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Modeling and Simmulation of Reliability of Networked and Distributed Systems: A Case User Reliability Component.

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Abstract: *What we have today as our integral part of our daily life is networked and distributed system, its application covers from handled device such as cellphone and remote car keys to sophisticated equipment used in aircrafts, power systems, nuclear plants and healthcare system. Considering the critical importance of these system any failures of any of the element/components can significantly affect the performance of component resulting having detrimental or catastrophic impact. One of key component is user who is responsible on operation of the system; failure of user is responsibilities can results into catastrophic impact. This paper discusses the issue of reliability of system particularly mathematical modeling of user reliability on Networked and Distributed systems. To accomplish this we have outlined the background of the study, reliabilities of systems, user models, user reliabilities (user profile) model and provide a proposed mathematical user reliability model and concluded by point out the importance user reliability model.*

Keywords— User model, User reliability model, Mathematical modeling user reliability.

1. BACKGROUND OF THE STUDY

A distributed system, also known as distributed computing, is a system with multiple components located on different machines that communicate and coordinate actions in order to appear as a single coherent system to the end-user (Gibb, 2019). Today integral part of our daily life is networked and distributed system, its application covers from handled device such as cellphone and remote car keys to sophisticated equipment used in aircrafts, power systems, nuclear plants and healthcare system. Considering the critical importance of these system any failures of any of the element/components can significantly affect the performance of component resulting having detrimental or catastrophic impact. (Joaquin dela Cruz, 2014), reported that Distributed System consists of hardware components such as processors; input-output device and so on, software including system software as well as application software, user, a person who use the system, Data which are to be manipulated by the system and also the system should have documents to be used by the users to accomplish his tasks.

Thus, software crashes, hardware breaks. Networks become congested. Viruses and worms bring down systems. Data gets corrupted. Users, for better or worse, use information technologies in ways designers never imagined. Processes evolve communication flows, and coordination links are restructured. Plans and strategies change, or they remain unchanged long after the world has moved on. Even when functioning well, information systems evolve in response to new problems and environmental changes (Truex et al., 1999). Hence the need of to study the reliability of the system as well as its components. Human errors can have a significant impact on the validity and accuracy of data (SIYAVULA, 2019) (Shahreki & Nakanishi, 2016) reported that human errors cause 40% of system failures and, through 2023 at least 99% of cloud security failures will be the customer's fault. Many of these successful cyber-attacks will be a result of hackers preying on the vulnerabilities of human weakness to successfully gain access to an organization's infrastructure and networks wreaking havoc and damage. It is better to have critical written policies and procedures for systems reliability management to cooperate with user reliability. So, thorough consideration is required for human behavior, management policies, and procedures to study system user reliability. This paper discusses the issue of reliability of system particularly mathematical modeling of user reliability on Networked and Distributed systems.

2. RELIABILITIES OF SYSTEM

A system is said to be reliable if it can function well in a specified time without undergoing any halting state, work precisely the way it is designed i.e. as per requirements, resist various failures and recover in case of any failure that occurs during system execution without producing any incorrect result, successfully run operation or its intended functions for a specified period in a specified environment, have the probability that a functional unit will perform its required function for a specified interval under stated conditions and can run correctly even after scaling is done concerning some aspects (Jacobs, 1993; Jürgen Bohn, 2002; Larrucea et al., 2017).

Apart from hardware and software factors, which are considered critical factors in predicting or measuring the reliability of networked and distribution systems, hardware-software interaction is another factor that needs to be considered. The user, Data, and documentation are other vital factors that should be considered since having a significant impact on making a reliable system. User is essential on

recovery, particularly on examining how effective the system is, while documentation of its availability, clarity, and usage directions make the system reliable. It is known that a reliable system can work better on decision-making for companies, sales trends, and increase the performance of a particular work.

