IJCAT - International Journal of Computing and Technology, Volume 3, Issue 9, September 2016
ISSN : 2348 - 6090
www.IJCAT.org

Collaborating USSD Platform in Web-Based Student Registration

Rajab Philip Muchiri

Computer Science Department
Egerton University
20115 Njoro, Kenya

Abstract - The number of students joining universities is increasing fast congesting existing registration systems. Online registration with student web portals common in many institutions of learning was adapted to solve this problem. Online registration has helped alleviate some of these problems, however it has not entirely eradicated the problem. Long queues and delays are still experienced during registration exercise. The reason is due to the huge number of students trying to access the web simultaneously. Accessing the web through the internet becomes slow and tedious process. The purpose of this research is to demonstrate the application of USSD protocol in students registration system. The USSD platform described below is not intended to substitute existing systems, but rather to enhance the reach of facilities to the target users using the most popular and commonly available technology with student populations.

***Keywords* - USSD Protocol, Mobile Communications, SMS.**

1. Introduction

Information, Communication and Technological (ICT) advances has triggered the transformation in education sector[1]. The number of students joining universities and institutions of higher learning continues to expand in order to sustain in the global competitive environment. Automated service delivery is common in many aspects of administration and management. Administrative duties are evolving quickly from the use of manual to desktop and from desktop to ubiquitous and cellular devices administration. Mobile Service(MS) delivery is the use of mobile wireless devices to provide services. MS delivery is not intended to substitute the existing administration system, but to enhance the reach of facilities to the target users. It presents the alternate means to provide all round the clock services[2]. Hence the primary idea is not to convert all computer based tasks to mobile depended, but to consider how best the mobile phone can be used to strengthen overall administration policy. Mobile technologies (i.e. SMS, USSD, geo-location, etc.) are nowadays used in the domains of citizens' participation[3], public awareness[4], management of emergencies and crisis[5], provision of public services[6], information, etc. to reach wider population segments (as compared to those currently accessing the Internet). It is well known that mobile phones have become in recent years the most ubiquitous communication device worldwide, with higher penetration rates than the Internet. ICT, as seen in many developed institutions, also facilitates a freer flow of information between institutions and stakeholders and opens up for opportunities for stakeholders to participate more directly in influencing decisions that affect them. From student populations to faculty and staff, nearly every user interaction that is taking place from a desktop browser is also occurring through smaller-screen phones and tablets[7]. From visiting websites, to registering for classes, to checking final grades, people interact daily with educational institutions through mobile devices

2. Methodology

2.1 USSD Protocol

USSD is a communication protocol that enables text messages between a mobile phone and applications running on Global System for Mobile Communications (GSM) networks[8]. Unlike SMS, USSD provides session-based connections utilizing the signaling channel to send data. Instead of having the store and forward functionality like SMS, it is session oriented, which means that when a user accesses a service with USSD, the session is established and the radio connection stays on until the user, application, or time out releases it therefore providing faster response times for interactive

IJCAT - International Journal of Computing and Technology, Volume 3, Issue 9, September 2016
ISSN : 2348 - 6090
www.IJCAT.org

applications[9]. The USSD Gateway supports GUI-based, menu-oriented service creation environment for definition of menu structures and integration with content providers together with internet interfaces to static messages web-based content providers[10]. The Gateway enhanced cell-switching features together with advanced session management capabilities of the USSD session manager enables session's preservation even when the subscriber changes cells[11].

2.2 USSD Architecture

Transactions in the USSD platform can be initiated either by the subscriber or the network. Figure 1 shows the USSD network architecture. It comprises; the Home Location Register(HLR), Visitor Location Register (VLR), Mobile Station Controller (MSC), Complex logic to support multiple applications within a single USSD platform, Simple Messaging Peer-Peer (SMPP) interface for applications to enable services, USSD Gateway and all specific USSD application servers[12]. USSD Gateway is open and can be integrated with any telecommunication system or device and the internet. Such features allow rapid deployment of new services and encourage existing messaging applications to leverage the USSD technology.

