ATM Enhanced Acessibility for Disabled Persons: A Study of Time Limits

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Abstract

This paper presents an accessibility study carried out to determine the most appropriate timeout values that allow users with disabilities to use ATM terminals to carry out banking operations. The paper describes the methodology applied to the study which consisted of a questionnaire phase, followed by a test phase which took place in an ATM test bed from which recommendations were drawn. This study addressed the diversity of problems presented by users with visual disabilities (low vision and blindness), motor disabilities (wheelchair, assistive walking devices and limited dexterity) and intellectual disabilities.

Keywords

Accessibility, user centred design, usability, experimental studies, ATM, timeouts.

1. FOREWORD

The most common complaint coming from ATM users is that the time limits to complete many operations are rather short. In fact, these limits, known as timeouts, were originally set with the following in mind:

- Safety – timeouts protect users against events such as forgetting to take out the card or the money or when the user is at loss and does not press the cancel button.
- Convenience – ATMs assume appropriate default choices to yes/no-like dialogues when timeouts expire.
- Turnaround time – the knowledge that timeouts are in effect prevents users from delaying, making ATMs available for more users and more banking operations.
- Security – timeouts protect users from long exposure and malicious intents and interference.

Current timeout values assume that users know exactly which transaction (operation) they want to make, how to navigate menus to reach the transaction dialogue and that the input data for the transaction is ready and present (e.g., a slip of paper with an account full number).

But it happens that many times users hesitate because they are uncertain of how to reach a given transaction dialogue. Other times they take too long to make sure that the transaction data has been correctly typed. In both cases the time limit expires and the user has to start all over again.

Furthermore, it is assumed that no environmental problems hamper users on their tasks. This is often not the case since ATM terminals may be located either too high or too low, in very narrow spaces or exhibit the very recurring and annoying screen glare due to direct bright sunlight in the daytime or improper, perhaps incorrect, illumination at night time.

There is no any way for ATM software to detect any of the above. However, users need more time than usual to carry out an operation and, therefore, it is more likely that the time allowed for the operation will expire.

1.1 Timeouts and Disabled Persons

These problems are even further compounded for disabled persons. Such users tend to be slower than the average. Moreover, the knowledge that time limits are short is yet another stress factor making disabled persons hurry up, thus creating the right conditions for them to make mistakes. Recurring mistakes and failures have the effect of discouraging everybody (and not only disabled persons) from using ATMs.

In a general way, ATM operators and designers overlook such user problems. Also, research on these matters is scarce, albeit inexistent, because most researchers tend to address the conditions for physical accessibility to ATMs and not their operation.

This reflects in the existing standards like CEN 15291 [CEN15291] that limit themselves to the enunciation of vague and general principles for accessibility in interface design. Another example, the Brazilian standard for ATM accessibility [ABNT15250], recommends only that there should be a 2s pause between audio messages and that users should be allowed a 5s wait time when prompted to start data input.

Other studies, like Davies at al [DLW02], concentrate on the rehabilitation of disabled persons. These studies focus on making such persons use ATMs again and not on ATM design issues.

This paper addresses the experimental determination of adequate timeout values for the different disabilities presented by disabled persons and, therefore, how to increase ATM accessibility

It is important to stress that ATM enhanced accessibility for elderly or disabled persons benefits not only such persons but the generality of ATM users.

This work was part of a larger study on how to improve accessibility to ATM terminals for elderly and disable persons [UTL06] carried out under a contract from SIBS (Sociedade Interbancária de Serviços) by the Technical University of Lisbon. The study involved the Department of Design of the Faculty of Architecture, the Computer Science Department of Instituto Superior Técnico and the Special Education and Rehabilitation Department of the Faculty of Human Kinetics.

2. TARGET USERS AND USERS GROUPS

The designation “disabled persons” encompasses such a very large number of disabilities that the current study, in its first step, opted to consider only three broad kinds of disabilities:

- Visual impairment (blindness and low vision).
- Motor impairment (wheelchair, device assisted walking, limited dexterity).
- Mental impairment.

Furthermore, it well worth noting that a person will often exhibit more than one typified disability.

No deaf persons were targeted in this study because deafness alone is no impairment to ATM use since deafness does not affect vision or motor dexterity, the two major requirements to operate an ATM terminal successfully without timeouts.

Disability/ Age Group	Total	Details
Visual	74	44 blind 30 low vision
Motor	74	30 wheelchair 37 device assisted walking 7 limited dexterity
Mental	118	
Elderly persons	80	

Table 1: Persons who answered the questionnaire according to disability type or age group.

