# Incorporating Human Computer Interaction with Web Technologies to Augment Communication and Interaction in Higher Learning Institutions

## A Study Conducted at the University of Dar es Salaam

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*Abstract*— **Application of human computer interaction in interactive environments design plays a key role in communication and interaction augmentation between higher learning institutions especially when combined with recently improved web based technologies. The University of Dar es Salaam currently lack an effective and reliable web based communication and interactive application where University members and alumni can communicate and interact. Globally, Universities depend on alumni financial and academic contributions for their development, then the need for effective and reliable web based communication and interaction applications where only authentic University members and alumni can communicate and interact is vital.**

**This paper explores the challenges, approaches and recommends appropriate solutions that can be adopted to augment communication in higher learning institutions. The study proposes a communication and interactive model designed to only enable authentic University members and alumni to communicate and interact for overcoming the anonymity challenge as it persists much in recent social networking websites while enabling the University to easily benefit from financial and academic alumni contributions.**

**Human centred design process and human computer interaction life cycle were used with object oriented approach. An interaction model between University members and alumni was designed and used as a framework to guide the analysis and design of the desired communication and interactive model. The paper provides the conceptual, interface and navigational models of the desired communication and interaction model for effective and reliable communication and interaction augmentation in higher learning institutions. Finally, the study provides evaluation results from the model obtained against existing communication and interaction means.**

*Keywords- Web technologies, Evaluation metrics, Human Computer Interaction, Human Centred design, Interaction Model, Object oriented, MSCW.*

## I. INTRODUCTION

The Information and Communication Technologies (ICTs) development has made higher learning institutions globally to adopt and incorporate ICTs in teaching and learning while providing greater information access such as improved communication; synchronous and asynchronous communication; increased cooperation and collaboration, cost-effectiveness and improvement of educational methods and principles [1].

Communication enhancement among parties such as student to student, student to instructors, students to alumni were done under separate web based communication environments and lacked the much needed interactivity among the involved parties [2][3][4]. This study highlights issues to consider in overcoming those challenges for effective and reliable communication and interaction augmentation between higher learning institutions and their respective alumni.

Communication between higher learning institutions members and their respective alumni is fundamental for these institutions to easily benefit from alumni financial and academic contributions. Alumni can benefit by being provided with networking opportunities, career related events, opportunities to have continued access to the intellectual life of the University, latest research and opportunities to meet with old friends and renew their bonds with the University.

Current communication means at UDSM are limited as they can not easily be used to simplify important tasks at UDSM such as curriculum development, convocation, University expansion and other development activities. Challenges such as high communication costs especially phone accounts re-charge costs, transport costs, family and work responsibilities and the rapid increase in the number of enrolled students affect face to face and phone based communications.

Online communication and interaction at UDSM is achieved via electronic mails and social networking websites such as Facebook, Twitter and the like. However, with electronic mail there is a challenge of how UDSM members

and alumni can be able to get electronic mail addresses of their fellow members unless they know each other either through friends or they had already met face to face.

With social networking sites (SNs), the anonymity challenge prevents UDSM members and alumni to be sure if they are communicating with authentic UDSM members or alumni. This is because with SNs' it is easy for someone to pretend being someone he/she is not for his/her own reasons. This is among the challenges of SNs' as they allow users to register and communicate without requiring them to supply authentic identities to verify that the registered person is truly an authentic one [5].

This paper provides a framework as to how communication in higher learning institutions can be augmented by incorporating human computer interaction (HCI) with web based technologies. An effective and reliable communication means should be reliable, cost effective, user friendly and provides communication capabilities to all involved parties. As recommended from HCI discipline; a human centered approach considers human requirements of the whole system (not just the user interface) and should focus on the entire interaction including usability and the broader user experience [6][7][8].

## II. LITERATURE REVIEW

### A. Web Based Technologies and Applications

Web based technologies are those technologies used in the creation of web based information systems (WBIS). These WBIS are based on web technologies which share infrastructure and communication protocols of Internet or Intranets, for example the TCP/IP. The wide spread of communication technologies exploited by WBIS, i.e. Internet; make these WBIS more pervasive than traditional ones [9].

WBIS offer competitive advantages to traditional software based systems allowing businesses to consolidate and streamline their systems and reduce costs. Focusing on deployment considerations; input validation, authentication and authorization, data sensitivity, configuration, exception management and logging to ensure accountability [10].
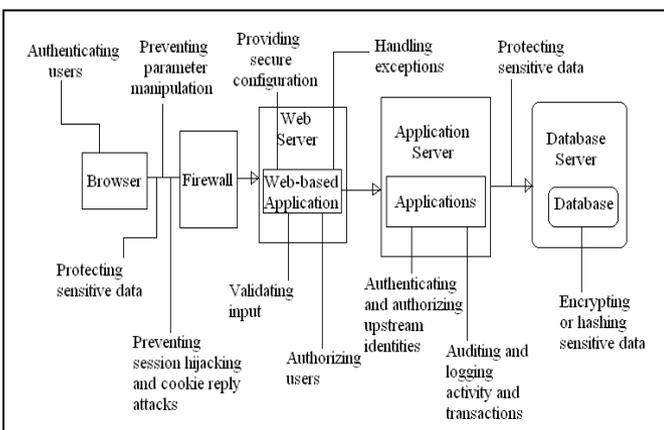


Figure 1.    Top Issues to be Addressed with Secure Design Practices [10]

### B. HCI Evaluation Metrics in Web Based Applications

One major reason for evaluating web based information systems is to take actions based on the results of the evaluation to generate change and betterment. This occurs due to several reasons including the expensive failure and increasingly high level of expenditure on information systems [11].