USSD services are housed as applications in the network where they can reside in the MSC, VLR, HLR or an independent server that is connected using SMPP through a USSD Gateway [13]. Such applications are under control of the mobile operator. Third-party applications are located in other telecom systems including the internet. When a message is not destined for an application in the VLR, MSC, or HLR; it is routed to the USSD Gateway by a USSD handler in these nodes using MAP protocol[10].

USSD code is interpreted by the gateway and routed to the corresponding USSD application server that contains the information requested by the customer. The relevant information is sent back by the application to the gateway which then formats the message into MAP and forwards it back to the user [11]. USSD modes of operations can be categorized into two groups; the mobile-initiated operations and the network-initiated operations. A session is created between the mobile terminal and the network for all information transfers in a mobile-initiated operation. Also, an application in the network may at any time send a message to a mobile station in a network-initiated operation [13]. In both cases, the session must be released upon completion before another session starts.

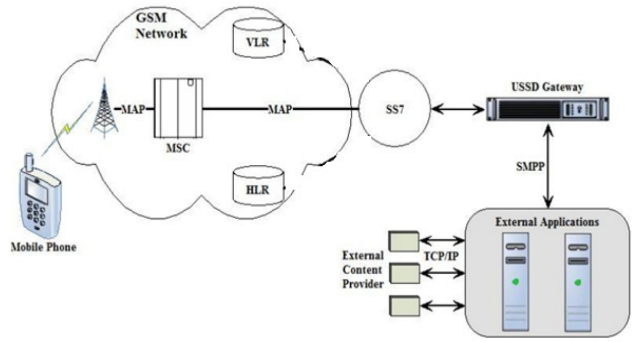


Figure 1:University Registration System Design

3. Design

3.1 Data Flow Diagrams (DFD)

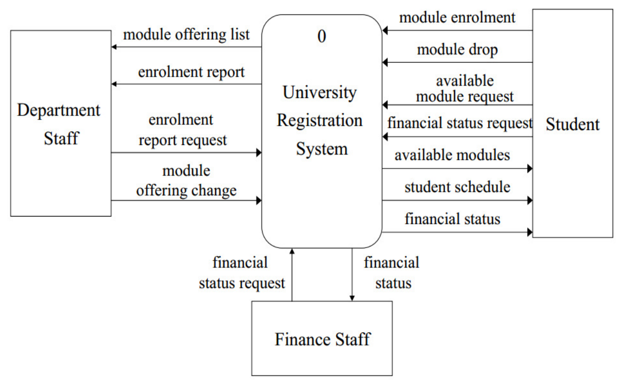


Figure 2: DFD

The system enables staff of each academic department to examine the modules offered by their departments, add, remove modules and change the information about them (e.g. the maximum number of students permitted). students can examine currently available modules, add and drop modules to and from their schedules, and examine the modules for which they are enrolled[14]. The department staff are able to print a variety of reports about the modules and the students enrolled in them.

The system ensures that no student takes too many modules and that students who have any unpaid fees are not permitted to register (students can verify their fee paying status). It is assumed that a fees data store is maintained by the university’s financial office and this data store is accessed by the registration system but the fees data store is not modified by the registration system[15].

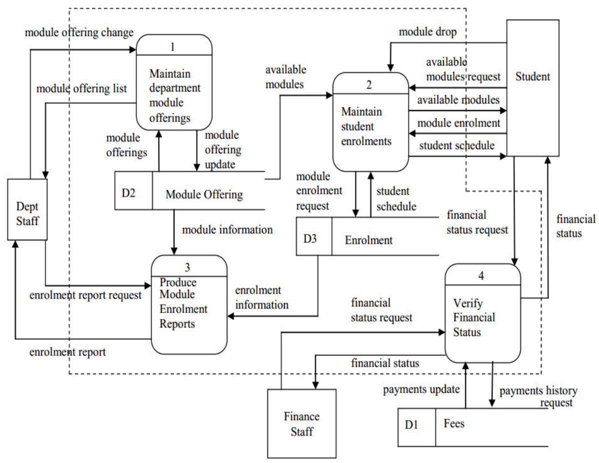


Figure 3: Decomposed DFD

Process 2 (maintain student enrolments) of the Level 0 DFD may be decomposed to a number of child processes[16]. The corresponding use case and user story can be used to guide the decomposition. The following are possible child processes that may be derived from level 0 DFD and the corresponding DFD for process 2 is shown below

