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Mobile Real-Time Feedback System for Education*

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The development of mobile real-time feedback systems is discussed along with their application to scenarios in education when some feedback from students is necessary to better direct the delivery of specific teaching materials, lesson planning or the use of an appropriate teaching approach. The requirements to be met by one such system are considered along with implementation and the field data collected from a variety of application scenarios.

Keywords: mobile system; student feedback; mobile system applications

INTRODUCTION

STUDENT FEEDBACK is an important element of education. When it is implemented well, student feedback is able to provide the essential information for an educator to improve on teaching materials, the approach to delivering them, as well as other finer details in education which would benefit even the most experienced educator [1]. However, the timeliness of feedback is a crucial factor governing the extent of its success. In many instances, a feedback exercise is carried out on a cohort or students batch basis, at the end of the teaching semester. So, the feedback solicited will be used to direct efforts to improve materials or teaching approach for the next cohort of students. In a way, this is analogous to inferential control in a process control system design, where feedback occurs at time intervals which are long compared to the batch processing time, so that effectively, it is open-loop control in action between each batch update.

It is common knowledge to a control engineer that such open-loop control based on last batch information is non-ideal, since disturbance factors can vary from one batch to another. In the same way, the nature, background, schedule, curriculum and learning environment can vary from one cohort of students to the next. However, this common phenomenon is understandable, considering the workload involved in administering a complete student feedback and analysing the feedback results. Until now, an efficient and systematic way of soliciting real-time field parameters from the class is mainly possible through smart classrooms with heavy infrastructure and equipment investment, and is limited to a small class [2, 3]. Otherwise, the 'quick show of hands' has remained basically as the educator's only tool to seek the simplest 'yes/no' immediate feedback from a class.

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There are many common scenarios when a real-time response and presentation of analysis and consolidated results is needed, especially in a large class. A number of these scenarios will be briefly highlighted and readers who are involved in teaching should be able to relate to them.

A lecturer has taught a big class for the past one hour and there are still two more hours remaining. The question is, should the remaining part of the current topic be completed, a break called , or a simple exercise be introduced to consolidate what has been covered till then? Clearly, a 'measurement' of the fatigue/concentration level of the students would be most useful.

A tutor would like to have a feel of whether the students are grasping the right concepts, by giving a number of multiple choice questions to a large class. The questions are handed out and answers collected from the class after a timed duration. It will be the next tutorial, or even later, before the scores have been processed and the statistics are ready to discuss with the students. Perhaps a less motivated tutor would be willing to take such an approach for milestone checks. How valuable it would be to have a system which would be able to automatically present the statistics just one minute after the short quiz has ended, for immediate discussion with the class!

A lecturer needs to schedule a hands-on session or a make-up lecture for a big class when everyone would be available. The timetable of the students is different from one to another, so that it is not a trivial task to fix a date. Could there be a system that would input a number of dates for students to choose their preference, after which the system would revert instantaneously to the date when most students are available?

A lecturer is disillusioned with the current feedback system. The feedback results are available only after the semester has ended so there is no chance to rectify any weaknesses in teaching methods of whichthe lecturer is unaware. How useful it would be to have regular feedback after each major topic, but the department is unable to provide the resources to make it possible!

These and other scenarios when it is necessary for an educator to be able to sense the response of the class to teaching/planning and to have an immediate presentation of the analysis results (so as to be able to respond to them in the most timely manner possible) set the motivation for the work in this paper. Our key objective has been to develop mobile real-time feedback systems which can be utilized by essentially the whole class of students without having to impose any noticeable costs on either the students or the school during the process, and without requiring expensive equipment to be installed in the classroom.

SHORT MESSAGING SYSTEM (SMS) AS FEEDBACK MECHANISM

Mobile subscriber penetration rate amongst tertiary students has been increasing and is expected to continue growing. It is now uncommon to come across a tertiary student who does not own a mobile phone with a basic function like SMS. In addition, with mobile messaging fast becoming a communication tool by choice amongst the students and the general public, the use of mobile messaging as the base mechanism for feedback of information has the highest potential as the mechanism which will attract ready participation from the largest pool of students. In Singapore, SMS is now a standard part of any mobile service subscription and there is no additional subscription fee necessary, unlike other services such as WAP/GPRS. In addition, no training is necessary on SMS to students at this level when many junior schools students are already highly proficient at messaging via their mobiles.

The utilization of mobile messaging for surveys, call for donations during charity shows, or request for latest soccer results etc., is already widely, some say rampantly, available in countries with high mobile service penetration rates [4]. While such uses have been rapidly evolving, the systems design and architecture generally utilize SMS on either a GSM modem or an SMS Gateway, as shown in Fig. 1.

For approaches based on the GSM Modem, the software is normally a desktop application on a stand-alone computer system running Windows or Linux [5]. The desktop application provides the user with ownership over the mobile number, but it only supports a single user usage. The setup requires a computer installed with both the GSM modem and the messaging program. As such, this system has a low accessibility factor as the user needs to be physically present at the computer to access the system. For approaches based on the SMS Gateway, the Mobile Service Providers run a web application on which clients can access through a web browser [6]. While this approach may offer higher mobility, it clearly also requires the explicit service and support of the service providers, with no owner having direct ownership of the system.

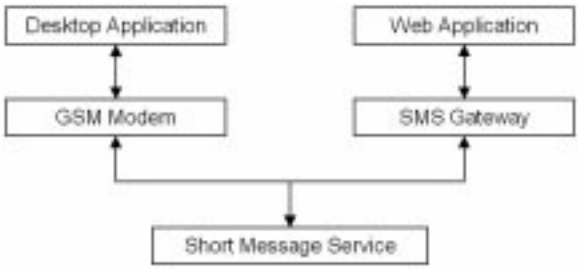

Fig. 1. Current SMS systems.

Thus, these approaches either require the support of a service provider or they are not amenable to supporting mass users and at the same time efficiently reconfigure (time- and cost-wise) to seek a variety of feedback. In fact, a variant of these architectures which can satisfy the low cost, wide participation base, and absolute controllability aspects of the application, have been designed and implemented.

PROPOSED SOLUTION

Constituent processes in the feedback system

There are generally five main processes that need to be present in the mobile messaging feedback system.

(1) The question(s) must first be conveyed to the targeted students.
(2) The feedback in the form of incoming messages must be consolidated for subsequent analysis.
(3) A categorization process will categorize the incoming messages corresponding to the survey/question(s) they are intended for.
(4) The user/responder information should be identified and correlated to the response received.
(5) Data processing will be necessary to yield the statistics which are needed by the initiator of the feedback session.

The five processes are listed in Table 1.