From HCI discipline point of view, HCI evaluation metrics should also be taken into account during evaluation of web based applications. Most considered aspects are user related such as learnability, effectiveness, efficiency, and satisfaction that are regular usability dimensions. These metrics guide the tasks in the design phase and offer key standards for summative evaluation in the implementation phase [7].

TABLE I.          HCI EVALUATION METRICS [7]

| Usability goals | User experience goals |
|---|---|
| Fewer errors | Aesthetically pleasing |
| Efficient | Enjoyable, entertaining, fun |
| Easy to learn | Motivating, engaging |
| Easy to remember and  Use | Trustworthy and Satisfying |

### C. Human Centred Design in Web Based Applications

The human-design process is fundamental in designing effective and reliable interactive communication models as illustrated in figure 2.
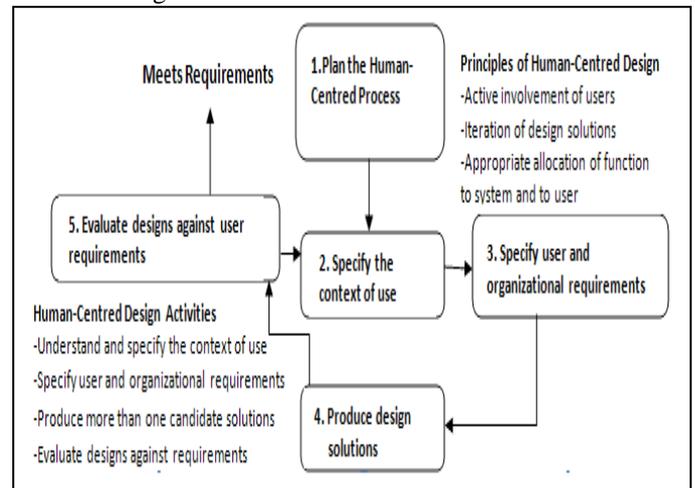


Figure 2.    Human Centred Design Process [7]

During the design and implementation processes for effective and reliable web based applications, both ISO 13407 for human centred design process and ISO 9241 standard for quality of use applicable for the design of interactive systems which emphasize on fulfilment of three main usability requirements for interactive systems: effectiveness, efficiency and satisfaction have to be applied [7].

*D. HCI Life Cycles in Designing Web Based Applications Design in Web Based Applications*

For the purpose of effective fulfilment of HCI principles and as recommended from the HCI discipline; a human centred approach considers human requirements of the whole system (not just the user interface) and should focus on the entire interaction including usability and the broader user experience. Incorporation of interactive systems and HCI life cycle models is key to effective and reliable web based applications implementations [12][13].
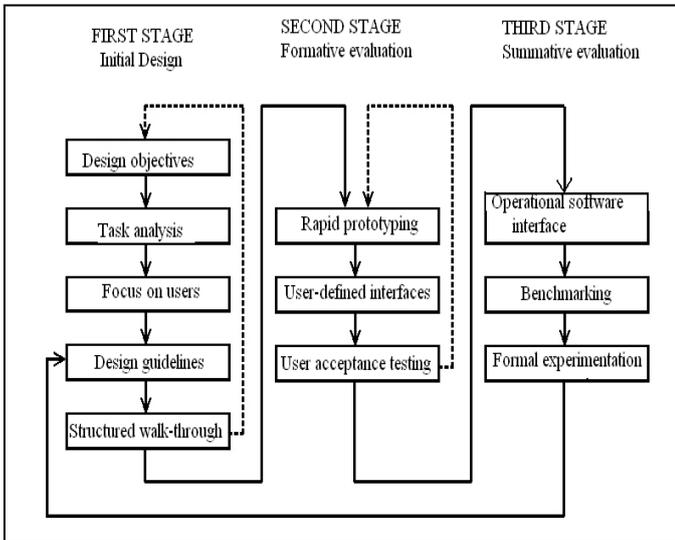


Figure 3.    HCI Life Cycle Model [17]

*E. Existing Communication And Interaction Means Status*

Communication can be modelled as a set of connections along which messages flow from a sender to a receiver on some medium. A given interaction may require several such connections; even a simple web request requires two connections, one from the person requesting the page, and one to return the page to that person [14].

Various communication means are used in Tanzania higher learning institutions. Among these is face to face communication which is preferred though it becomes difficult as the number of members in those institutions increase. Transport costs and family responsibilities also affect this means of communication. Other challenges facing people communicating via this means include less time to think about the message delivered, synchronous based communication where the communicating parties must all be there and it is less likely to have a record of the discussion since most people don't record or transcribe their spoken communication [15].

Phone based communication is the other means used in higher learning institutions. Among the challenges facing this communication means is that any one who knows your phone number may try to call you for different reasons and possibly waste your time while at the same time leaving you with too many unwanted calls. The potential cost of using phone based communication, especially phone accounts recharge costs, is another challenge facing this means of communication. So phone based communication works out as an expensive and less effective means to be used [15].