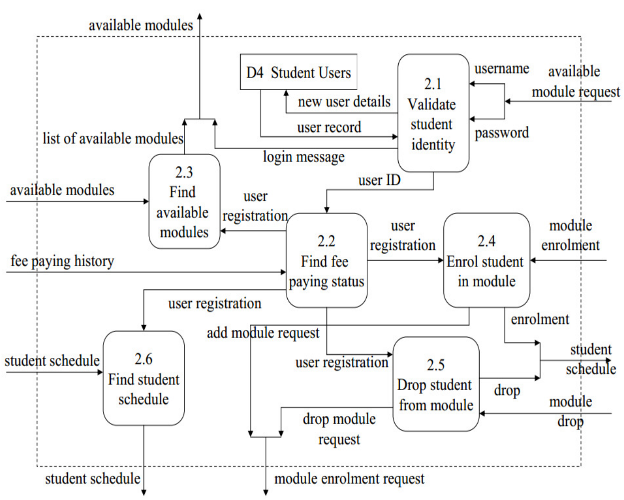


Figure 4: Process 2 Decomposed DFD

Based on the DFD diagrams described above, a use case diagram is constructed (fig4). It shows the relationship between the main actors {staff, students and financial staff } and the use-case scenarios[17]. The use-case scenarios are derived from the DFD data stores.

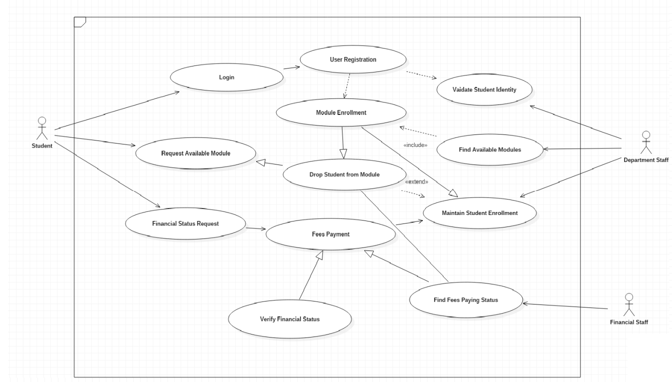


Figure 5: Use-Case Diagram

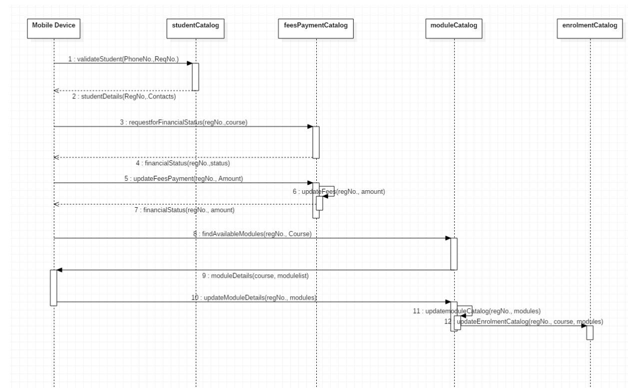


Figure 6: Interaction Diagram

An interactive or sequence diagram shows the message passing behaviour of components displayed on the horizontal axis[18]. The actual messages passed from one component to the next are numbered while timelines are shown on the vertical axis. Timelines show the time slag or delay from the time a message is send and the time it is replied. This leverages the corresponding USSD packet delivery time between when it is send and when a reply is received.

3.2 Accommodation Booking

In many universities, accommodation booking is treated separately from registration system. Upon request for accommodation, a student is required to make payments before confirmation for booking is done and subsequent award of a room. This can be modeled using DFD, use-case diagrams and interactive diagrams[16, 17, 18]. The zero DFD summarizes the whole process.