Table 1. Processes in the mobile messaging feedback system

Steps	Process
1	Question Dissemination
2	Message Collection
3	Survey Identification
4	User Identification
5	Data Processing

Their specific functions and interaction within the messaging system are shown in Fig. 2.

A simple example is given below to illustrate the processes and how they will work together to fulfil the functions of the feedback system.

A lecturer is in her office when she wishes to post her class a question on whether they have the basic

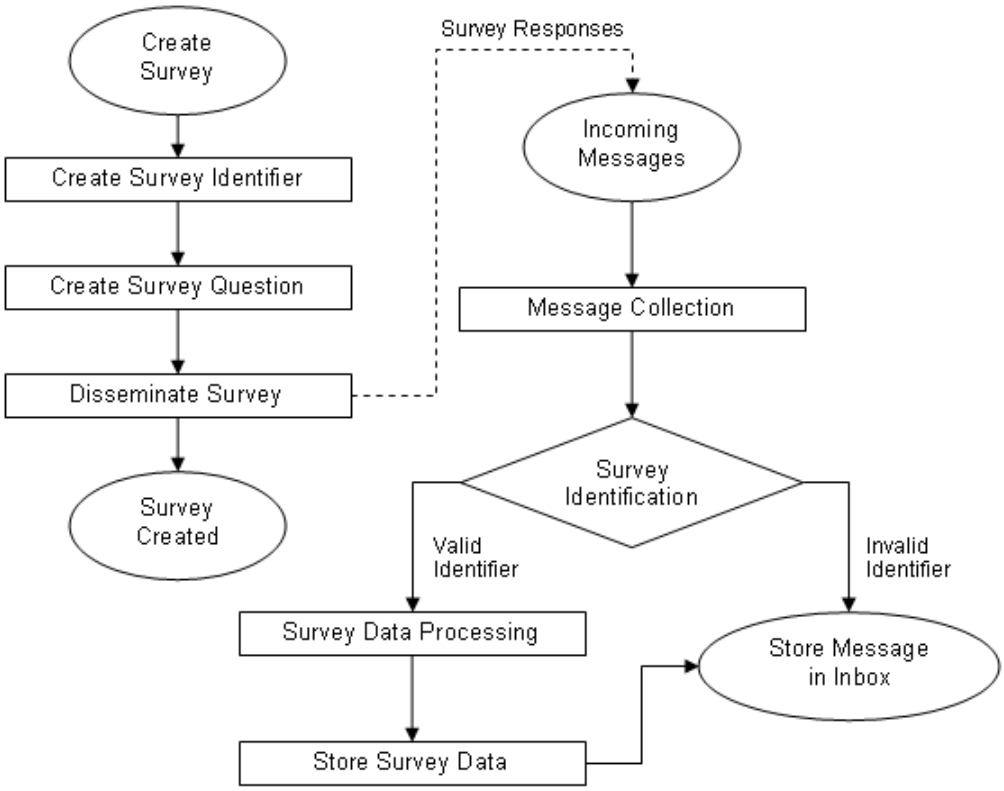

Fig. 2. Processes and data flow in the mobile messaging feedback system.

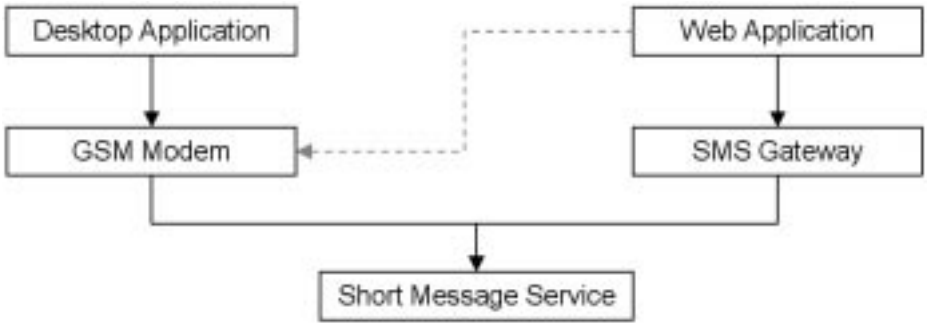

Fig. 3. Proposed web application using GSM modems.

knowledge of System Control, so she can decide if she needs to go through the basic concepts in her Advanced Control class. She logs on to the SMS Feedback System web portal to create a survey with two options (yes and no) and a unique identifier (control). The question can then be posted onto the whiteboard during class. The students participate in the survey via SMS with either 'control yes' or 'control no'. Once the SMS reaches the server, the survey is identified by the first word 'control' and the student is identified by the mobile number. The answers will then be processed according to the two options available. The processed outcome in terms of the percentage of students with and without prior control knowledge will be made available.

System configuration

The proposed system should be able to support multiple users and multiple ongoing surveys. To facilitate operational independence, reconfigurability and future expansion, it is also desirable for the surveyors to have direct physical ownership over the mobile number in the form of the Subscriber Identity Module (SIM) Card. However, the current systems depicted in Fig. 1 are not able to fulfil both attributes. A web application based on a GSM modem is potentially able to offer direct ownership, as well as support multiple users and multiple ongoing surveys.

A proposed architecture is given in Fig. 3, and the physical configuration of this system is shown in the block diagram of Fig. 4.

In this proposed configuration, an SMS feedback web application is developed based on a GSM modem. The web application is built totally on Java Servlet API, Java Communication API and Java Activation Framework. The application