The other means of communication is online communication which is the most effective, convenient and efficient especially in higher learning institutions. This means is less expensive and allows institution members to be accessible at any time as long as there is an Internet connection and a suitable web based communication and interactive environment [15]. Higher learning institutions need to ensure effective and reliable communication through the adoption of web based communication and interaction applications for communication and interaction enhancement.

*F. Communication and Interactive Model Design*

Based on object oriented approach, the conceptual model with three sub models (functional, object and dynamic sub models), should be designed using the Unified Modelling Language and being governed by Modelling Language for Interaction as Conversations (MoLIC) principles. The interface and navigation models should also be designed using appropriate programming languages for the interface model and appropriate indexes, contexts and links for the navigation model. Figure 7 illustrates.
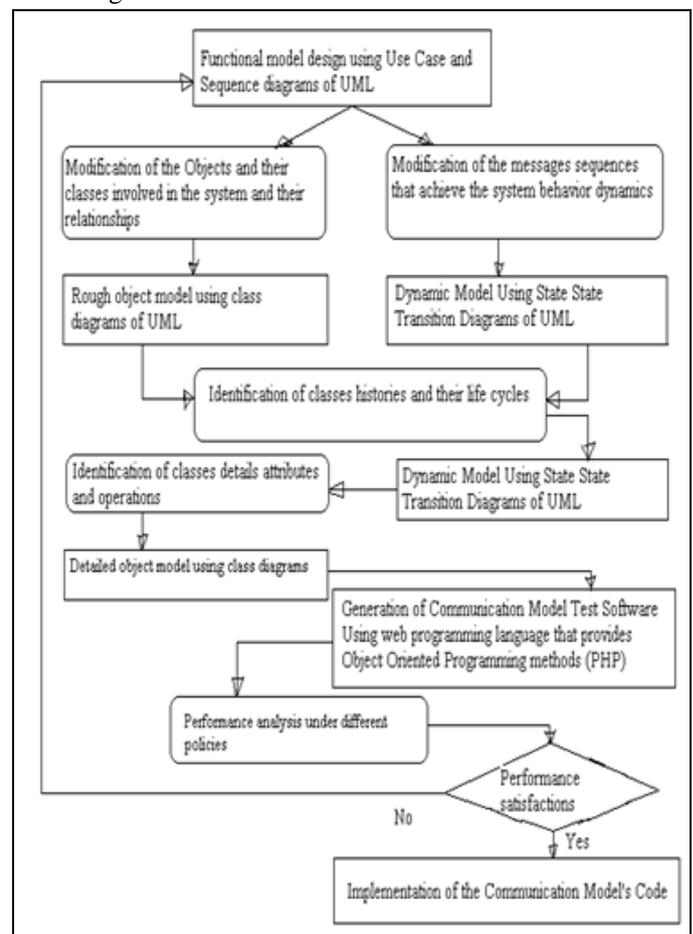


Figure 4.    Methodology Employed for the Model's Design [16]

### G. *Proposed Interaction Model in Higher Learning Institutions*

The model proposed can enable most of the conversations taking place via face to face communication also take place effectively and reliably in a web based communication environment. This model does not exclude any important party among UDSM members and UDSM alumni and based on computer science and Internet security principles, the model goes further to prevent any external party to have access on it for anonymity problem control.
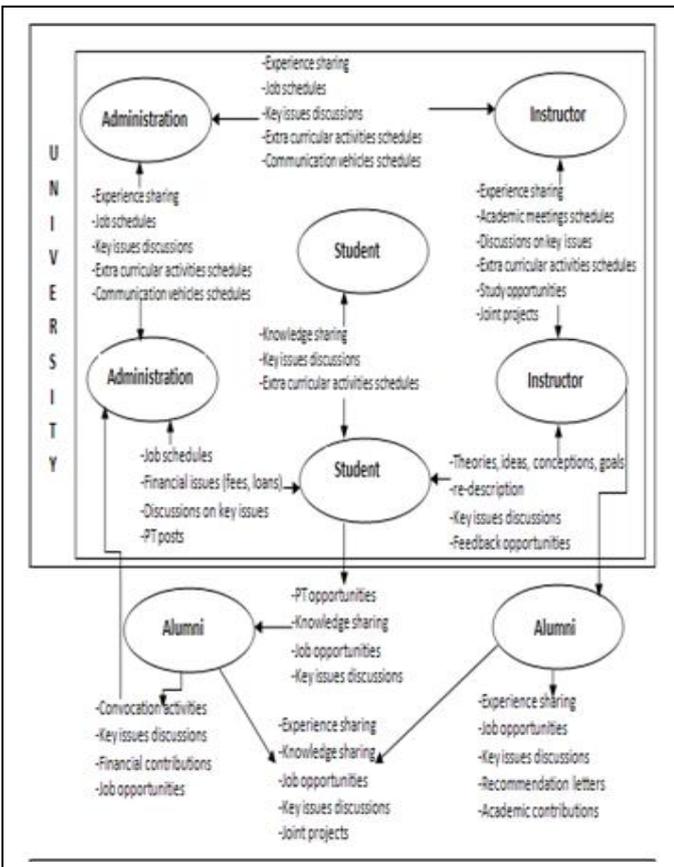


Figure 5. Interaction Model between UDSM Members and UDSM Alumni

### H. *Alumni Associations*

An alumnus (plural alumni) is the person who was previously a member of an institution or someone who was previously a member or an employee of a certain institution. Higher learning institutions globally have recognized the benefits of maintaining communication with their alumni by establishing alumni associations and systems [17].

