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International Journal of Computing and ICT Research

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International Journal of Computing and ICT Research

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Building a Strong Undergraduate Research Culture in African Universities

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ABSTRACT

Africa had a late start in the race to setting up and obtaining universities with research quality fundamentals. According to Mamdani [5], the first colonial universities were few and far between: Makerere in East Africa, Ibadan and Legon in West Africa. This last place in the race, compared to other continents, has had tremendous implications in the development plans for the continent. For Africa, the race has been difficult from a late start to an insurmountable litany of problems that include difficulty in equipment acquisition, lack of capacity, limited research and development resources and lack of investments in local universities. In fact most of these universities are very recent with many less than 50 years in business except a few. To help reduce the labor costs incurred by the colonial masters of shipping Europeans to Africa to do mere clerical jobs, they started training “workshops” calling them technical or business colleges. According to Mamdani, meeting colonial needs was to be achieved while avoiding the “Indian disease” in Africa -- that is, the development of an educated middle class, a group most likely to carry the virus of nationalism. Upon independence, most of these “workshops” were turned into national “universities”, but with no clear role in national development. These national “universities” were catering for children of the new African political elites. Through the seventies and eighties, most African universities were still without development agendas and were still doing business as usual. Meanwhile, governments strapped with lack of money saw no need of putting more scarce resources into big white elephants. By mid-eighties, even the UN and IMF were calling for a limit on funding African universities. In today’s African university, the traditional curiosity driven research model has been replaced by a market-driven model dominated by a consultancy culture according to Mamdani (Mamdani, *Mail and Guardian Online*). The prevailing research culture as intellectual life in universities has been reduced to bare-bones classroom activity, seminars and workshops have migrated to hotels and workshop attendance going with transport allowances and per diems (Mamdani, *Mail and Guardian Online*). There is need to remedy this situation and that is the focus of this paper.

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1. INTRODUCTION

Africa had a late start in the race to setting up and obtaining universities with research quality fundamentals. According to Mamdani (Mamdani, *Mail and Guardian Online*), the first colonial universities

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were few and far between: Makerere in East Africa, Ibadan and Legon in West Africa. This last place in the race, compared to other continents, has had tremendous implications in the development plans for the continent. For Africa, the race has been difficult from a late start to an insurmountable litany of problems that include difficulty in equipment acquisition, lack of capacity, limited research and development resources and lack of investments in local universities. In fact most of these universities are very recent with many less than 50 years in business except a few. Even with these few that have relatively a long history of educating Africa's young minds, their missions were not genuinely, at least at the start, for developing African nations other than educating low level and half-baked Africans to help reduce the labor costs of the colonial masters who were finding it increasingly expensive to ship Europeans to Africa to do mere clerical jobs. To solve this problem, they started training "workshops" calling them technical or business colleges. According to Mamdani, meeting colonial needs was to be achieved while avoiding the "Indian disease" in Africa -- that is, the development of an educated middle class, a group most likely to carry the virus of nationalism.

At independence, most of these "workshops" were turned into national "universities", but with no clear role in national development. These national "universities" were catering for children of the new African political elites. Cast into new roles of national administrators with little to no preparations, the new African elites did not formulate development agendas for these universities. So many of them continue to float with no development agenda only teaching students for personal prosperity, thus leading to the mass migration of the educated Africans to Europe and North America. Through the seventies and eighties, most African universities were still without development agendas and were still doing business as usual. Meanwhile, governments strapped with lack of money saw no need of putting more scarce resources into big white elephants. By mid-eighties, even the UN and IMF were calling for a limit on funding African universities.

In today's African university, the traditional curiosity driven research model has been replaced by a market-driven model dominated by a consultancy culture according to Mamdani (Mamdani, *Mail and Guardian Online*). This has led to negative consequences for education and research. The consultancy culture is institutionalized through short courses in research methodology, courses that teach students a set of tools to gather and process quantitative information from which to cull answers. In this environment, researchers will become managers whose real work is to supervise data collection (Mamdani, *Mail and Guardian Online*). Mamdani summarizes the prevailing research culture as intellectual life in universities reduced to bare-bones classroom activity, seminars and workshops have migrated to hotels and workshop attendance going with transport allowances and per diems.

