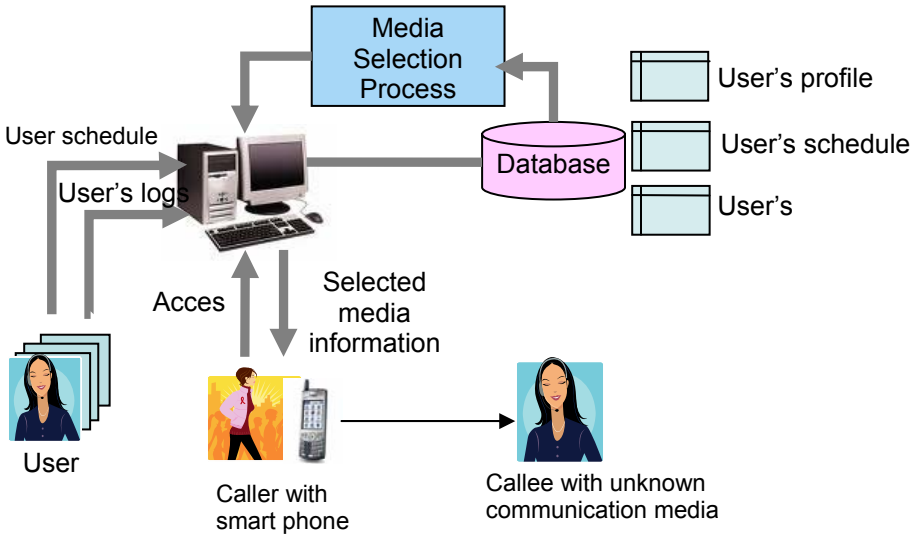


**Figure 2. System architecture for communication media selection**

In order to get the user information, users will have to input their schedules every 30 minutes. As time and location would be very good predictor for people availability [4] and due to the relation of location and schedule information to availability in the context-aware messing service [6],[7], we have no doubt that user schedule should be used for predicting user availability. However, users might have the different activities with their schedules. Therefore, we combine user logs and call history to predict the available media more accurately.

User profiles including user name, phone numbers, email address and user accounts are also stored in the database for letting the caller access the system with any information of the receiver such as name, office phone number and mobile phone number.

In the above prototype system, the media selection component gets the information about the available media from user schedule, user log and profiles stored in database. Then the preferred and stable media is selected among the available media according to the algorithm. When the caller accesses the system with one of user contact information, the system will support the caller with the information of the best media to reach the receiver.

### 4.1. A typical use case

User A, user B and user C willingly share their information with each other and they login to access the system. As user A realized that the meeting will be started 1 hour earlier than usual, he changed the schedule. User B want to contact with User A at that time and user A accesses the system with the name of user B to know the most appropriate communication media of user A. As system recommends the user B to use IM, User B choose to send message to user A so that the unnecessary call can be avoided

as well as the communication can be established via the most suitable media. In Figure 3 and 4, user's interface for querying the most appropriate media, the returned service from the system and updating user schedule are depicted.

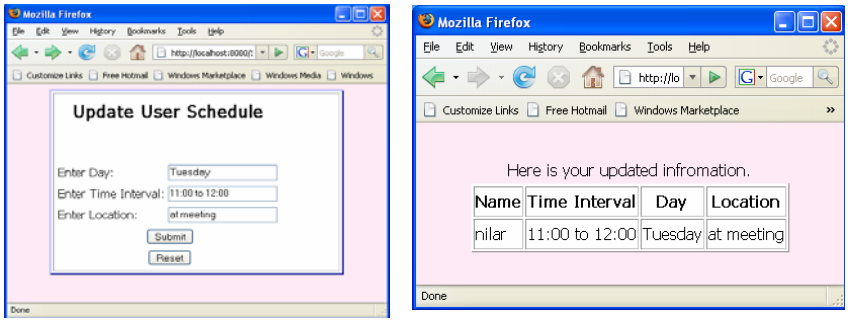


**Figure 3: User's query and system recommendation**

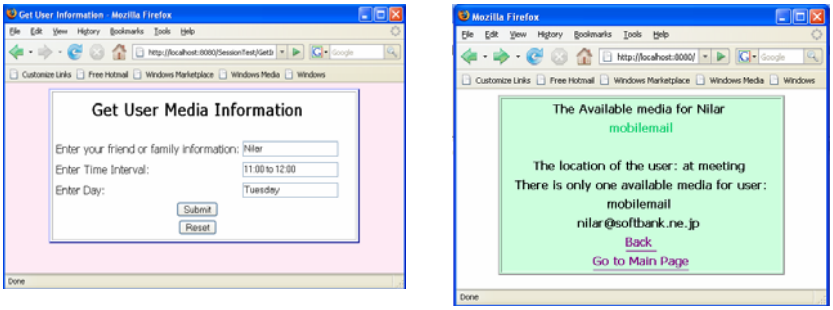


**Figure 4: Updating schedule and updated information**

## 5.Preliminary Evaluation

### 5.1. User studies

We conducted user studies by collecting data from 4 students belonging to the different laboratories of our university. We collected the data based on time of the day and location of the users including home, lab and class. A total of 54 self-reported data for each participant such as the current location of the user and available media of the current location have been collected. For example, when the location of the student is laboratory, the available media are IM, mobile phone, mobile mail, email and lab phone.