Communication and interaction is among the preliminary goals of these associations. Alumni systems and websites play an important role in communication and interaction simplification between alumni and their respective institutions. Alumni are very important as they help the institution to overcome several challenges such as generation of additional

financial resources for running their programmes from alumni contributions as well as benefiting from alumni academic contributions. It is through effective and reliable communication means these benefits can be easily obtained [17].

### III. METHODOLOGY

### A. *Study Design*

The study involved the analysis of existing means of communication and interaction used at UDSM where face to face interviews, personal observation and comparative analysis techniques were employed. Based on the analysis process, an interaction model between UDSM members and UDSM alumni as depicted in figure 5 was designed. Then the desired communication and interactive model for augmenting communication and interaction at UDSM was designed under object oriented approach based on the interaction model. The model's capability was also evaluated by being compared with existing communication and interaction means.

The author was also aided by the human centred design process described in figure 2, HCI life cycle model indicated in figure 3 and the methodology employed for the design process as illustrated in figure 4.

### B. *Communication and Interactive Model Design*

The Communication and Interactive Model (CIMO) consists of three different sub-models. These are conceptual, navigational and interface sub-models. The conceptual sub-model has been described using UML diagrams (use cases, class, state transition as well as sequence diagrams).

The navigational sub-model has been specified with two schemas, the navigational schema showing nodes and links (as views of conceptual objects) and a context schema that shows indexes and contexts in the application while the interface sub-model has been specified using PHP (Hypertext pre-processor) pages.
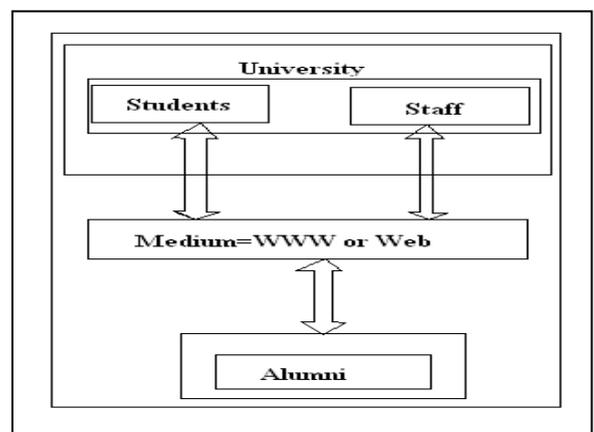


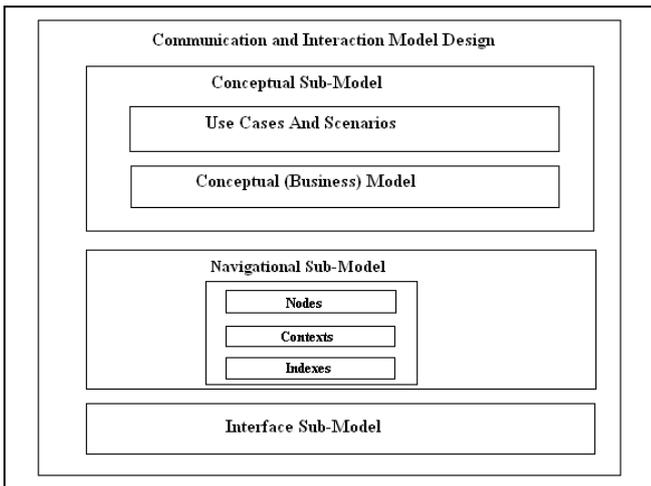Figure 6. Many with Many Communication and Interaction Model

Figure 7.      Communication and Interaction Model Design

## C.  Use Case Modelling

The Conceptual model Use Case modelling describes the proposed functionality of the new system. A Use Case represents a discrete unit of interaction between a user (human or machine) and the system. Table II shows a sample of how use cases were documented during this study using Actor Goal List with MSCW (M stands for MUST, S for SHOULD, C for COULD and W for WOULD) prioritization.

TABLE II.        USE CASE DOCUMENTATION USING THE ACTOR GOAL LIST WITH MSCW PRIORITIZATION

| Actor | Goal | Brief Description | Prior |
|---|---|---|---|
| Student | Register | Use the home page to create user account. | M |
|  | Login | Use the login page to login into the communication and interactive environment. | M |
|  | Access the communication and interactive environment | Interact with other registered users via messages. | S |
|  | Access news, scholarships and vacancies features | Use the home page to have access to news, scholarships and vacancies. | W |
|  | Information tracking | Access other information such as financial issues (fees, loan status, contributions). Access to latest projects and research undertaken by instructors and students. | W |

| Actor | Goal | Brief Description | Prior |
|---|---|---|---|
| Administrator | Validate user | Validate user details | C |
|  | Manage user accounts | Deny access to invalid user accounts. | M |
|  | Manage news, scholarships and vacancies features. | Update news, scholarships and vacancies features. | M |
|  | Information tracking | Financial contribution status from users, e.t.c |  |
| Alumni | Register | Use the home page to create user account. | M |
|  | Login | Use the login page to login into the communication and interactive environment. | M |
|  | Access the communication and interactive environment | Interact with other registered users via messages i.e. email, discussion forum. Interact with staff members for academic and financial contributions. | S |
|  | Information tracking | Access other information such as academic and financial contributions records, current contributions required e.t.c |  |
|  | Access news, scholarships and vacancies features | Use the home page to have access to various features (news, scholarships and vacancies). | W |
| Staff | Register | Use the home page to create user account. | M |
|  | Login | Use the login page to login into the | M |
|  | Access the communication and interactive environment | Interact with other registered users via messages | S |
|  | Information tracking | Access to students, alumni and staff projects and research work. Access other information such as academic and financial contributions records, current contributions required e.t.c |  |
|  | Access news, scholarships and vacancies | Use the home page to have access to various features (news, scholarships, e.t.c). | W |