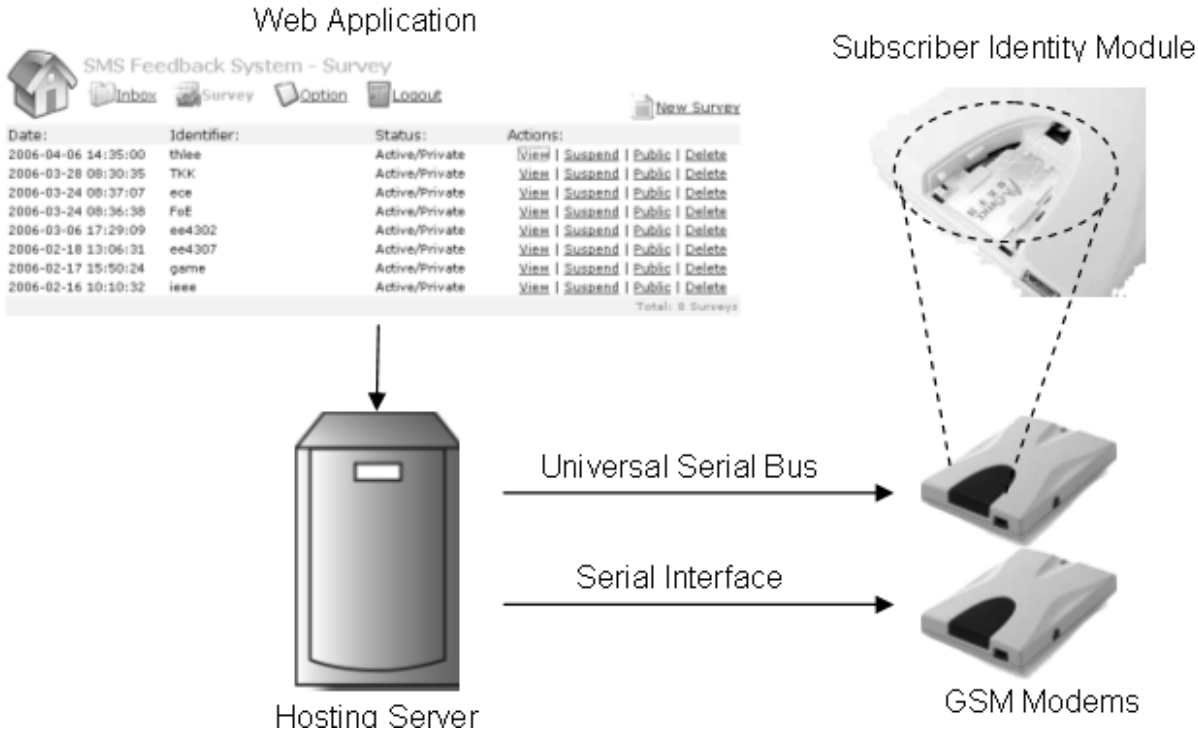

Fig. 4. Physical configuration of web application using GSM modems.

is deployed on Apache Tomcat 5.5 and the Windows 2003 Server Operating System. The computer is linked via USB interface to a GSM modem and GSM communication is enabled by a SIM card from a local mobile service provider. Users are able to create, view and administer the SMS feedback using either the internet browser or SMS administration tools.

The main challenge in developing the multiuser web application on the GSM modem lies in the synchronization of simultaneous access to the GSM modem. While web applications are built for simultaneous access by multiple users, GSM modems are basically serial devices operating on AT commands. When multiple users simultaneously attempt to send and receive messages, there is a primary need to synchronize the read and write operations executed on the GSM modem.

Furthermore, each messaging action consists of multiple AT commands in sequence with responses from the GSM modems (see Table 2). Therefore, there is a secondary need to synchronize the respective messaging actions which may contain multiple read and write operations. The implementation deployed by us for evaluation uses two Java monitors to synchronize both the basic read and write operations. In addition, each messaging action should also consider the various serial port interrupts that are enabled in the interrupt register. For example, Data Available Interrupt may occur to indicate an incoming SMS.

Table 2. Sending an SMS text message

Steps	Actions
1	Enters Messaging Monitor
2	Disables Data Available Interrupt
3	Enters Read/Write Monitor
4	Transmits "AT+CMGS=+123456789"
5	Leaves Read/Write Monitor
6	Enters Read/Write Monitor
7	Receives ">"
8	Leaves Read/Write Monitor
9	Enters Read/Write Monitor
10	Sends "Hi" following by CTR-Z
11	Leaves Read/Write Monitor
12	Enters Read/Write Monitor
13	Receives "OK"
14	Leaves Read/Write Monitor
15	Enables Data Available Interrupt
16	Leaves Messaging Monitor

System administration

The administration of mobile messaging feedback in web and desktop applications has largely been confined to a graphical user interface application. The possible administration through SMS has not been well explored. With administration through SMS, the user will be able to access the final processed data through a mobile device. This will greatly expand the application of the feedback system as there is no need for even a web browser to access the web portal. Feedback can be conducted even during outdoor field educational trips where there is no computer available. Administrative functions, suitable for SMS administration, include the listing, viewing, posting, editing and deleting of surveys.

Each administrative action must be identified with a unique keyword. The main consideration is that the SMS text messages must be confined to

Table 3. SMS-based feedback administration

Administrative Actions	SMS Keywords (Example)
Listing All Surveys	LIST < ALL or ACTIVE or SUSPENDED>
Viewing Survey Results	VIEW <SPACE> <IDENTIFIER>
Posting Survey	POST <SPACE> <IDENTIFIER> <SPACE> <QUESTION>
Editing Survey	EDIT <SPACE> <IDENTIFIER> <SPACE> <ITEM NAME = VALUE>
Deleting Surveys	DELETE <SPACE> <IDENTIFIER>

supported character sets and message length. All English characters-based SMS text messages must be confined to 160 characters while Unicode characters-based SMS text messages must be confined to 70 characters. The identity of the administrator can be further established through the mobile number of the sender of the message.

This constraint can be overcome by concatenated or multiple SMS messages. In such cases, a mechanism should be designed to identify and arrange SMS messages that may arrive out of sequence. This mechanism will be similar to the commonly known methodology used in TCP/IP. However, unless the automation of the SMS indexing and rearrangement can be automated at the sender end, its usage can be complex and tedious.

With this system, any message received from the predetermined administrator mobile number will be checked for administrative action keywords (LIST, VIEW, POST, EDIT and DELETE) associated with the respective administration actions, as shown in Table 3.

To avoid problems on character case error, keywords identification will be case insensitive. Upon detection of the administrative action keywords, the message will be further examined for the specific administrative action commands. If the command is correctly resolved, an SMS text message containing the results will be sent back to the administrator. If there are formatting or system errors, it will alert the administrator with an SMS text message containing the error code and corrective action advices.

ALTERNATIVE MOBILE APPLICATION APPROACH

The proposed system requires modest equipment, including a GSM modem. A completely mobile version of the SMS feedback system has been developed as a Java application for mobile phones, thus doing away with even this requirement. The application targets users who desire full privacy and maximum portability. However, there will be some constraints with this totally mobile solution. Due to the small screen associated with a mobile device, and the difficulty in inputting text and tedious navigation with a mobile device, the application does not include the advanced features of the web application. Nevertheless, the mobile application will be able to perform similar though minimal functions of the web application, namely:

- Posting a new survey
- Listing all surveys
- Viewing a survey
- Deleting surveys
- Informing survey targets.

The equipment necessary in this setup is only the user's mobile phone installed with the SMS-feedback mobile application. Hence, the system is completely independent of the internet or a third-party server. The phone-based application can be deemed as a logical evolution of the current desktop-based application as it is able to offer the same set of features without the need for additional GSM modem equipment.

The mobile application is built on Java 2 Mobile Edition (J2ME) using MIDP2.0 profile and CLDC1.1 configuration with JSR-75 package (access to Personal Information Management data and file systems). It is compatible with mobile phones having the specifications above and can be downloaded to the mobile phone via either data cable, Bluetooth or WAP Push. The application has been tested on the Nokia 6630. All administrative functions for the SMS Survey can be controlled with the Java mobile application.