Researchers on Information Systems field also have examined the nature of information system reliability problems. One perspective treats a lack of Information system reliability as an agency problem. Software errors (Austin, 2001), data quality problems (Oliveira et al., 2005), and system failures happen because information system personnel focus on objectives other than reliability (Javadi & Dastjerdia, 2011). From this perspective, the solution is to realign incentive structures, encouraging individuals to focus on creating reliable systems (Ravichandran & Rai, 1999).

3. USER MODELS

(Fernandez et al., 2014) defined User models as are explicit representations of the properties of an individual user including needs, preferences as well as physical, cognitive and behavioral characteristics. The characteristics are represented by variables. The user model is established by the declaration of these variables. Due to the wide range of applications, it is often difficult to have a common format. A user model can be seen from a functional point of view (focus is laid on processes and actions that the user carries out to accomplish tasks) or from a more declarative point of view (focus is set on definitions and descriptions of the properties and characteristics of the user).

User modeling covers many different aspects, including the interaction of the user with interfaces and devices, the analysis of user tasks and the analysis of user characteristics (sensory, physical and cognitive abilities, psychological and behavioral characteristics). In what approaches do a modeler want to create your user model or what features do you want you model to include, this depend on the aspect of the modeler.

Among user related models are task model, device model or environment model (Petter et al., 2008). Task models describe how to perform activities to reach users' goals and it can be represented at various abstraction levels. When designers want to specify only requirements regarding how activities should be performed, they consider only the main high-level tasks. On the other hand, when designers aim to provide precise design indications then the activities are represented at a small granularity, thus including aspects related to the dialogue model of a user interface (which defines how system and user actions can be sequenced)(Mohamad & Kouroupetroglou, 2014). The subject of a task model can be either an entire application or one of its parts. The application can be either a complete, running interactive system or a prototype under development.

A device model is a representation of the features and capabilities of one or several physical components involved in user interaction. The device model expresses capabilities of the device (Petter et al., 2008) where Environment models are set of characteristics used to describe the use environment. It includes all required contextual characteristics (Kjällström, 2009) (Moe et al., 2020).

(Mohamad & Kouroupetroglou, 2014)(La Fors, 2020)report that there are bunch of application-independent models which merges psychology and artificial intelligence to model human behavior in detail. In theory they are capable of modeling any behavior of users while interacting with environment or a system. This type of models is termed as cognitive architecture and has also been used to simulate human machine interaction to both explain and predict interaction behavior (Mantovani et al., 2020). A simplified view of one of these cognitive architectures is known as the GOMS(Goals, Operators, Methods, Selection rules) model (Mantovani et al., 2020) and still now is most widely used in human computer interaction though it does not consider people with disabilities or non-expert users in detail as well as user reliabilities himself.

The World Wide Web Consortium (W3C) (Dalrymple, 2015)developed the Composite Capabilities/ Preference Profiles (CC/PP) framework which offer the possibility to define user and device profiles for an adequate adaptation of content and presentation for internet services and is based upon purpose metadata description -a general 200 at el.G ,Klyne)(2015 ,Dalrymple)language4). (McBride, B. 2004) and (Xie, 1997) describe Resource Description Framework (RDF) as to provide the framework with the basic tools for both vocabulary extensibility, via XML namespaces, and interoperability. RDF can be used to represent entities, concepts and relationships in the web. So far, the only practical implementation of CC/PP is the user agent profile (Era & Nilsson, n.d.) (UAProf) developed by the Open Mobility Alliance (formerly the WAP-Forum) and targeted to mobile devices (Glover, T. at el. 2005). This approach was extended further developments by W3C groups in the W3C Delivery Context Ontology; it provides a formal model of the characteristics of the environment in which devices interact with the web or other services. The delivery context includes the characteristics of the device, the software used to access the service and the network providing the connection among others. The universal remote Console URC Standard (ISO/IEC 24752), state that the goal of URC technology is to allow any device or service to be accessed and manipulated by any controller. Again users can then select a user interface that fits their needs and preferences, using input and output modalities, and interaction mechanisms that they are familiar with and work well with them. All these models does not study the reliabilities of users.