3. METHODOLOGY

This study was conducted in three phases [Pereira07]:

- Identification of the ATM models in operation
- User survey
- Trials involving users

The first phase was carried out in order to identify the different ATM terminals in operation in Portugal because of their diversity of device layout and keypad layout, to name just a few.

In the second phase a questionnaire was prepared and distributed to associations of disabled persons, day centres, clubs and other institutions frequented by disabled and elderly persons. Questionnaires were filled in by users or by staff of this study if the person would not be able to do it.

In all 346 persons answered the questionnaire. Table 1 shows the number of answers received according to type of disability.

Of these 206 were ATM users while the remaining 150 were not.

Processing of the questionnaire answers showed some interesting results. One of the most relevant was that the short time allowed to carry out operations. A related conclusion was that respondents not using ATMs or who had quit using them would consider using ATMs if they were given the chance to train using ATMs without time limits, especially in the case of the more complex tasks.

The questionnaire phase also allowed us to identify users who could be retained for third phase, the trial phase.

The third phase aimed at testing solutions for enhanced accessibility on a test bed where it was possible to change its physical layout, illumination and software.

The software was runtime configurable, i.e., had many alternative options that could be set on and off while tests were running.

The software also had data collection built in so that it was possible to collect user data.

The 20 users who participated in the third phase were chosen so that they each one presented at least one of the following conditions:

- Difficulties pressing a key and introducing the card in the slot
- Wheelchair or walking assistive device usage
- Height less than 1.35 m or higher than 1.85 m
- Ability to read small sentences or simple numbers or “read” them from audio output devices
- Ability to follow instructions

3.1 Tasks Involved

It is well worth noting that disabled persons that operate ATMs and experiment timeout operation termination are usually faced with difficulties in at least one of the following [Gill98]:

1. Insert the card
2. Read the screen
3. Use of the keypad, screen lateral keys or a touch screen
4. Listen to audio output
5. Retrieve the card

These tasks are essential to complete a transaction at an ATM terminal. Any delays while performing any of them add to the overall time taken and increase the likelihood of a timeout happening.

However, there can be simple and complex transactions. In Portugal, the most frequent operations are money withdrawal, account balance inquiries, prepaid mobile telephone payments and paying bills. Besides having to select and carry out these operations by themselves, users must at all times insert the card, key in the PIN code and take out the card and any bills and receipt slips.

Figure 1: A user at the ATM test bed.

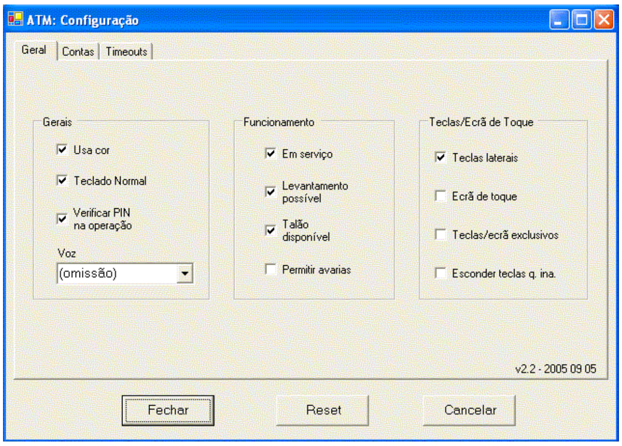

Figure 2: Main ATM test bed configuration panel.

Although the test bed software was capable of simulating all the banking operations available from all SIBS network ATM terminals, this study concentrated in the following most frequent and relevant operations:

- Cash withdrawal
- Payment of bills
- Prepayment of mobile telephones

3.2 Trials and the Test Bed

Trial users were asked to perform the operations listed above on an ATM test bed specifically designed to test accessibility improving solutions. Figure 1 shows a test user performing tasks at the test bed.

Because lighting conditions (and glare) affect user performance (and success), it was possible to change lighting conditions. Light sources located on the sides and above the test bed provided different lighting conditions. The room where the trials took place also allowed the control of other environmental conditions as well as illumination.

The test bed software was specifically designed to reproduce the software that was currently installed in all ATMs of the SIBS network. However, its software behaviour could be modified through a configuration panel that allowed the setting of many options through a series of configuration panels. Figure 2 shows the main configuration panel. The timeouts configuration panel (see Figure 3) allowed several ways to control timeouts.

Timeouts could be individually configured. This meant that the time limit to input the PIN code, the time limit to select an operation and the time limit to fill in the data to a bill could be individually set even a runtime, for instance. This allowed the exploration of values not tied to the values that were in effect in ATMs from the SIBS network at the time.