In any new mobile application, the surveyor will be prompted to input an identifier (unique to the other existing surveys stored in the mobile phone), the survey question and the list of survey targets to SMS about the new survey from an address book. A survey question message may look like this: From Prof Tan: Rate the exam difficulty on a scale of 1 to 5, in increasing order of perceived difficulty. Reply 'exam <Ans>'. In this example, the name 'Prof Tan' is configured in the mobile application setting and 'exam' is the survey's identifier. A survey target may respond by sending a SMS in the following format: 'exam 3'. The SMS will go into the surveyor's mobile phone's SMS inbox like any other SMS. At any time, the surveyor may choose to look at the survey results. The application will search through the SMS messages in the inbox having the message starting with 'exam', update the survey database accordingly, delete the SMS messages and display the information to the surveyor. These processes are summarized in Fig. 5.

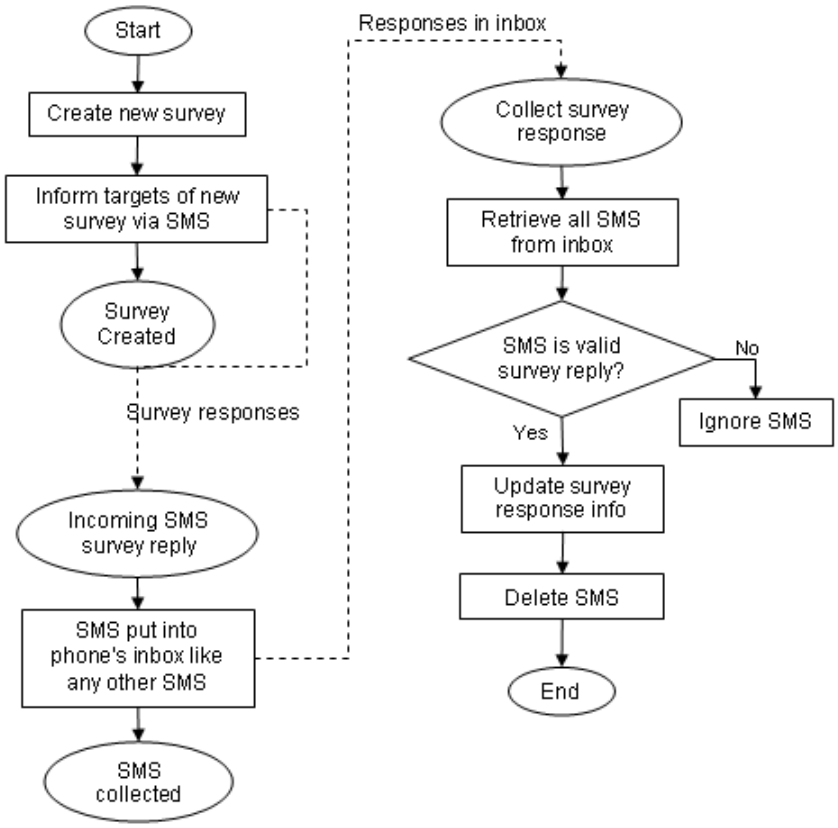

Fig. 5. Processes in the mobile messaging feedback application on mobile phones.

Table 4. Deployment costs

Item	Costs
Integno GSM modem (series 3000)	SGD$250
Intel Pentium 4 2.8 GHz, 512 KB Ram, 40 GB Hard disk Computer	SGD$700
Server 2003 Operating System (Academic Edition)	SGD$200
Prepaid Subscriber Identification Module	SGD$18
Total:	SGD$1168

IMPLEMENTATION AND EVALUATION

Deployment cost

The deployment cost for the equipment and software used for the setup as depicted in Fig. 4 is shown in Table 4.

The alternative mobile application presented above 4 will incur even far lower deployment cost since the GSM modem, computer and operating system will not be necessary.

Operation costs

With the use of the GSM modem and prepaid card, there is no direct operation cost involved in receiving the SMS feedback. For the purpose of SMS administration, the server will need to respond to SMS admin commands with a SMS response. The sending of SMS responses generally comes with a fixed unit cost. The current operational cost structure is given in Table 5.

The same operation costs can be expected for the alternative mobile version of the solution.

Illustration of the processes

To use the web version of the SMS Feedback System, a user would log in to the web site (the URL for our test server is http://137.132.165.18/SMSFeedback Upon logging in, the user would see the SMS Feedback System Inbox as shown in Fig. 6. On the navigation bar in the order from left to right, the inbox contains a list of incoming SMS replies, the survey link leads to survey management

Table 5. Operational costs

Item	Costs
Sending SMS	SGD$0.05 / SMS
Receiving SMS	Not Applicable

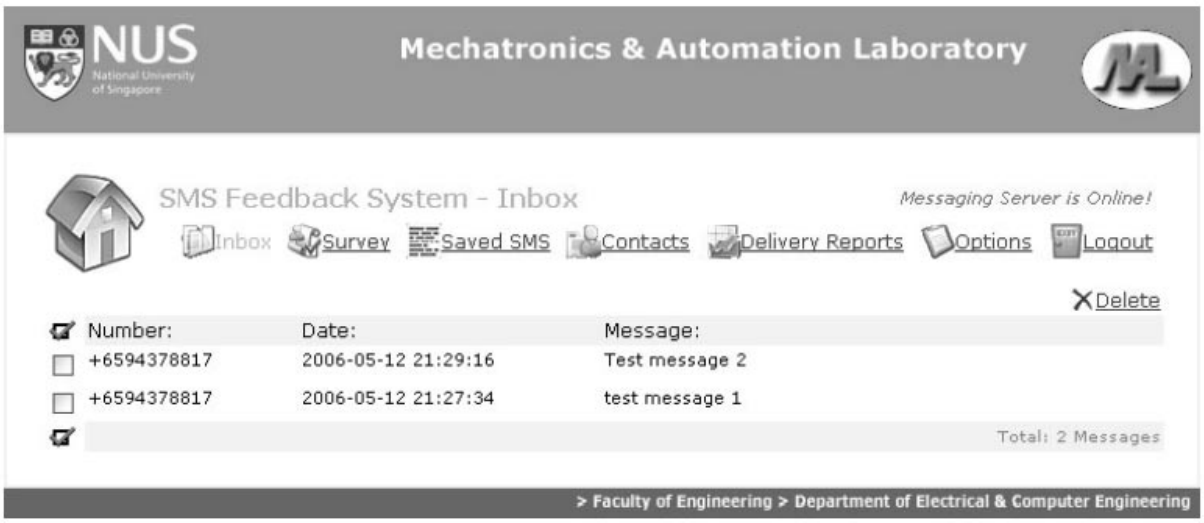

Fig. 6. SMS feedback system—inbox.

and the listing of existing surveys; the saved message link enables users to compose and send SMS to individuals and groups, mobile contacts can be stored and retrieved through the contacts link, the delivery report link allows users to check on the SMS delivery status, the admin option link allows the user to change settings and the logout link will exit the user from the web application.