Several commercial user modeling tools exist in the market with the objective of adapting content to users' preferences in web and e-commerce field (Hasan et al., 2015). Standards and recommendations in this area had to cope with the spread of service-oriented architectures in ubiquitous environments and to cover workflow and user interface aspects (Mohamad & Kouroupetroglou, 2014)(Ahmed & Wu, 2013) e.g. UsiXML , EMMA and MARIA XML(Tripathi et al., 2021) in all these frameworks contains a user model component but does not cover all user modeling aspects, specifically user reliability modeling. Another major source for the development of user

models was the E-Learning sector (Kritikou et al., 2008), e.g. IMS AccLIP and AccMD, which have been internationalized in the ISO/IEC JTC1 Individualized Adaptability and Accessibility for Learning, Education and specification for the User Modeling software Training (ISO/IEC 24751-1:2008) (Quality Assurance Project Plan, 2008) but again no model to study the reliability of users of the systems.

Despite the studies presented above, a study is hardly found a mathematical model which simulates the reliability of user component in networked and distributed system.

4. USER RELIABILITY (USER PROFILE)

Many theoretical perspectives have been employed to investigate Information technology use, such as expectation-confirmation theory (Oliveira et al., 2005), theory of planned behavior (Jennings & Seaman, 1990) and the theory of reasoned action (Fishbein & Ajzen, 1975). Such perspectives help explain intent to accept (Davis et al., 1989) and continue using Information Technology, as well as post-adoption behaviors associated with Information Technology (Roberts et al., 2006). Researchers currently suggest utilizing the concept of mindfulness in Information system research (Butler & Gray, 2006). To develop user reliability we consider the elements which compose the user profile to be mindfulness, background (a person's background knowledge, experience, education level, and working environment) and documents features.

(Roberts et al., 2006)describe mindfulness to refers to continuous scrutiny and refinement of expectations based on new experiences, appreciation of the subtleties of context, and identification of novel aspects of context that can improve foresight and functioning while Mindlessness is a state of reduced attention resulting from premature commitment to beliefs that may not accurately reflect the phenomena at hand to add more It tends to lead to "mechanically employing cognitively and emotionally rigid, rule-based behaviors" Mindfulness consists of four elements alertness to distinction, openness to novelty, orientation in the present, and awareness of multiple perspectives. Thus, within the Information system domain, mindful individuals may create multiple uses of a specific application, even uses unintended by the original designer. Hence a mindful individual is termed to be reliable. Our primary task is to create a mathematical model that relies on mindfulness concepts as a first component for users' reliability model.

Education develops individual into critical thinking (Hassan et al., 2014). This is vital in teaching a person how to use logic when making decisions and interacting with people (e.g., boosting creativity, enhancing time management) (Duran et al., 2021). That Education is the process where an individual acquires or imparts basic knowledge to another. It is also where a person: develops skills essential to daily living, learns social norms, develops judgment and reasoning, and learns how to discern right from wrong. The ultimate goal of education is to help an individual navigate life and contribute to society once they become older (Duran et al., 2021). An individual having specialized education is considered to more reliable than uneducated one, we consider this as second component for user reliability model.