The software also allowed adapting almost all individual time limits to the pace of input of a relevant data item, e.g., the PIN code. Furthermore, all time limits could be multiplied by a given factor. In practice, we could set this factor so high that no time limit would be reached.

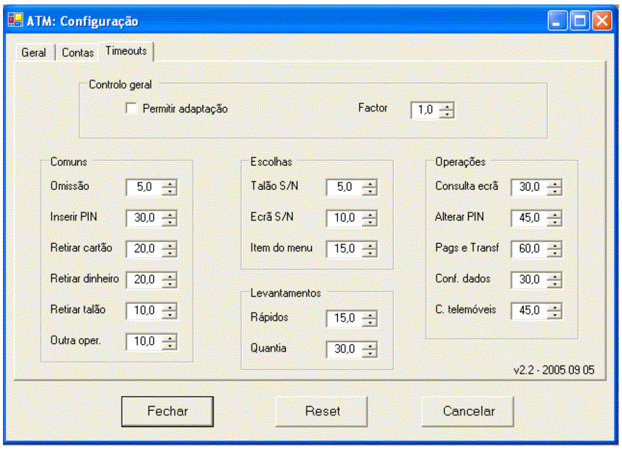

Figure 3: ATM test bed timeouts configuration panel.

The test bed software was also able to collect usage data, namely user actions. Particularly, the software recorded which keys the user pressed and the time at which each key was pressed on a log file.

Since the log file also contained the times of screen transitions, it was therefore possible to calculate the time taken by the user to complete a dialogue, make a selection on a menu and the user's pauses and hesitations.

All this data was automatically recorded on the log file and was complemented by notes taken by an experimenter who would observe the user performance (effort, insecurity, remarks, etc.).

After a briefing interview designed to identify the user's main concerns, priorities and needs, the user would then get acquainted with the test bed and freely explore it. This would be followed by the execution of the transactions assigned to the user by the experimental protocol.

After finishing the transactions, a final debriefing interview would follow to evaluate accessibility and other relevant issues from the user's point of view.

4. TRIAL RESULTS

The following presents the results obtained from trials that involved the following kinds of users:

- Blind
- Motor impaired
- Mentally impaired

No elderly persons or persons with low vision were involved in these trials because the disabilities they exhibit are encompassed by the disabilities of the users listed above.

4.1 Blind Users

All vision impaired users selected for the trials were blind users since they constitute the most demanding user subgroup in the visually impaired category. The reason for this choice was that we wanted to assess the operation of ATMs by blind persons and determine the appropriate values for timeouts when using the ATM interface variant that provides auditory output.

SIBS specifically designed this interface for this kind of users a few years ago, but no specific study of timeouts was done at the time. Instead, the timeout values for the average user were adopted for this interface without considering the specific needs of blind users.

An already large number of SIBS network ATM terminals present this special interface with different menu and dialogue screens and sound output.

ATM terminals enter this special interface operation mode if the user presses keypad key 5 right after keying in their PIN code.

In this audio output mode, ATM terminals read out aloud the choices and instructions through loudspeakers. Some recent terminal models have also a 3.5 mm audio earphone jack that provides privacy and increased security.

The audio operation mode restricts the operations the user can make to the following[1]:

- Cash withdrawal
- PIN code change
- Bill payment

Because blind users mentioned that they considered very important to be able to make mobile phone prepayments, we decided to add this operation to the list above for exploratory purposes and for determining its appropriate timeout values. It must be stressed that this operation is not currently available in audio output operation mode.

The operation of an ATM terminal in audio output mode is as follows. After pressing key 5, the user is prompted to select one of the operations listed above and then taken to the normal screen dialogue for the operation chosen. The terminal reads out any instructions specific to the operation that was selected and, as it is the case of cash withdrawal, restricts the dialogue to the one where the user types in the amount to withdraw.

Depending on the operation selected, the terminal may present the user with a confirmation dialogue right after the operation dialogue. Confirmation dialogues are not usually entered in normal mode (i.e., without audio output) but are used by SIBS ATMs in most of the operations carried out with audio output.

In order to be able to determine a most comprehensive set of timeout values to recommend, we decided to present confirmation dialogues for all operations carried out in audio output mode. This choice was based on the opinions collected from the focus group of blind persons at the time the test bed was validated.

Confirmation dialogues read out the values keyed in by the user (e.g., amount to withdraw) and then prompt the user to confirm (green key) or to cancel (red key) the operation.