Users of the SMS Feedback System for the first time should click on the Admin Option to specify the administrator's settings as shown in Fig. 7. The settings include the user's name which would be appended to the survey for identification by the people who receive the survey questions, a mobile phone number for administrator verification and preferred administrative keywords.

To create a survey or view a list of current surveys, the user clicks on Survey from the main menu. On this section of the web service as shown in Fig. 8, there is a list of existing surveys that have been created by the user, each with a list of actions which the user can perform on the surveys. The user can also create a survey by clicking on the new survey link located at the top right. From there, he would create the survey question and the survey options as shown in Fig. 9.

Following creation of the survey, the system is ready to receive feedback. The system contains

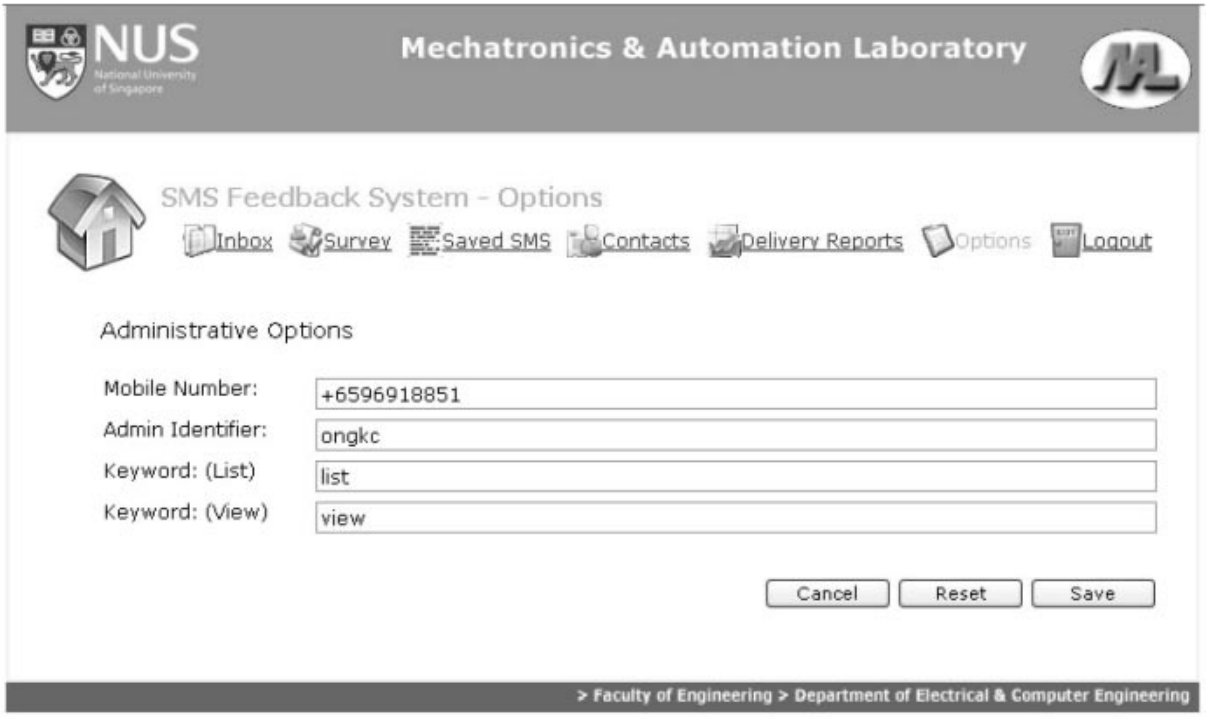

Fig. 7. SMS feedback system—administrative options.

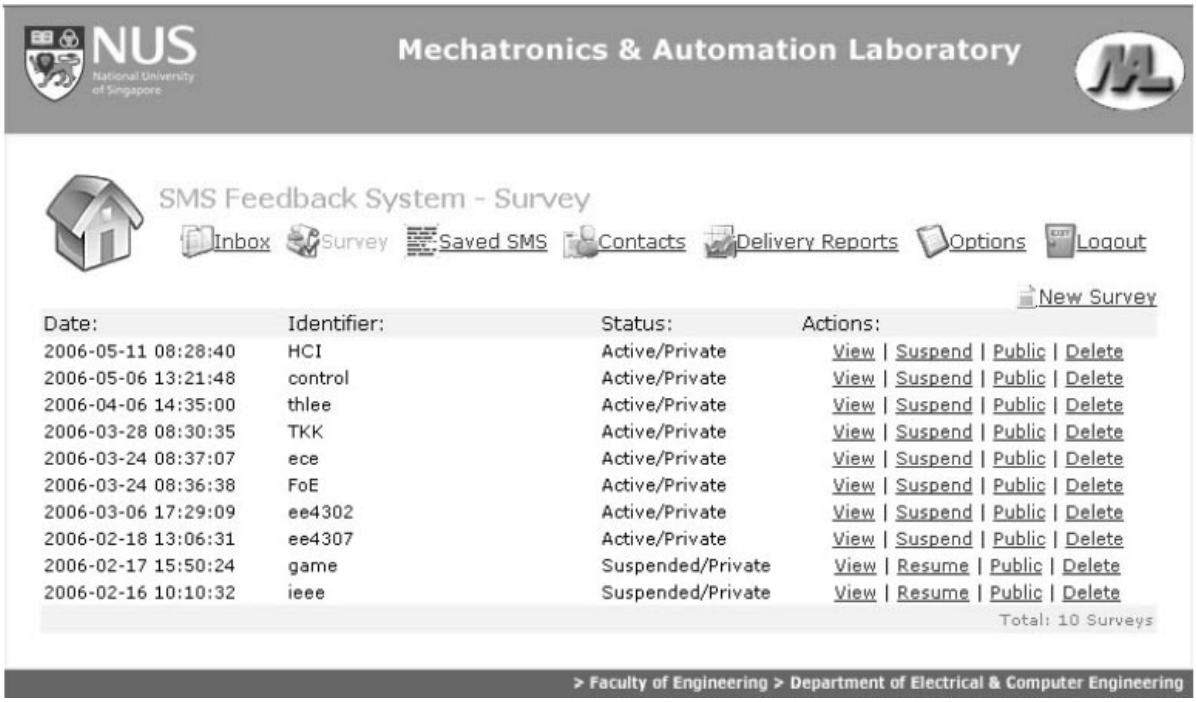

Fig. 8. SMS feedback system—survey section.