2. Challenges, Bottlenecks and Problems in African Research

According to Mamdani (Mahmoud Mamdani, *online*), many of the problems existing in the African institutions of higher education that are hindering research include:

- Heavy teaching responsibilities leading to - little time for research
- Reluctance of the state to finance research
- Low pay - so would be researchers are often reluctant to use part of their salary for research, leading to a preference of consultancies to improve their salaries
- Low and decreasing numbers of senior professors
- Deterioration in the general education standards
- Mushrooming universities

Sawyer (Sawyer, 2004) notes that current African institutions lack:

- Vision
- Appropriate policy frameworks
- Strategic planning
- Service culture within the structures responsible for administering, coordinating, and promoting research
- Reliance on individual rather than team or multidisciplinary research work thus limiting the capacity of researchers to undertake fundamental work with significant breakthroughs
- Weakness of graduate study and postdoctoral training and its effect on the research environment

3. Essentials Basics for Research for both Undergraduate and Graduate Students

For any institution of higher learning be it in Africa or elsewhere, to claim to foster research at both undergraduate and/or graduate levels, there are essential basics, forming the building blocks of basic research that must be in place for any meaningful research to start and take root. Sawyerr (Sawyerr, 2004) outlines the following three conditions to build intellectual environments that are strong enough to sustain meaningful intellectual culture.

1. *Policy and Resources*

Public policy and resource allocation in which research interests and individual capacity are rooted in the quality of education in the society generally. The policy must consist of:

- Educational systems that encourage and equip people to be curious about nature and society and to develop interests in the pursuit of knowledge and ideas that create indispensable general condition for the development and sustenance of a research culture,
- Broad social policies and practices that encourage and facilitate the flow of information and reward innovation and inquiry,
- Social recognition of achievement and the ready utilization of good ideas provide nonmaterial but powerful incentives to research excellence and innovation, and
- Available and adequate ways means for undertaking research for those interested.

2. *Institutional Conditions*

Institutions must create an environment in which the conditions are conducive and encourage research. Such environment should consist of:

- A minimum research infrastructure, such as laboratories, equipment, libraries, and an effective system of information storage, retrieval, and utilization;
- Appropriate management systems, and
- Policies and incentives that facilitate and support the research enterprise including incentives that recognize and reward high-calibre research.

3. *Research Management*

No institution can claim to support research without a basic research management framework. This may include developing and providing essential project support, management skills, and services that the individual researcher, or even project team, could not be expected to deploy on his/her/their own.

4. Steps Needed to Strengthen African Research

Against this somber general background, a number of steps need to be taken to improve the quality of research in African universities. These include (Alioune Camara and Kathryn Toure, Akilagpa Sawyerr):

- Mentorship of junior faculty and strong supervision of graduate study
- Creating collective or networked research pools
- Adequate institutional framework at the national level for the definition and communication of research priorities
- Institutional support to research centres and laboratories and the development of synergies amongst research teams
- Continuous consultation and dialogue with users of the research
- Inventories and evaluations of research conducted within the university
- Effective mechanisms for funding research

- Developing curricula that emphasizes developing relevant solutions and best practices, in all areas of development, to solve these problems and deal with the challenges.
- Building a culture needed to promoting the use of scientific and technological tools and best practices to solve emerging local problems and challenges
- Strengthening the newly developed research capacity through continuous improvement like the setting up of African Research Academies
- Establishing an African Center of Excellence for Innovative Solutions for Emerging Economies for sustainable relevant research and development solutions

5. Providing undergraduate research opportunities and collaborations across international boundaries

With the above situation, how can we encourage both non-African and African undergraduate students to benefit from any research opportunity and collaboration across the international boundaries, given the many research opportunities available to non-African students in many African universities and the African research space? Several approaches worthy of discussion are available including student exchanges where African bound non-African students carefully identify researchable problems and opportunities in a country of choice. Then, with the help of a student's home institution research advisor and host institution advisor, students take a study tour abroad with a research goal.

6. What others are saying:

- A PERVERSIVE CONSULTANCY CULTURE

Today, intellectual life in universities has been reduced to bare-bones classroom activity. Extra-curricular seminars and workshops have migrated to hotels. Workshop attendance goes with transport allowances and per diem. All this is part of a larger process, the NGO-ization of the university. Academic papers have turned into corporate-style power point presentations. Academics read less and less. A chorus of buzz words have taken the place of lively debates (Mamdani, *Mail and Guardian Online*)

- Mahmood Mamdani: African Universities Breed "Native Informers", Not Researchers
A leading East African political scientist, Prof. Mahmood Mamdani, who is the director of Makerere University's Institute of Social Research has put universities in Sub-Saharan Africa in the dock by accusing them of not creating researchers but churning out native informers to national and international non-governmental organisations. (Mamdani, *Mail and Guardian Online*)
- Now, new statistics from the United Nations Educational Scientific and Cultural Organisation (UNESCO) reveal that the entire African continent contributes only 2.3 per cent of the world's researchers. (*Wachira Kigotho, online*)
- UNESCO estimates that on average, Africa has only 169 researchers per one million inhabitants. Apart from having the lowest density of researchers in the world, investment in research and development in Africa stands at 0.9 per cent. (*Stepps in Sync.*)

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A Business Intelligence Model for Indian Consumers' Behaviour with respect to Motivation

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ABSTRACT

This research attempts to design a framework for Business Intelligence based on critical motivational factors that influence the online buying decisions of Indian Consumer and to establish their causal impact. The effectiveness of the motivational factors is tested through the online users of Indian Railway website (irctc.co.in).