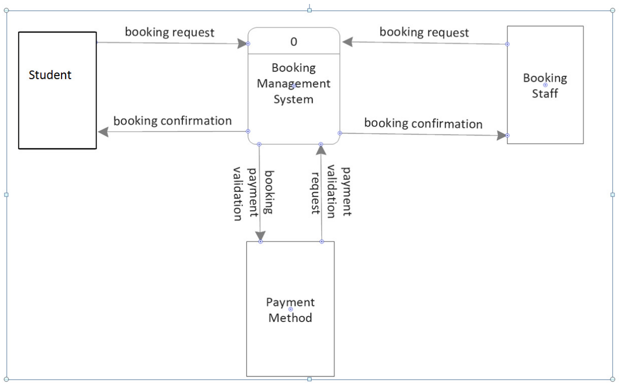


Figure 7: Accommodation Booking DFD

A student must first identify a room by searching from the rooms catalogue. Once a room is identified, the student logs in with the details and makes necessary payment arrangement before the booking is done. Payment arrangements include choosing a payment method such as M-pesa, airtel-money, PayPal or through a bank. Verification is part of payment processing that results in provision of a booking reference that enables a student to secure a room. The DFD below shows this process. Shown in the diagram are four data stores (D1 to D4) and five processes namely; search for room, login, booking, payment processing and payment validation. The information flows is indicated with directional arrows.

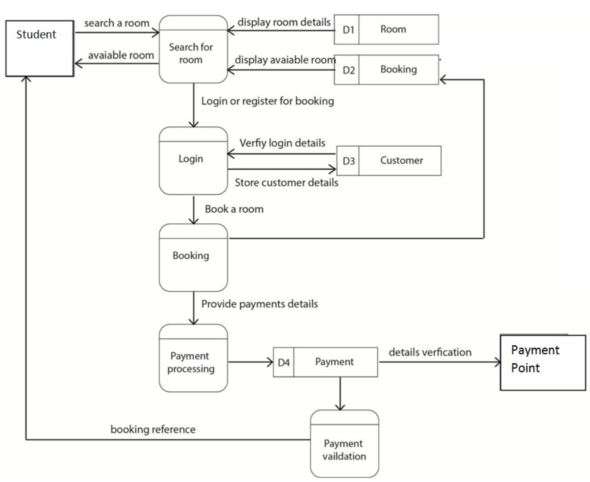
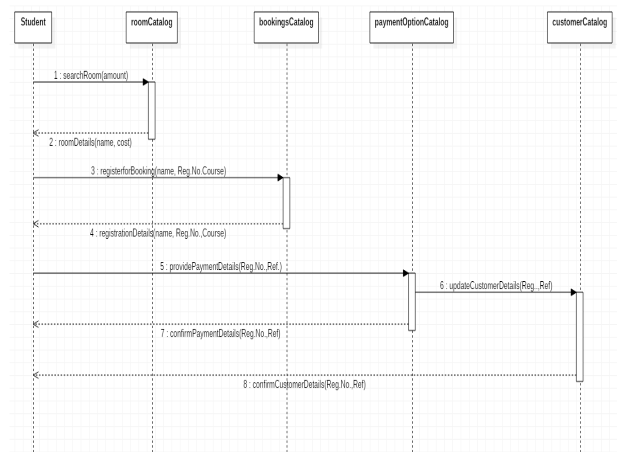


Figure 8: Accommodation Booking DFD Decomposed

Interactive diagrams leverages USSD message processing[19] that takes place between the mobile device used by the student and the system. The sequence diagram below shows message exchange between system components. The components are placed on the horizontal axis while timeline are shown on the vertical axis. Timelines represent the delay between when a message is sent and the time a reply message is received. Messages are numbered with an arrow showing the direction they are send to. Every component must do some message processing before a reply is made. The processing of the message takes a maximum of 2 seconds.



9: Accommodation Booking Interaction Diagram

Figure 2 shows an example of the MAP/TCAP message sequence required to realize the data transfers between a student's mobile handset and the USSD application to implement the “Accommodation booking” service described above[10].

1. The mobile-initiated USSD service commences with a mobile user dialing the USSD string (for example, *#333#). A TCAP dialogue is initiated following this, with a MAP_PROCESS_UNSTRUCTURED_SS_REQUEST service component sent to the USSD application platform[20].
2. The USSD application platform receives the request to initiate a USSD service from the mobile user. The platform determines the specific USSD service requested by checking the USSD string dialed. The USSD platform requests additional information from the mobile user via the MAP_UNSTRUCTURED_SS_REQUEST service[21].
3. The USSD platform receives the user’s response within a MAP_UNSTRUCTURED_SS_REQUEST return result component.
4. 4-7. The USSD application could request additional information from the mobile user several times for the same TCAP dialogue, each time the MAP_UNSTRUCTURED_SS_REQUEST service would be used, as shown in sequence 4 through 7[22].

at length, the network USSD application platform ends the TCAP dialogue, sending MAP_PROCESS_UNSTRUCTURED_SS_REQUEST return result.