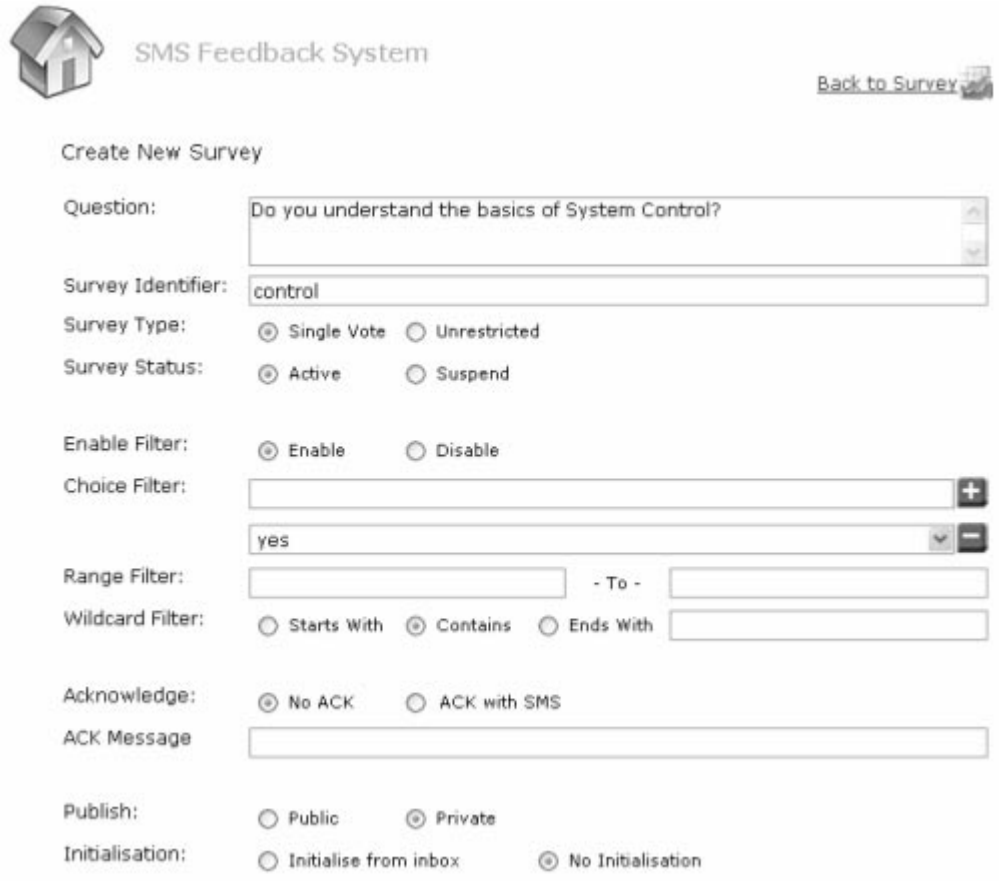

Fig. 9. SMS feedback system—creating a new survey.

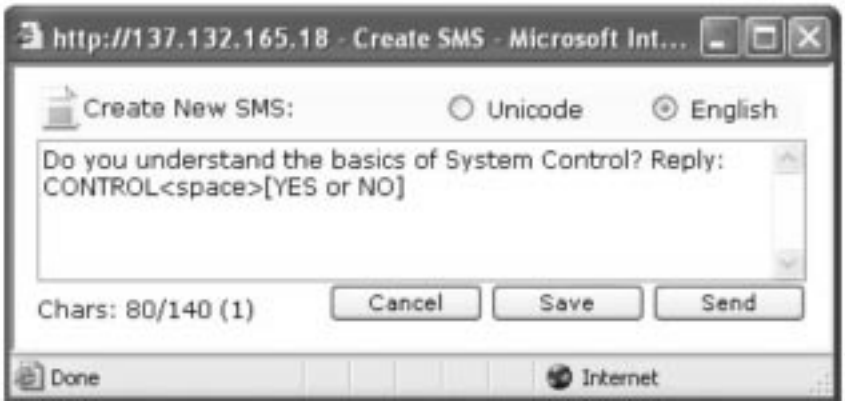

Fig. 10. SMS feedback system— compose SMS.

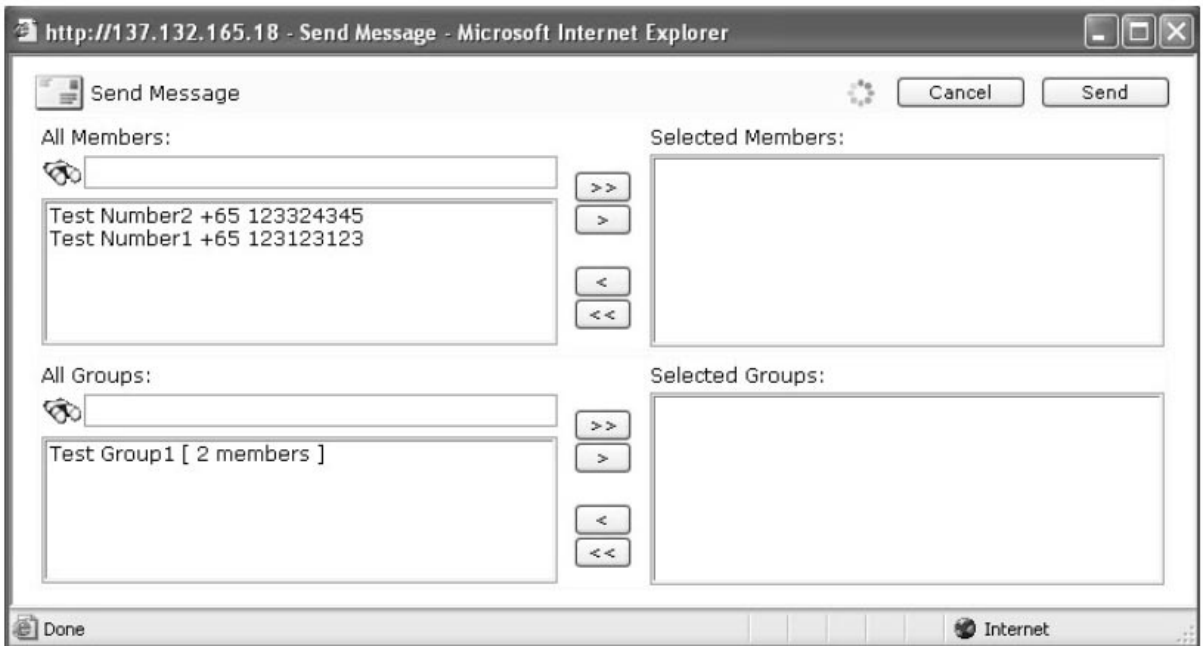

Fig. 11. SMS feedback system— send SMS.

further capabilities to compose and disseminate the survey question via SMS as shown in Figs 10 and 11. In Fig. 10, the user can compose the SMS with the survey question together with the method for taking part in the survey.