We asked the participants to indicate whether they are available or not according to their current location and also asked to indicate which media is the most preferable among available media for the following different communication media.

Communication Media

- Home phone
- Mobile phone
- Lab phone
- Mobile mail
- Email
- Gtalk Call
- Gtalk IM

**Table 1. Example data set used in simulation**

| Available media | Number of usage |
|---|---|
| Lab phone | 2 |
| Mobile phone | 5 |
| Mobile mail | 3 |
| Email | 5 |
| Gtalk IM | 7 |
| Gtalk call | 0 |

The above table shows the example data set collected from a participant during 90 minutes when he is in the laboratory. The available media are the media that are currently used by the user when he is in the laboratory. The number of usage means how many the user communicates with others or is communicated by the others. As shown in Table 1, the user communicates the most via IM. Therefore, the user preferred media is IM among the available media. Moreover, IM can be defined as the stable media from the stability point of view. Therefore, the system will recommend the communication initiator to use IM reach the recipient when the receiver is in the laboratory. The system will support the caller with the information of the best media to reach the receiver.

### 5.2. Evaluation results and discussion

Table 2 shows the simulation result of the accuracy that represents how much the recommended media selected by the system can be reached to the receiver.

**Table 2. Results for system simulation**

| Location | Accuracy |
|---|---|
| Home | 78% |
| Lab | 85% |
| Seminar | 89% |
| Class | 92% |
| On the way | 90% |

As shown in Table 2, the results shows the high accuracy rate, on the other hand, the system can meet the high user's satisfaction as the media recommended by the system is mostly reachable to the user. We found that we got the high accuracy rate because the users give the correct information to the system regarding their current location and schedules.

For the above mentioned user studies, the data are collected from the users who do not have heavily changing daily schedules. We assumed that the users update their schedules every 30 minutes and they are actually available via the media which they marked as available.

The location of the user is strongly connected with the available media. The participants are usually available via the media of the certain location. For example, it can be normally said that a person is available via home phone when he is at home.

The logs of computer and call history are good to ensure which media are used in which location. If the logs of the computer show that a user communicates a lot via email and IM when the location in the user's schedule is Laboratory, the system will select IM as the best media to reach when user is in the laboratory. But if there is no use of IM when the schedule shows user is in the meeting, the system will recommend another media rather than IM as the most appropriate media based on the three measures.

It looks like it is less accurate to reach user when user is at home. The reason is that when user is at home it can be more possible of not being near the computer, or being switch off the mobile phone or not being in the distance of hearing the ringing sound of the telephone. In such case, the most update information is needed by using PC activity and location sensor data for tracking the user's location and activities.

Therefore, the location information and context-aware information can be added for guessing the available media of the users. Moreover, location information seems to be also important to guess the appropriate media for the mobile users with heavily changed schedules.

Our work intends to focus on selecting the most appropriate media to reach the receiver among the available media. According to the above user studies, the accurate information on the user's availability can give the better result to our system. Since there have been much works for guessing the user's availability by using location and schedule information [6], [7], sensor data [11], [12], [13] and user state, activities, social relationships and communication urgency [3], [4] our method will work well with these existing works in the ubiquitous environment.

## 6. Conclusions

We have presented the research prototype that can select the most appropriate communication media to reach the receiver. We have described the three effective measures- availability, user preference and stability. To realize the method we have proposed a simple media selection algorithm to select the best reachable media to the receiver. Our system can give the high accuracy to reach the receiver without letting the users in too many decisions to select the media by themselves. We used the reported data of the users to guess the media and our system can integrate with the existing technologies to get the user information automatically.

Our current experiment described before is based on the students who usually have regular schedules. A larger study for the different societies and for mobile users who have highly changed schedules would be needed. Our work can be further extended by integrating with the existing technology such as user's location detection, context-aware technologies and ubiquitous technologies so that the most appropriated media can be predicted more accurately by using these three proposed measures.

It would be worthwhile if the system not only can give the information of the best media to reach the user but also can support the direct communication to the most appropriate media. For example, instant messaging box would be appeared on the display when the most appropriate media is IM, or the system would make a call to home phone when the most appropriate media is home phone.

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