Another difference of the audio output mode relative to normal operating mode is that the user has no choice to request or reject printing a paper slip with the details of the operation. In audio output operating mode this receipt is always printed.

For these trials, as well as for the trials with other kinds of disabled persons, the timeouts built into the test bed software were completely disabled. This allowed the determination of the exact times taken by the users without masking out those times above the current SIBS timeout values and, therefore, provided data that could be used to set new timeout values ranges appropriated for each kind of disabled users.

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[1] Recently, another operation, MB purse card fill-in was removed following the end of this type of card.

Task	Min.	Max.
PIN code input		
Overall	5	32
Code input	3	22
Key 5	1	9
Audio menu selection	7	24
Card withdrawal		
No cash	3	46
Cash	10	28
Cash withdrawal		
Overall	8	25
Amount selection	4	12
Confirmation	5	14
Mobile phone prepayment		
Overall	46	58
Data input	39	49
Confirmation	17	28
Bill payment		
Overall	43	45
Data input	36	37
Confirmation	7	25

Table 2: Minimum and maximum times (in seconds) taken by blind users at the ATM test bed.

Table 2 shows the maximum and minimum values that were recorded in the trials with blind persons.

The values ranges are relatively wide because subjects' ATM usage expertise varied widely. Some users were experienced in using keyboards and keypads with a relatively low number using them everyday. On the other end of the spectrum, there are users who only sporadically use them and this shows in the higher values that were recorded.

However, the most important values are represented by the maximum values that can be read as "no (much) lower than this value".

The overall values shown on the table represent the time taken from the moment the audio prompt starts to the moment the user finishes typing the input data. The difference between an overall time and its corresponding data input time (taken from the moment the user presses the first key) should roughly represent the time taken by the software to output the audio instructions plus the user to reaction time.

This reflects in the minimum and maximum values quoted for mobile phone prepayments and the payment of bills but not in cash withdrawal operations. This is because this operation is the most frequent operation and frequent users need no longer listen to the audio output. Instead they can immediately start typing in the amount they wish to withdraw[2] because they know or decided upon this amount in advance. Infrequent users still need some time to make up their mind about how much to withdraw.

[2] Audio output stops when the user presses the first key.

4.2 Motor Impaired Users

The tests with motor impaired users were conducted using the normal user interface (no audio output) but were given the choice to use a modified user interface that allows users to signal their choice using the PIN pad keys instead of using the keys located on both sides of the screen.

The use of the modified user interface affects the time taken to select an operation because users no longer need to move their arms (elbow, shoulder, hand) from the PIN pad to the keys located on the side of the screen that are typically some 30 cm above the surface where the PIN pad is.

This modified interface does also away with the need for the opposite movement and can therefore improve user performance. This is the case of dialogues such as the yes/no (or cancel/confirm) dialogues to be answered through the green and red keys following an action where the user pressed a key on the side of the screen.

In fact, data analysis showed that the exclusive use of the PIN pad in operation selection resulted in lower task times concentrated in the lower part of the span of experimental values. The values for operation selection reported on Table 3 show that users took between 5 to 18 seconds to select an operation. The range of times corresponding to operation selection with exclusive use of the PIN pad is significantly lower with most of the values falling in the range of 5 to 13 seconds.

The modified user interface Confirmation (or cancellation) when requires the opposite displacement.

For the remaining data collected, and given the diversity of the impairments of the test users, it was no surprise that the minimum and maximum times listed on Table 3 show large differences.

Task	Min.	Max.
PIN code input		
Overall	5	19
Code input	3	15
Operation selection	5	18
Cash withdrawal selection	1	8
Choice of slip printing	2	6
Card withdrawal		
No cash	9	15
Cash	23	28
Bill payment		
Overall	33	76
Data input	30	66
Confirmation	4	8

Table 3: Minimum and maximum times (in seconds) taken by motor disabled users at the ATM test bed.

However, on the whole, the maximum and minimum times are roughly of the same order of magnitude except in the case of PIN code input and payment of bills. The reasons behind this should be made evident so that the adoption of larger timeout values may be duly justified.

In the case of PIN code input one must bear in mind that it follows an action that is generally difficult to perform: insert the bank card into the slot. After this, motor impaired users must displace their arms and hands from the vicinity of the card slot to the PIN pad. Depending on the individual capacity, the time it takes a more severely impaired user to make this movement is necessarily longer than the time for a user with less movement constraints. Again, we must make allowance for the worst case.