In Fig. 11, the user can send the SMS to selected individuals and groups from the contacts lists. When the user wishes to look at the response of a survey, he would click on the *View* action corresponding to the survey. An example of the view result is shown as Fig. 12.

The user will also be able to see all the responses for all the surveys in the Inbox option found on the main menu. To do this, it is not necessary to have access to a web browser in order to view the results. Results may be sent to a mobile in the form of an SMS through an administrator view SMS command to the server, i.e. admin view control. An example of the SMS response from the survey view request is shown in Fig. 13.

For the SMS feedback mobile application, an example of the user interface on the mobile phone is shown in Fig. 14, which also shows the main menu displaying a list of items available upon starting the application.

The 'Settings' option in the main menu allows the user to specify a name for identification by recipients of SMS surveys. The user can create a new survey by selecting 'New Survey' from the main menu. Figure 15 shows the page sequence in so doing.

The user can also view an existing survey by selecting 'View Survey' from the main menu. Figure 16(a) shows the list of surveys that have already been created. Figure 16(b) shows the top view of the survey with the identifier, exam and Figure 16(c) shows the bottom (scrolled down).

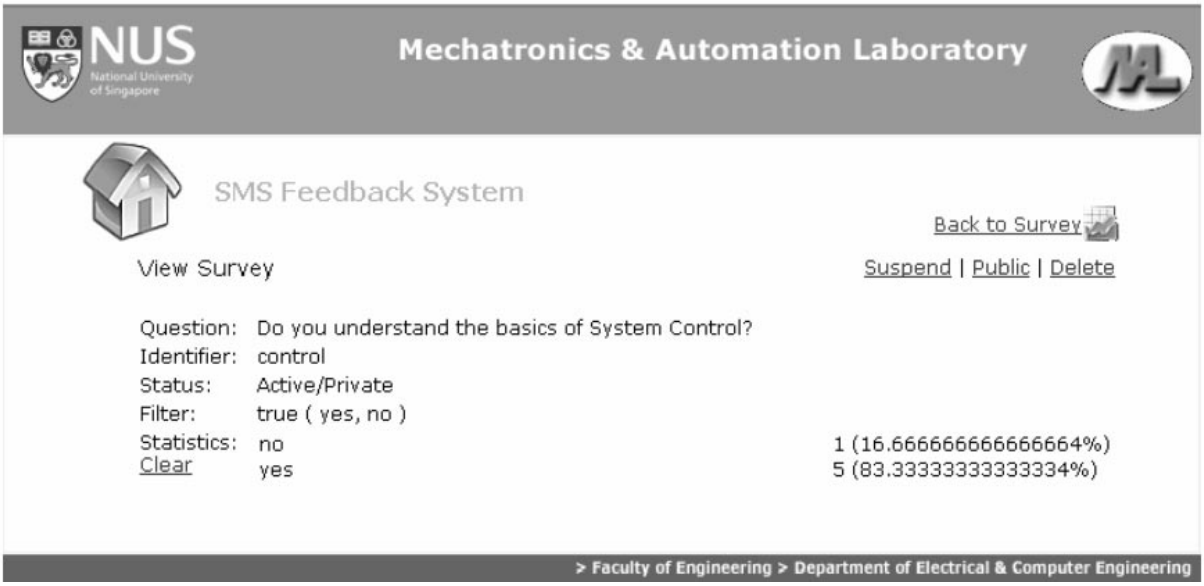

Fig. 12. SMS feedback system— viewing survey results.

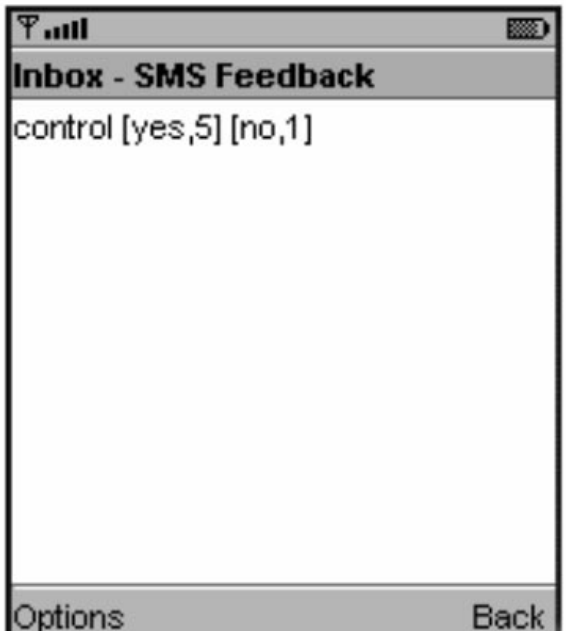

Fig. 13. SMS feedback system—viewing survey results.

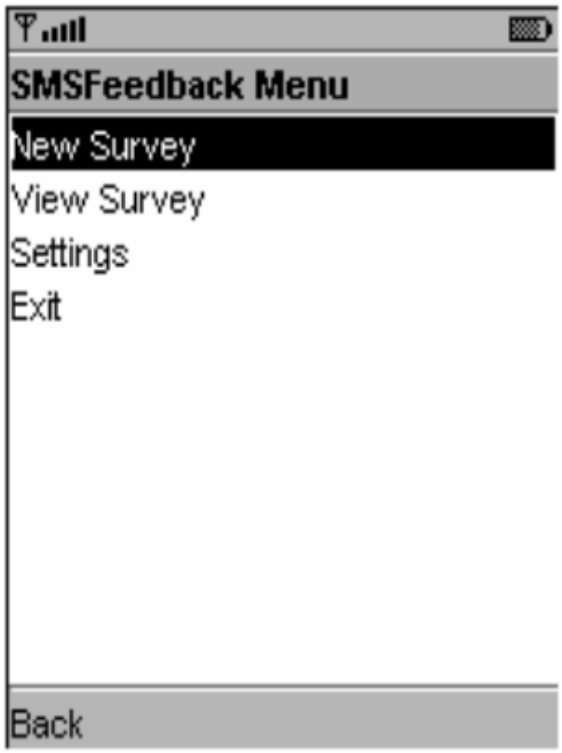

Fig. 14. SMS feedback mobile application—the main menu.

Application scenarios

The mobile feedback system has been used in the following applications:

- Adaptive teaching

  The system has been used in a class of 50 students over a semester to serve as a fatigue level check for the lecturer to decide, in real-time, the approach to adopt for the latter part of the lecture, depending on the students' concentration level. The lecturer has found the feedback very helpful in deciding on a next course of activities for the lecture, which can be giving a break, doing a quiz or continuing with original plans.