## D.  Use Case Diagram for the Proposed Model

The Use Case diagram below was designed using UML following the use case documentation as illustrated in table II. Figure 16 depicts the use case diagram under discussion.
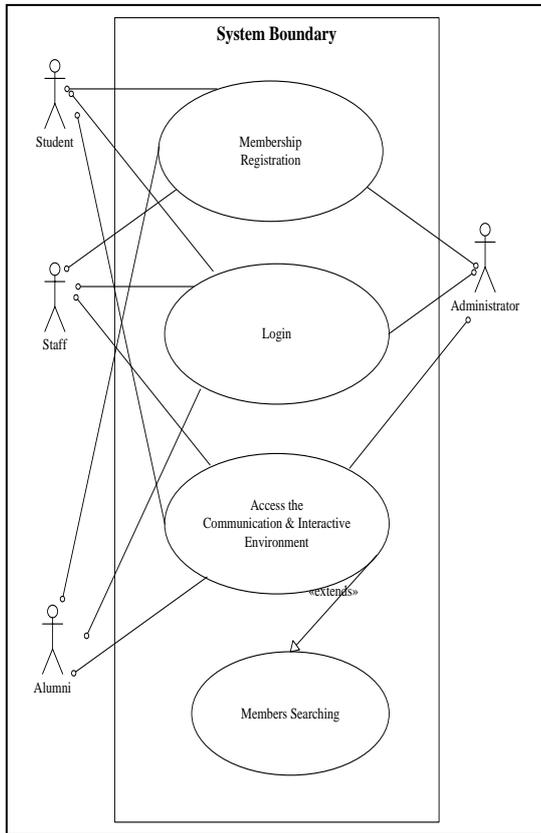


Figure 8.        Use Case Diagram from Use Case Documenation

## E.  Class Diagram for the Proposed Model

The class diagram consists of all important parties involved at UDSM. The diagram also includes communication and interaction classes which are essential for communication and interaction augmentation between UDSM members and UDSM alumni.
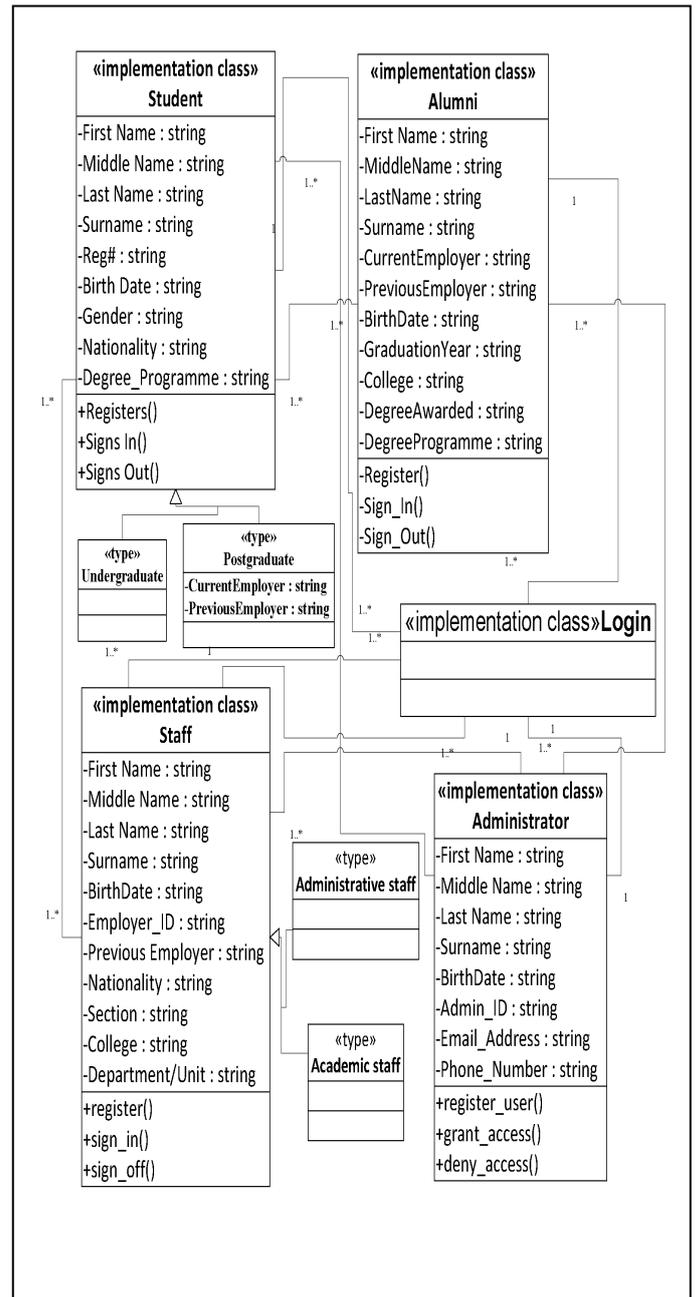


Figure 9.        Class diagram for the proposed Model

Communication and interaction classes linked with the Login class have also been provided below in figure 10.