In the above example, the USSD platform requests further information from the mobile user via the MAP_UNSTRUCTURED_SS_REQUEST service[10]. If the USSD platform did not require any further information from the mobile user, the USSD application could respond by sending a MAP_PROCESS_UNSTRUCTURED_SS_REQUEST return result component and ending the TCAP dialogue.

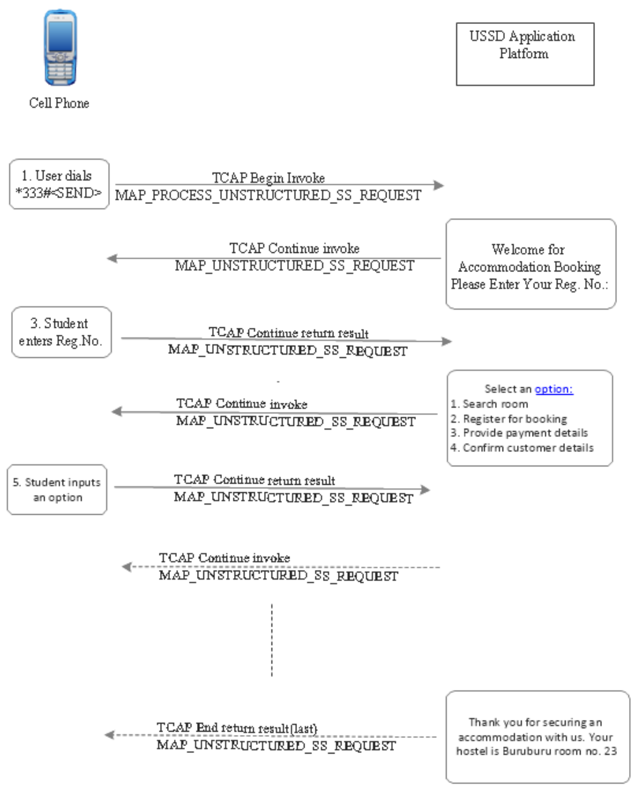


Figure 10: MAP/TCAP Message Sequence

Creating USSD Applications with **MAP Services (source Dialogic)**

The two MAP services "MAP_UNSTRUCTURED_SS_REQUEST" and "MAP_PROCESS_UNSTRUCTURED_SS_ REQUEST" are used to deliver text that forms the menus, questions, and answers between a network USSD application platform and a mobile user's handset. They are defined in [21] and both use parameters "USSD Data Coding Scheme" and "USSD String". This parameter details "the alphabet and the language used for the unstructured information in an Unstructured Supplementary Service Data operation."Encoding is according to 3GPP TS 23.038 section "Cell Broadcast Data Coding Scheme". The "GSM 7 bit default alphabet" encoded within the parameter as "00001111" could be encoded within a customer application as follows[10]:

```
/* USSD coding parameter */
bit _ set(req.pi, MAPPN _ USSD _ coding);
bit _ to _ byte(req.ussd _ coding.data, 0x1, 0);
bit _ to _ byte(req.ussd _ coding.data, 0x1, 1);
bit _ to _ byte(req.ussd _ coding.data, 0x1, 2);
bit _ to _ byte(req.ussd _ coding.data, 0x1, 3);
bit _ to _ byte(req.ussd _ coding.data, 0x0, 4);
bit _ to _ byte(req.ussd _ coding.data, 0x0, 5);
bit _ to _ byte(req.ussd _ coding.data, 0x0, 6);
bit _ to _ byte(req.ussd _ coding.data, 0x0, 7);
req.ussd _ coding.num _ bytes = 1;
```