- Immediate teaching feedback

  The system has been used in three classes of 50, 80 and 120 students, to collect immediate feedback on the teaching of a guest lecturer as well as the students' perception of the difficulty of quizzes conducted in class. With the system, feedback is available minutes after the request is transmitted to the students. Such a scenario has not been possible in a normal modest classroom, before the implementation of the system.

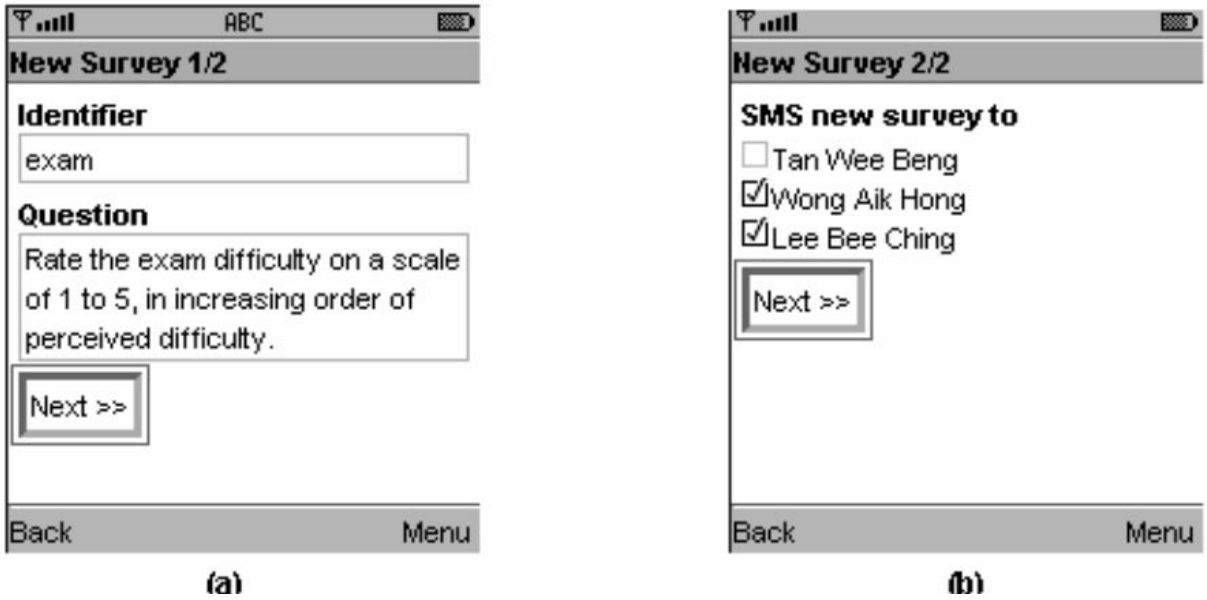

Fig. 15. SMS feedback mobile application—creating a new survey.

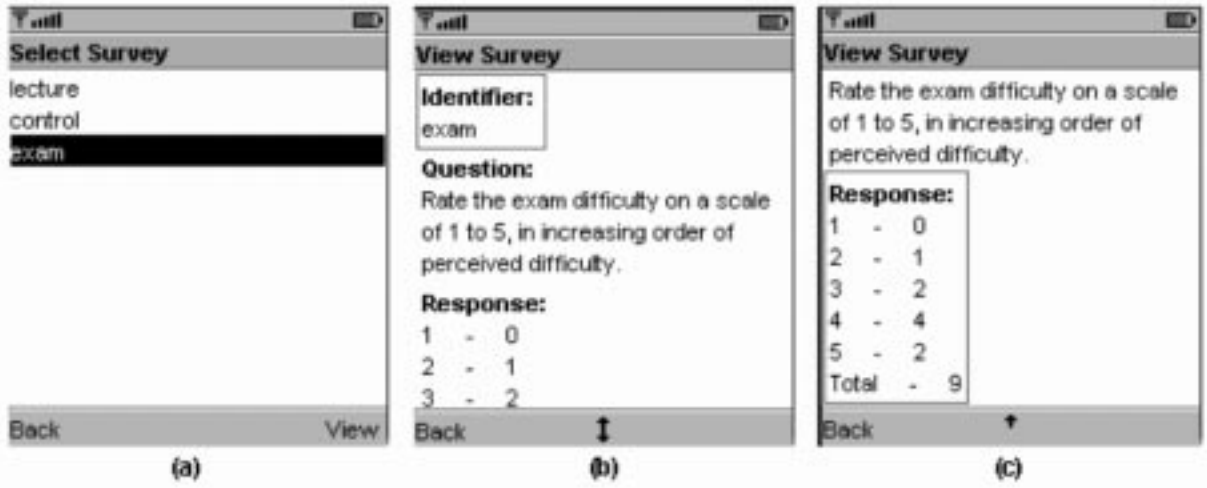

Fig. 16. SMS feedback mobile application— the main menu.

- Class planning
  The system has been applied to a class of 120 to allow the immediate scheduling of a make-up class based on the date and time (out of a range provided) when a maximum number of students can make it. Such logistics arrangement used to be quite a tedious chore.
- Outreach survey
  The system has been applied to students outreach activities by a survey of their relative interest in a whole range of programs available at the National University of Singapore, as well as for prospective students to message for query and attention during the university open house when a large turnout is expected.

There has been no problem with the infrastructure of the system. Close to 100 per cent of students in the classes where the system is being experimented with, own the necessary mobile to facilitate the feedback. Feedbacks from the students themselves also show that the small cost is not a problem to them. The major problem pointed out is the privacy of the mobile number as the number will appear along with the feedback in the Inbox. However, this problem can be solved by providing students with an option (via a simple identifier in the message) as to where they would mind their numbers been made available to the administrator. If the student would like to keep the number private, the application will blank off the numbers from the survey response.

FUTURE EXPANSION

Use of a web server with a GSM modem is not limited to SMS surveys. Future expansion of the

system includes GPRS or 3G surveys which can be more interactive and contain richer contents. This is especially feasible with the expected lower cost of mobile data transfer, and for countries like Thailand, India, Japan, Korea and China where unlimited data rate is offered by some mobile phone operators at a flat rate. Future work on a similar setup in the education scenario includes mobile collective learning where students can use their mobile devices to capture videos or photos, make audio recordings or write notes and have them uploaded to a centralized server.

CONCLUSIONS

Mobile technologies have continued to enable new innovations and approaches in education. The development of a mobile real-time feedback system has been presented in this paper, with details of its requirements, configuration, functionalities and implementation. An alternate version of the system based on mobile application is also presented, offering an integrated solution which does not require a separate GSM modem.

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