Figure 10.    Class diagram for Communication Sub-Models

objects are said to have "state" the value of its attributes at one point in time. However, the author presents the state transition diagrams for alumni, communication data, news and topic.
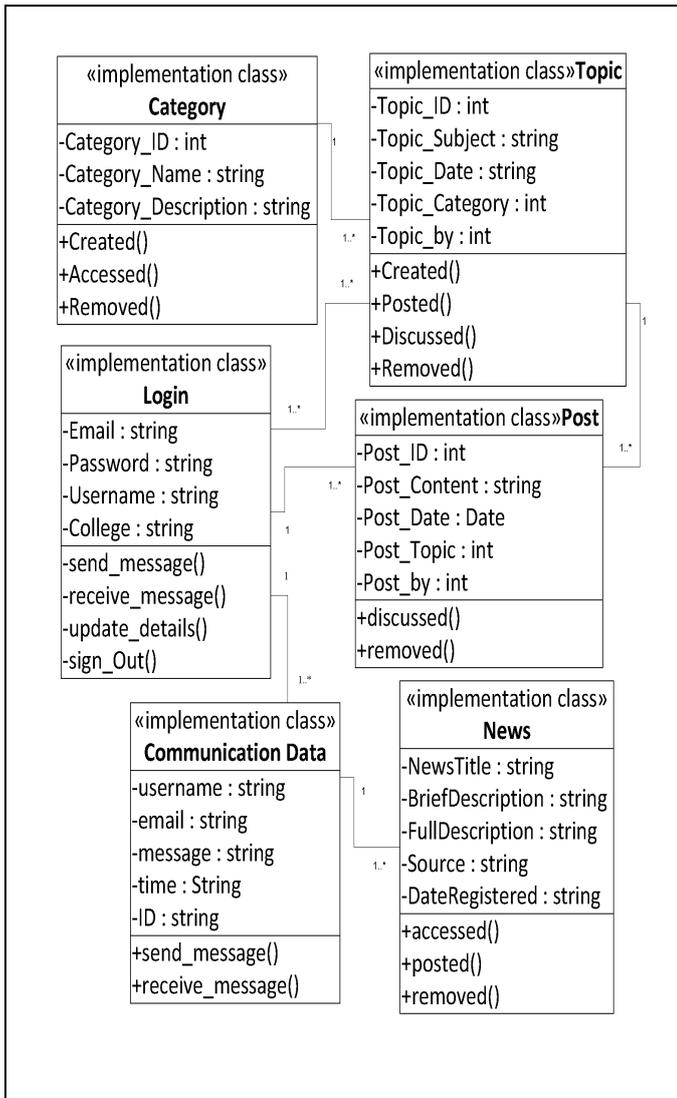


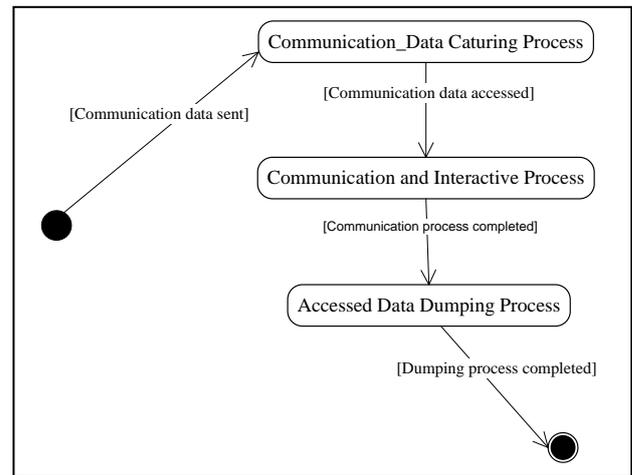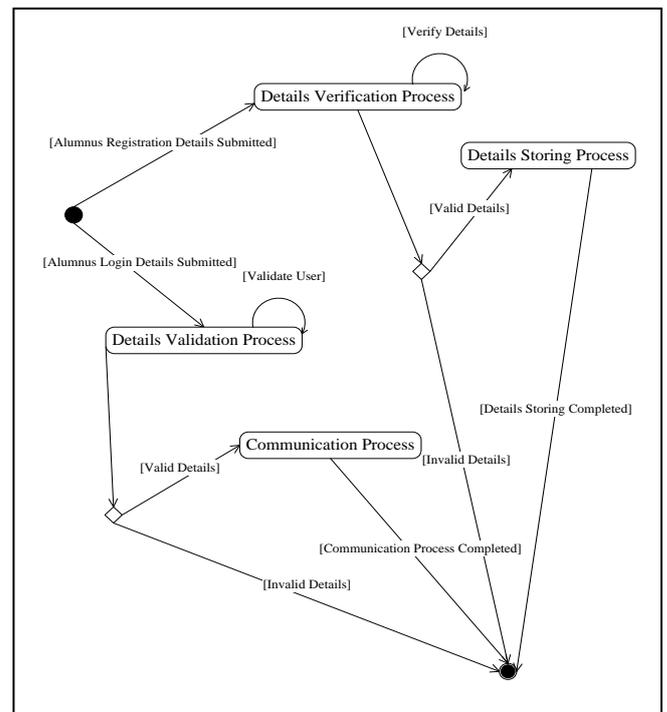Figure 11.    State Transition diagram for Communication Data Class

## F.    Modelling of Objects Behaviour

The modelling of objects behaviour describes the dynamic model of the proposed Model. The dynamic model represents the temporal behavioral aspects of the Model, in which any change is described by activities and events, sequences of events and states. In this phase, the author has proposed the state transition diagrams to model the objects behaviour. A state transition diagram for each class has been designed.