A function MTU_str_to_def_alph() may be created that converts an ascii string into "GSM 7 bit default alphabet" encoding, following rules defined in [3GPP TS 23.038] useful for creating a USSD string text to send over a GSM network based on input from the user. The following code sample (based upon MTU source code) encodes a USSD string menu text:

```
/* USSD string parameter */
bit _ set(req.pi, MAPPN _ USSD _ string);
/** USSD string*/
mtu _ args.message= "Welcome for Accommodation Booking\n Select an option:\n 1. Search for room\n 2. Register for booking\n 3. Provide payment details\n 4. Confirm customer details";
num _ da _ chars = MTU _ str _ to _ def _ alph(mtu _ args.message, &req.ussd _string.data[req.ussd _ string.num _ bytes], &da _ len, MAX _ DATA _ LEN - req.ussd _ string.num _ bytes);
```

Below is a function that can be used to send the service MAP_PROCESS_UNSTRUCTURED_SS_REQUEST to initiate a USSD session. It is based on the structure of existing code for other MAP services supplied for the MAP Test Utility (MTU) .It indicates how to set the MAP service name for MAP_PROCESS_UNSTRUCTURED_SS_REQUEST and includes the USSD specific parameters "USSD Data Coding Scheme" and "USSD String" described above.

```
static int MTU _ process _ uss _ req (dlg _ id, invoke _ id) /* USSD */
u16 dlg _ id; /* dialogue ID */
```

```
u8 invoke _ id; /* invoke ID */
{
MTU _ DLG *dlg; /* dialogue data structure */
MTU _ MSG req; /* structured form of request message
*/
u8 da _ len; /* length of formatted u-data */
u8 num _ da _ chars; /* number of formatted*/
dlg = &(dlg _ data[dlg _ id]);
/*The following parameters are set in the MAP _
PROCESS _ UNSTRUCTURED _ SS _ REQUEST: ussd-
DataCodingScheme ussd-string - this will be entered by
the user e.g. *#123# */
memset((void *)req.pi, 0, PI _ BYTES);
req.dlg _ id = dlg _ id;
req.type = MAPST _ PRO _ UNSTR _ SS _ REQ _ REQ;
req.invoke _ id = invoke _ id;
bit _ set(req.pi, MAPPN _ invoke _ id);
/* USSD coding parameter */
bit _ set(req.pi, MAPPN _ USSD _ coding);
/* USSD coding set to 'GSM default alphabet' 00001111
as in 3GPP TS 23.038 'Cell Broadcast Data Coding
Scheme' */
bit _ to _ byte(req.ussd _ coding.data, 0x1, 0);
bit _ to _ byte(req.ussd _ coding.data, 0x1, 1);
bit _ to _ byte(req.ussd _ coding.data, 0x1, 2);
bit _ to _ byte(req.ussd _ coding.data, 0x1, 3);
bit _ to _ byte(req.ussd _ coding.data, 0x0, 4);
bit _ to _ byte(req.ussd _ coding.data, 0x0, 5);
bit _ to _ byte(req.ussd _ coding.data, 0x0, 6);
bit _ to _ byte(req.ussd _ coding.data, 0x0, 7);
req.ussd _ coding.num _ bytes = 1;
/* USSD string parameter */
bit _ set(req.pi, MAPPN _ USSD _ string);

/ * USSD string */
req.ussd _ string.num _ bytes = 1; /* USSD string, allow
byte for data length */
num _ da _ chars = MTU _ USSD _ str _ to _ def _
alph(mtu _ args.ussd _ string,
&req.ussd _ string.data[req.ussd _ string.num _ bytes],
&da _ len,
MAX _ DATA _ LEN - req.ussd _ string.num _ bytes);
/ * fill in the ussd _ string, the number of formated default
alphabet characters * /
req.ussd _ string.data[req.ussd _ string.num _ bytes - 1] =
num _ da _ chars;
req.ussd _ string.num _ bytes += da _ len;
/ * Operation timeout - 15 seconds * /
bit _ set(req.pi, MAPPN _ timeout);
req.timeout = 15;
MTU _ send _ srv _ req(&req);
return(0);
} /* end of MTU _ process _ uss _ req() */
```

The following code sample can be used to add support within MTU for the USSD version 2 application context, as defined in [3GPP TS 29.002]. Add the following definition to mtu.c:

```
/* new application context
networkUnstructuredSsContext-v2 */
static u8 networkUnstructuredSsContextV2[AC _ LEN] =
{
06,     /* object identifier */
07,     /* length */
04,     /* CCITT */
00,     /* ETSI */
00,     /* Mobile domain */
01,     /* GSM network */
00,     /* application contexts */
19,     /* map-ac networkUnstructuredSs */
02      /* version 2 */
};
```