(Tworek, 2018) describe User Experience as the feeling users experience when using a product, application, system, or service. It is a broad term that can cover anything from how well the user can navigate the product, how easy it is to use, how relevant the content displayed is etc. User Experience is the holistic journey user's traverse as they use a product. Not only does it include their direct interactions with the product, but also how it fits in with their overall task completion process. Strengthening the user experience has numerous benefits that are all associated with user/employee job satisfaction leading to higher profits and better marketplace positioning. These include more engaged, productive employees. Increased quality of work and Improved customer relations (Jennings & Seaman, 1990). The International Organization for Standardization (ISO) (Quality Assurance Project Plan, 2008) (Oliveira et al., 2005) has the following definition "a person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service. Is what we call it experience" "User experience includes all the users' emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviors and accomplishments that occur before, during and after use." A user of information system has fundamental effect being experienced. An individual having experienced to field is considered to more reliable than inexperienced one, we consider this as another component for user reliability model

A work environment is the setting, social features and physical conditions in which you perform your job (Fernandez et al., 2014). These elements can impact feelings of well-being, workplace relationships, collaboration, and efficiency and user health. Some element of a work environment (Ravichandran & Rai, 1999)(indeed Editorial Team, 2022), these include Physical environment(size, layout, location of a workplace, whether work is conducted indoors or outdoors, the facilities offered in a workplace and the furnishings used while working), company culture (way a company and its employees operate, including what effective communication looks like between different levels of staff, employees' perspective of company leaders), the company's goals and what the organization values, working Condition (Formal terms under which staff members are hired, such as the rate of pay, contract of employment and length of the workday). It can also cover recreational activities and other initiatives to promote a healthy workplace). So work environment have significance impact on the reliability of a user, hence we consider this as another component for user reliability model

A document (Urdell, 2015) is crucial facet for system management which helps the user to perform his daily activities on managing the system unfortunately incorrect, missing, brief, or out-of-date documentation available resulting to be considered primary attributes responsible for poor system quality. Therefore, system development associations need to have appropriate document control strategies. For every system, irrespective of its size and complexity, system documentation is generated. An

inappropriate generation or omissions of documentation sometimes even leads to system failure (Chomal, 2015).
(Oprea & Ioan, 2016) describes eight processes (analysis, design, development, validation, production, manufacturing, delivery, and customer satisfaction) that guide document creation. Document preparation is the process of creating a document and formatting it for publication (Sommerville, 2010). The other study (Zintl & Kempen, 2011) gave seven rules for proper documentation. These rules include: (1). Documentation should be written from the point of view of the reader, not the writer, (2.) Avoid repetition, (3.) Avoid unintentional ambiguity, (4.) Use a standard organization, (5.) Record rationale, (6.) Keep it current and (7.) Review documentation for fitness of purpose.
(Edwards, 1993) and (Dennis S et al., 2012) points out that system document have four types concerning the user of the systems, these are: Management documentation: This document for supervisors, team leaders, and other people in administration for decision-making purposes. User documentations: These are for normal users of the system, Program Documentation: This is for programmers, and other technical staffs. Operation Documentation: This document tells the computer center/department staff how to run the system. Sometime is called a run manual it is a document for system administration staffs.
The importance of documentation in system use has not yet been fully understood. Many specialists emphasize the importance of documentation without pointing out its qualitative features. Documentations are often incomplete and rarely updated, which diminishes their quality and reliability (Oprea & Ioan, 2016).

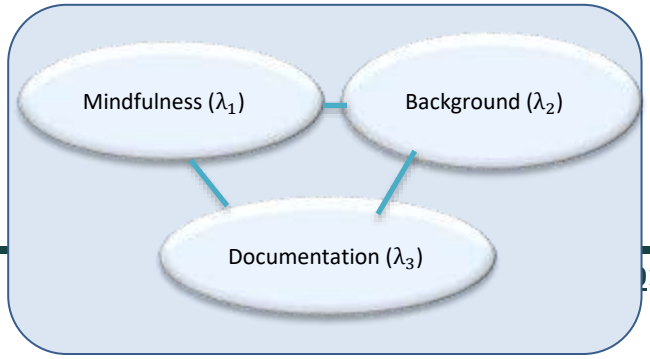
5. MODELING USER RELIABILITY

As discussed above, User models are explicit representations of the properties of an individual user including needs, preferences as well as physical, cognitive and behavioral characteristics. The characteristics are represented by variables. To model user reliability we propose the variable (properties/features) concerned to be mindfulness, background (immediate social context, a person's background knowledge, experience, education level, and working environment and knowledge in form of document which facilitate user to perform his task, then for that case we have the following.