The state transition diagrams and the associated class definitions are concurrently described. The attributes are related to the states, whereas operations are associated to those events implying a state transition. Note that in a state diagram of a specific class, the events originated from a different class method, are translated into operations of the class itself. All



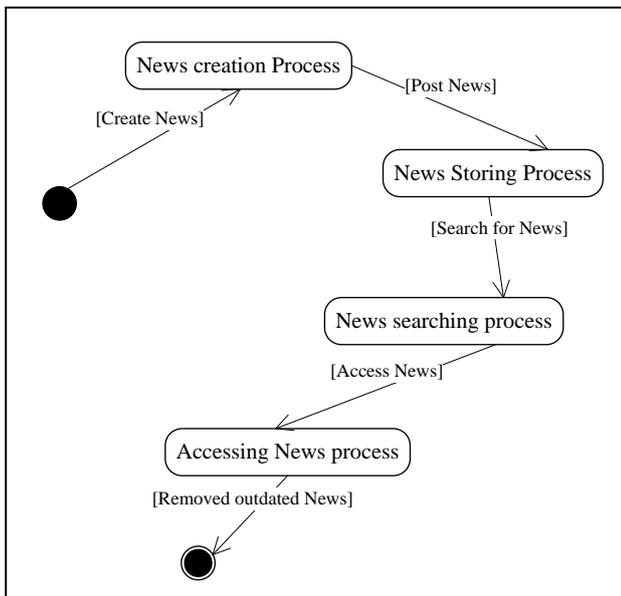Figure 12.    State Transition diagram for Alumni Class

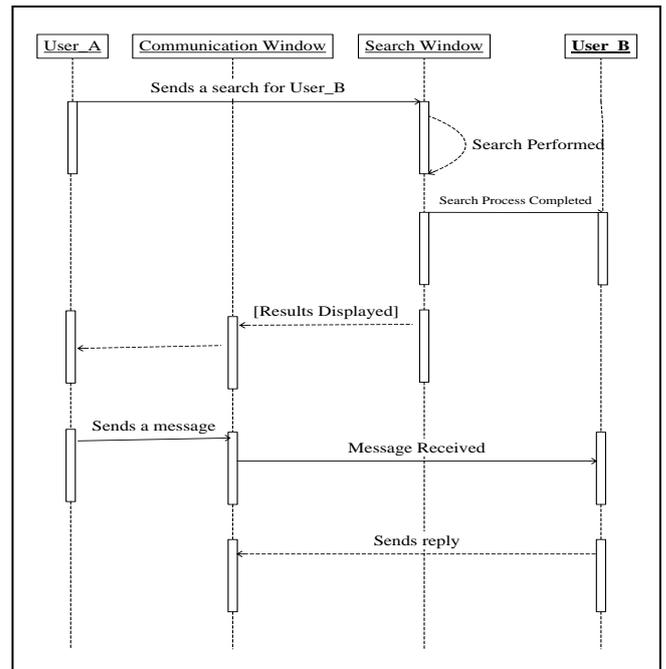Figure 13.    State Transition diagram for News Class

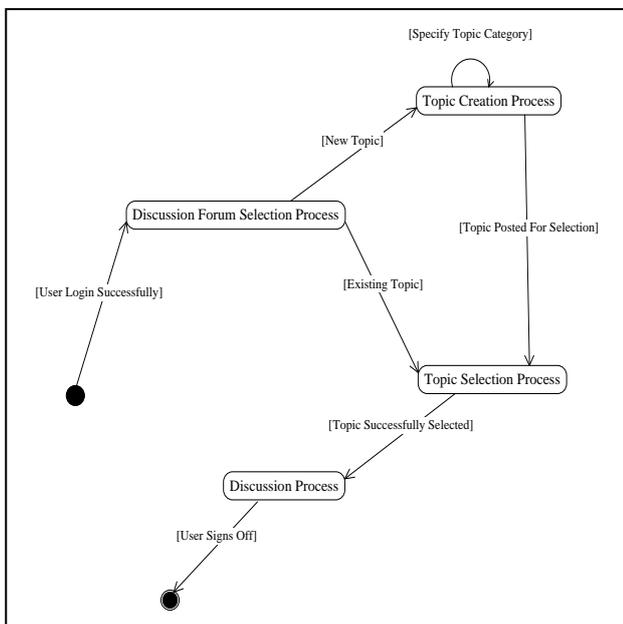Figure 15.    State Transition diagram for Communication Environment Class