The longer starts up delays in the case of the payment of bills have the same cause with a variation. In this operation the user needs to hold the bill in order to be able to read (and transcribe) the three sequences of digits on the bill. This requires the execution of several arm, elbow, shoulder and hand movements to manipulate the bill and therefore depends on the dexterity of the user.

4.3 Mentally Impaired Users

The test results produced in the trials with mentally impaired users are not significantly different from the values recorded with persons with other kinds of impairments as Table 4 shows.

Cash withdrawal times are very close to the values that are typical of average users as well as PIN code input.

However, one must make some allowance for the fact that these users are very much diverse in terms of capacities, experience, training and use of terminals.

This is shown on Table 4 by the fact that PIN code input minimum and maximum are roughly similar whereas total time varies from 2 seconds (almost no thinking) to 15 seconds of which 12 seconds correspond to the memory recalling followed by the decision to act.

Also, one must keep in mind the complicated nature of taking out the card and money for some mentally impaired persons who are not aware or forget the task sequence required to take possession of the two. In fact, some of these persons may take the card and leave without taking the money because the two happen in sequence and not at the same time.

Again, it is important that the software may make the user aware of this and give him/her time to recall the existence of two steps. This is why the timeout value for withdrawing the card and the money should be relatively higher for these users.

Almost the same must be said for confirmation dialogues. Once the data to make a mobile phone prepayment has been keyed in and the green key has been pressed, mentally impaired users may think that this is the end and focus their attention elsewhere and forget completely that a confirmation dialogue that must be answered to has shown up.

Task	Min.	Max.
PIN code input		
Overall	2	15
Code input	2	3
Operation selection	2	10
Card withdrawal		
No cash	7	10
Cash	10	35
Cash withdrawal selection	1	3
Choice of slip printing	1	6
Mobile phone prepayment		
Overall	30	60
Data input	26	53
Confirmation	4	28
Bill payment		
Overall		23
Data input		22
Confirmation		3

Table 4: Minimum and maximum times (in seconds) taken by mentally impaired users at the ATM test bed.

5. CONCLUDING REMARKS

A study of the times taken by disabled persons to perform banking operations on an ATM test bed has been presented. This paper has shown this determination to be essential for the success of extending banking operations by means of ATMs to persons with disabilities so that they will switch to ATMs. In fact, if timeout values are not adapted to their difficulties by giving these persons extended times to carry out banking operations, they will be discouraged to further use ATMS and will inevitably quit.

More than showing the need to extend timeout values, this study has also showed the new values that should be adopted and determined the differences in those values according to the kind of disability. The reasons for these differences were also made clear.

The question now stands on how to set the recommended timeout values for a given user depending on his/her disability.

This question has an immediate answer in the case of blind users since the ATM software detects this kind of user when key 5 of the Pin pad is pressed after the user keys in the PIN code. Given this, the values shown on Table 5 are the values to recommend when audio output operation mode is used. These are the minimum values that should be used for this kind of operation mode.

For the remaining users the answer depends on the scope of the modifications that will be introduced to the ATM software which were recommended by the wider study of which the timeout values study was only a part [UTL06]. To keep interaction uncomplicated one may devise a means similar to PIN pad key 5 that makes available to the other kinds of disabled users the new timeout values as well as other increased accessibility facilities.

Task	Timeout (seconds)
PIN code input	25
Selection of audio mode	10
Audio menu selection	10
Card withdrawal No cash Cash	 20 40
Selection of amount to withdraw	20
Mobile phone prepayment	45
Bill payment	45
All confirmation dialogues	10

Table 5: Minimum timeout values recommended for operations carried out with audio output help. All times are counted from the time audio prompts finish or the user presses a key.

Task	Timeout (seconds)
PIN code input	15
Operation selection	20
Card withdrawal No cash Cash	 20 40
Cash withdrawal	10
Bill payment	60
Bank transfers	60
All confirmation dialogues	10
Receipt printing choice	8

Table 6: Minimum timeout values recommended for operations carried out without audio output. The above values apply to PIN pad only interaction.

Table 6 presents the recommended timeout values for operations performed by mental and motor impaired persons. For implementation simplicity, the timeouts for the two kinds of users were combined in one single table

6. AKNOWLEDGEMENTS

The authors wish to acknowledge the involvement and participation of APD, ACAPO, ADFA, CM Cascais, CM Lisboa, CECD, Centro de Recursos para a Deficiência Visual, ME, CERCI Lisboa, Cooperativa de S. Pedro, Liga Portuguesa de Deficientes Motores, SNRIPD, UMIC, APPACDM – Marinha Grande

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