Categories and Subject Descriptors: J. [Computer Applications] : Business Intelligence in E-Retailing J.4. [Computer Application in Online Buying Behaviour]: Business Intelligence Model for Online Buying Behaviour in Indian Context;

Subject descriptor: Designing and Developing Business Intelligence Model based on Motivation for Online Buying Behaviour of Indian consumer through Empirical study

General Terms: Business Intelligence Model, Online Buying Behaviour, Motivation

Additional Key Words and Phrases: Online Consumer Behaviour, E-Retailing, BI, Decision making in Online Buying, Motivation to Buy Online, Empirical Study to Conform the Factors that Motivate Indian Consumer to Buy Online, Application of Business Intelligence in E-Retailing

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1. INTRODUCTION

Business Intelligence (BI) provides powerful and useful information for businesses that enable useful insight and understanding into the fundamental component behind business success: the people (customers). Ultimately it is the customer that drives the decisions and they need to be won over in order for a business to succeed. Understanding what people do and why they do it provides great business insight while making strategic decisions. These powerful insights into consumer behaviour and their dynamics can mean the difference between success and failure of a business strategic plan. Business Intelligence allows firms to predict the behaviour of existing and potential customers. Empowered with this information, firms are able to devise suitable strategies to better manage their respective businesses.

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Dr. Ujwal Lanjewar

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With the worldwide growth of the Internet and an emergence of e-commerce over the past two decades, there has also been a revolution in the basic format of transaction from a physical store format to a non-store one. With a change in the consumers' mindset of purchase made from a physical store to online buying, the industry has witnessed the ever-increasing volumes of online transactions. The growth in online buying is mainly due to advancement in technology; consumer characteristics, both demographic as well as psychographic; and situational influences.

The rapidly growing Indian economy is catching the attention of local as well as global retailers and thereby unlocking the doors for new genres of online consumer research. The growth of the Internet presents a huge opportunity to online retailers to capture a considerable share of sales. In this context it is important to understand the factors that motivate Indian consumers to indulge in online buying; in fact the drivers, enablers and the inhibitors, all need to be identified and addressed. A framework is needed to structure the complex system of effects of the demographic, psychographic and situational factors that impact a consumer's decision to shop online, and develop an in-depth understanding of consumers' motivation to shop online.

The objective of the study is to explore the critical motivational factors that influence the online buying decisions of people, establish their causal impact, and develop an integrated framework for BI based on motivation driven decision making. Critical factors that motivate Indian online buyers are tested through empirical studies done on users of irctc.co.in, an online reservation system of railway tickets.

2. WHAT MOTIVATES INTERNET USERS TO BUY ONLINE?

Consumer shopping motivation in the context of online has been well researched (Alba et al., 1997; Burke 1996, 1997; Childers et al., 2001; Koufaris et al., 2001-2002; Wolfinbarger and Gilly, 2001; Babin et al., 2003; Rohm and Swaminathan, 2004). Numerous consumer needs such as browsing and searching for products, ease and convenience, obtaining information about firms, products and brands, comparing product features and prices, shopping 24/7, having fun and excitement, maintaining anonymity while shopping for certain products, are all fulfilled more effectively and efficiently than conventional shopping. In fact, the benefits that consumers derive out of the online shopping experience are two fold, viz., functional and utilitarian dimensions, like "ease of use" and "usefulness", or emotional and hedonic dimensions like "enjoyment" (Hirschman and Holbrook, 1982; Childers et al., 2001; Mathwick et al., 2001; Menon and Kahn, 2002). Such factors are moderated by exogenous factors like "consumer traits", "situational factors", "product characteristics", "previous online shopping experiences" and "trust" (Eastin and LaRose, 2000; Lee and Turban, 2001; Shim et al., 2001; Wolfinbarger and Gilly, 2001; Burke, 2002; Dabholkar and Bagozzi, 2002; Grewal, 2002; Yoon, 2002).

With convenience, price, product variety and product access as major motives in the context of online shopping, the functional aspects of shopping motivation have been stressed upon (Alba et al., 1997; Donthu and Garcia, 1999; Wolfinbarger and Gilly, 2001). Suki et al., 2001, speaks of user's motivation and concerns for shopping online and mentions motivation factors like accessibility, reliability, convenience, distribution, socialization, search ability and availability; among issues of concern are privacy, reluctance to change, quality, security, trust, connection speed and non disclosure of complete product information.