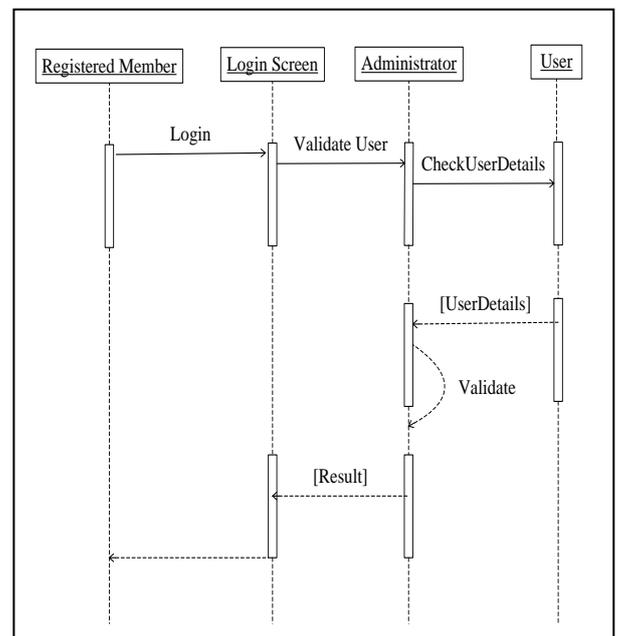Figure 14.    State Transition diagram for Topic Class

Figure 16.    State Transition diagram for Login Class

### G.  *Modelling Object Interactions and Behaviour*

This activity involves modeling object interactions and behavior that support the Use Case Scenario by drawing the sequence diagrams for each use case. It identifies the object interactions, their responsibilities, and their behaviors. A detailed model of object interaction for "Login" and "Access to Communication and Interactive Environment" use cases are presented using sequence diagrams.

### H.  *Comparing Existing Communication Means with UDCMO*

The communication and interactive model abbreviated as UDCIMO (University of Dar es Salaam Communication and Interactive Model) designed had to be evaluated by being compared with existing communication and interaction means.

Tables 4.7 and 4.8 summarize the comparative analysis study made.

TABLE III.  SUMMARY OF EVALUATION RESULTS

| Communication and Interaction Means | Internet/Online Anonymity Control | Automatic Change of Users' Accessibility |
|---|---|---|
| UDCIMO | Well controlled -Only UDSM members and UDSM alumni can register. -Registration numbers and staff identity card numbers are used. -Possible as the application has to be linked with the databases of UDSM members and alumni). | The application has the capability of changing accessibility of users' registering with students' accessibility to alumni accessibility once they graduate (by comparing the time of registration with the degree programme duration). |
| Existed Web based Systems | Controlled -Only certain parties involved -In some cases registration numbers are used while staff identity card numbers are rarely used. -Not for communication and interaction purposes. | Automatic accessibility change could hardly be provided. |
| Other websites used at UDSM including social networking websites(SNSs') | Not well controlled due to privacy issues. -Anyone can register provided has 13 years or above and resides in a country where SNSs' are not burned. -No authorized identity is used during registration. | Automatic accessibility change can hardly be provided. |
| Phone based means | Not Applicable (for online communication). | Not possible. |
| Face to face | Not Applicable. | Not possible. |

TABLE IV.  UDCIMO AGAINST EXISTING COMMUNICATION AND INTERACTION MEANS ANALYSIS

| Communication Means Capability | Communication Costs Estimates | Involved Parties | Information Tracking Services |
|---|---|---|---|
| UDCIMO | Extremely Low communication costs. | UDSM members and UDSM alumni from all schools and colleges of UDSM. | Easy to track important information (email contacts accessible only for UDSM members and alumni). |
| Existing Web based Systems | Costs could not easily be estimated (no system was implemented for communication purposes). | Only certain parties involved (some parties left out, some schools and colleges left out). | Hard to track important information (some parties are left out, not designed for communication purposes) |
| Other websites used at UDSM | Low costs though hard to be sure if communicatin | All parties involved (but a challenge of being sure if | Hard to track important information due to privacy issues in |

| Communication Means Capability | Communication Costs Estimates | Involved Parties | Information Tracking Services |
|---|---|---|---|
| including social networking websites | g partners are authentic UDSM members or alumni. | communicating partners are authentic UDSM members or alumni) | social networking websites. |
| Phone based means | High communication costs (phone accounts recharge, purchasing costs). | Some parties involved (need to know phone numbers of communicating partners). | Information tracking capabilities can hardly be provided. |
| Face to face means | High costs (transport costs, etc.) | Some parties involved (need to know whom to communicate with). | Information tracking capabilities can not be provided. |

CONCLUSIONS

This study has provided the framework as to how effective and reliable web based communication and interactive models to augment communication in higher learning institutions can be designed. The models should be designed under strong usability strategy as a crucial part of the design. These models should be user centric by being strongly designed focusing on users' communication and interaction needs, putting users' needs and values at the centre of the design.

On the other hand, HCI investigates ways of building interactive systems' user interfaces with high quality of use, considering users' needs and preferences. Thus, with any development project, HCI should involve at least three major activities:

i. Analysis, when the designer seeks to understand who the users are, what they do and how, and how the usage of the system influences and is influenced by their context of use;

ii. Design (alongside formative evaluation), when the designer defines how the user may (or must) interact with the system through the user interface, to achieve a range of goals;

iii. Implementation and testing, when the user interface previously defined is coded and tested with users.

Furthermore, Higher learning institutions should understand that communication hardships prevent alumni to engage in various activities taking place in their respective institutions, thus strong emphasize should be made in providing effective and reliable communication and interaction means between higher learning institutions members and their respective alumni [18].

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