First we assume that a user possess a certain level mindful of the following components, assuming that every individual poses a certain level of
(i) Openness to novelty (the ability to reason about new kinds of stimuli).
(ii) Alertness to distinction (involves an ability to compare, contrast, and make judgments about how things are the same or different),
(iii) Sensitivity to different contexts (is an awareness of the characteristics of whatever particular situation an individual faces, which is a precursor to being able to notice when situational characteristics change,
(iv) Awareness of multiple perspectives (engage in dialectical thinking—that is, to see things from different or opposing points of view.), and
(v) Orientation in the present (individual devote more of their attention to their immediate situation (as opposed to contemplating future possibilities or recalling past events))
Hence U (mindfulness) =f (openness, alertness, sensitivity, awareness and orientation) for each Users. Where users of system can be categorized as Normal users, System administrator/Data officers+, Programmer/Analyst+, and Managements staffs (Dennis et al., 2012) (Edwards, 1993).
Secondly the user is composed of the immediate social context, a person's background knowledge, exprience, education level, and working environmemt we call it backgroug model which assume the user possing the following.
(i) An individual have certain level of Education (P) about the field,
(ii) An individual have/not a certain Experience (E) about the field, and
(iii) Working environment t(W)
Hence the sub model is
Thirdly, a user should have available information in form a document about the system, thus a piece of written, printed, or electronic matter that provides information or evidence or that serves as an official record, these includes
(i) Management documentation: This document for supervisors, team leaders, and other people in administration for decision-making purposes.
(ii) User documentations: These are for normal users (e.g. student's normal lecturers) of the system,
(iii) Program Documentation: This is for programmers, and other technical staffs.
(iv) Operation Documentation: This document tells the computer center/department staff how to run the system. Sometime is called a run manual it is a document for system administration staffs.
To every type of document to be reliable should be Compatible, Comprehensible, Informative, Adequate, Structured and Maintainable.
Hence doc reliability=f(Compatible, Comprehensible, Informative, Adequate, Structured and Maintainable) for each document (Program, User, Operation and Management)

6. USER RELIABILITY MODEL FORMULATION

Here we model using Fault tree concept



User reliability model(U_r)

$$U_r(t) = f(m, bk, doc)$$

Fig. 1: User/documentation sub model

Fig. 1: User/documentation sub model

User reliability model (U_r)

$$U_r(t) = f(m, bk, doc)$$

Where m stand for user's mindfulness, bk stand for background factors of a user and doc stands for document reliabilities.

CONCLUSION

A reliable User is one who has a track record of doing what he or she promised to do. If a User continually completes tasks she promised to do, she is then considered reliable. If a user has says he will show up at 10:30, and he is known to be reliable, you can count on him to be on time. This paper has presented our thought of how we can develop a mathematical user reliability model, most the model exist covers many different aspects, including the interaction of the user with interfaces and devices, the analysis of user tasks of user characteristics (sensory, physical and cognitive abilities, psychological and behavioral characteristics)such as task Models, device and environmental models. All the models discussed it is hardly to find a mathematical model to study user reliability on distributed systems. This work is a first step towards the development or formulating mathematical user reliability model basing mindfulness, background (a person's background knowledge, experience, education level, and working environment) and documents features it is just an abstract model, next is develop specification develop a specification model, i.e., a more detailed one than conceptual, and this will include the developing algorithms (sub-models algorithms to be integrated into main model) necessary for computing and computation model i.e. an executable model, for simulation purposes. Then later this sub model (User reliability model) will be integrated together with others System Unit (SU) reliability sub model and Data Reliability sub model to have A Networked and Distributed system model for higher learning Institution in Tanzania in totality.

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