Add the following code to mtu.c function "MTU_open_dlg" to make use of the USSD version 2 application context:

```
case MTU _ PROCESS _ USS _ REQ:
/*
* Send MAP _ PROCESS _ UNSTRUCTURED _ SS _
REQUEST
*/
for (i=0; i<AC _ LEN; i++)
req.applic _ context[i] =
networkUnstructuredSsContextV2[i];
break;
```

Below are mobile device screen shots obtained from these process. From the mobile device, a student dials 333 code request for a connection to the booking application. Once a connection is established, then the student can select from the available options to search for a room before registration for booking. Registration number is required during booking. A list of available rooms is displayed from which the student chooses and then selects payment options before booking can be confirmed.

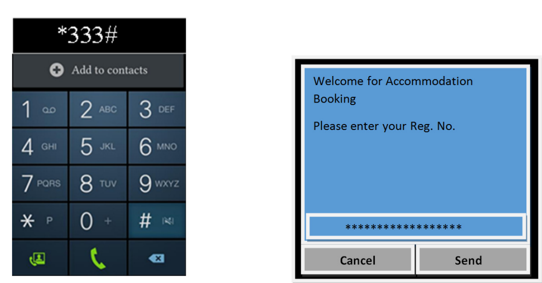


Figure 11: Mobile Phone and Screen short

Figure 12: Screen-short messages

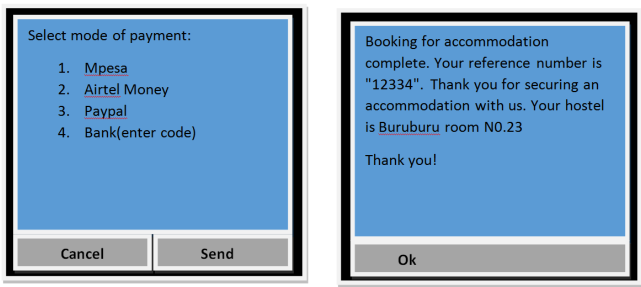


Figure 13: Screen-Short Messages

Evaluation:

	Poor	Fair	Good	Very Good	Outstanding
Originality	○	○	○	●	○
Innovation	○	○	●	○	○
Technical merit	○	○	○	●	○
Applicability	○	○	○	●	○
Presentation and English	○	●	○	○	○
Match to Journal Topic	○	○	○	●	○

Recommendation to Editors

	Strongly Reject	Reject	Marginally Accept	Accept	Strong Accept
Recommendation	○	○	○	●	○

Comments:

Accepted

Review comments to prepare final camera ready paper –

- Comments are provided into research paper.
- Technical contents on USSD protocol are very good.

4. Conclusion

This research has demonstrated how USSD platform can be cooperated in online student registration system. The purpose is to enhance registration management services. It is not meant to replace them but to enhance their usability. Though USSD protocol is efficient it however should be applied with caution. In GSM, all requests to Service Codes in the range *100# to *499# should go through the originator's home HLR while requests to code *500# and above in theory need to be handled by the VLR of the visited network and routed to a local USSD Gateway[23]. In ordinary circumstance, HLR validates by checking that the subscriber is active in its records and the service code is active and valid then routes the request via a USSD Gateway to the appropriate application. The application may perform its own validation during the session such as verifying the IMSI of the request or or performing multi-phase authentication. This may enable someone to sniff on the radio interface or to hi-jack it entirely and record these inputs for subsequent fraudulent use[24]. End-to-end encryption between a client (SIM toolkit or Java) on the handset and the application attached to the USSD Gateway is the only way of guaranteeing the security of such services[25].

References

[1] Shrinath S Pai J Meenakumari, (2013). SWOT Analysis of M-Governance in Higher Education Administration. International Journal of Computer Applications (0975 – 8887). International Conference on Current Trends in Advanced Computing "ICCTAC-2013"

[2] Maged F., (October, 2007). Automated Student Course's Registration using Computer Telephony Intergration. The International Arab Journal of Information Technology Vol. 4, No. 4 Oct 2007

[3] Angela C. and Leonida M., (2012). M-Governance: Exploratory Survey on Kenyan Service Delivery and Government Interaction IST-Africa 2012 Conference Proceedings Paul Cunningham and Miriam Cunningham (Eds) IIMC International Information Management Corporation, ISBN: 978-1-905824-34-2. iHub Research

[4] Omar Al-Hujran (March, 2012). Toward the Utilization of M-Governance Services in Developing Countries. International Journal of Business and Social Science Vol. 3 No. 5

[5] Rajab Philip Muchiri, Lucyann Muthoni Karani (October, 2015). Developing a Campus Emergency Management Information System (CEMIS) International Journal of Computer Trends and Technology (IJCTT) – volume 28 Number 2.

[6] iHub Research Report (November 2012). "Mobile Phone Usage at the Kenyan Base of the Pyramid".

[7] Maria R. Lee. Utilizing PDA for Campus M-Service, Department of Information Management Shih Chien University 70, Ta-Chih Street, Taipei 104, Taiwan

[8] Puneet Gupta (July 7, 2010). End to End USSD System. TATA Tele Service Limited, India.

[9] Taskin E., (2012). GSM MSC/VLR Unstructured Supplementary Service Data (USSD) Service, Uppsala University.

[10] Dialogic (August, 2008). USSD Service for Interactive Mobile Users. Building user friendly mobile telephony applications using Dialogic Distributed Signalling Interface Components.

[11] Sanganagouda J.,(2011). USSD: A communication Technology to Potentially ouster SMS Dependency, Aricent.

[12] Baraka W. N., Anael S. and Loserian S. L., (2013). Security Perspectives For USSD Versus SMS In Conducting Mobile Transactions: A Case Study Of Tanzania. International Journal of Technology Enhancement and Emerging Engineering Research, Vol. 1 Issue 338 ISSN 2347-4289

[13] Desai S., (2011). Mitigating Security Risks in USSD-Based Mobile Payment Applications. Aujas: Bangalore.

[14] Arielarnesto, (20th Dec 2011). Online Student Registration and Billing System

[15] E. Ramganesh E., Kirubakaran E. and Gobi R.,(August, 2015). A Roadmap for a Higher Learning Institution based m-Governance Framework in the Grey Revolution. International Journal of Advanced Research in Computer Science and Software Engineering. Volume 5, Issue 8. Available online at: www.ijarcsse.com

[16] Kendall K. and Kendall J., (2002). Systems Analysis and Design, Fourth Edition.

[17] Muchiri Philip Rajab, Zakary O. Bosire and Peter Kemei (2015). Development of a Web Based Electronic Procurement System International Journal of Advanced Research in Computer Science. Available Online at www.ijarcs.info

[18] Pressman B. and Roger S., (1999). " Software Engineering", Fourth Edition.

[19] Daniel T. K., (June, 2013). Unstructured Supplementary Service Data (USSD) Based Prototype for Credit Unions' Loan Request Processes in Kenya. Master of Science Thesis in Information Technology at Strathmore University.

[20] [3GPP TS 22.090] Digital cellular telecommunications system (Phase 2+);
Universal Mobile Telecommunications System (UMTS); Unstructured Supplementary Service Data (USSD); Stage 1

[21] [3GPP TS 23.038] Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); Alphabets and language-specific information
[3GPP TS 23.090] Digital cellular telecommunications system (Phase 2+);

[22] Universal Mobile Telecommunications System (UMTS); Unstructured Supplementary Service Data (USSD); Stage 2

[23] PMT Document Report. Secure USSD Facility for Financial Institutions Analysis and Recommendation Report. PMT Document No. PMT/AMR/USSD/SF version 2.0d1

[24] P. Kaur and K.K. Saluja, (February, 2012). A Review of Security issues and mitigation Measures in GSM. International Journal of Research in Engineering & Applied Sciences. Volume 2(Issue 2: p. 16.

[25] Toorani M. and A. Beheshti(2008). Solutions to the GSM security weaknesses in the Second International Conference on Next Generation Mobile Applications, Services and Technologies. NGMAST'08. 2008: IEEE.