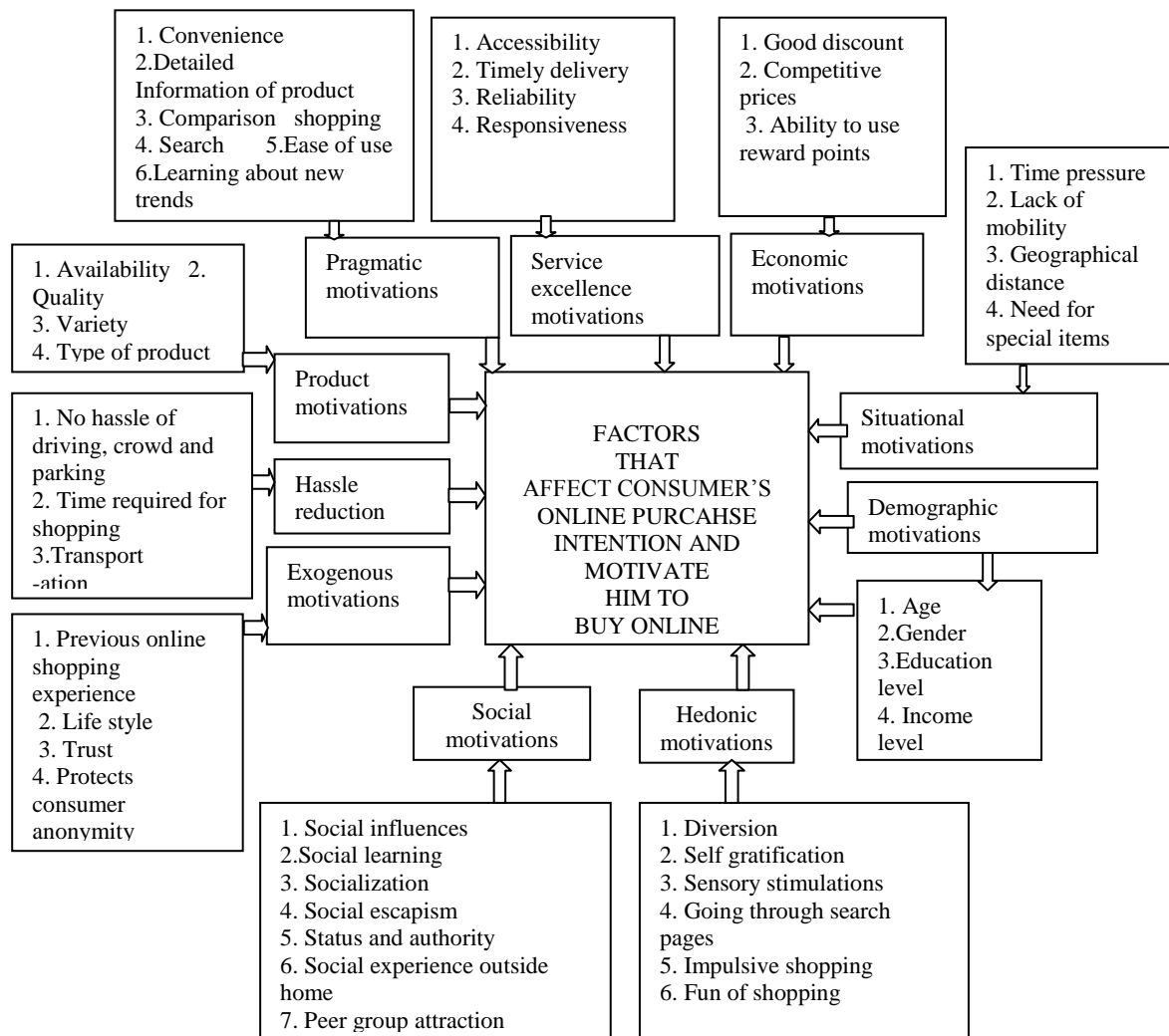
Rohm and Swaminathan, 2002, speak of a typology amongst consumers, based upon their motivation for shopping online; viz., online convenience (convenience shoppers), physical store orientation (variety seekers), information us in planning and shopping (balanced buyers), and variety seeking in the online shopping context (store oriented shoppers). Swaminathan et al., 1999, refer to the convenience factor, i.e., being able to shop 24/7 from one's home as the most compelling motivation. While the TAM (Technology Acceptance Model) (Davis, 1989; Davis et al., 1989), explain easy adoption through website characteristics and purchase intentions, Lee et al., 2007 propose an e-Com adoption Model that include "perceived ease of use, perceived usefulness, perceived risk with products and services, and perceived risk in the context of online transaction".

Rajamma et al, 2007, speak of ‘key dimensions that drive the shopping process’ and they describe them as first, “merchandise motivation” where availability, quality and variety of merchandise are the guiding forces; second, “assurance motivation”, which comprises dimensions like “confidentiality and shopping security”; third, “convenience and hassle reduction motivation”; fourth, “enjoyment motivation” (Hoffman and Novak, 1996; Burke, 2002; Evanschitzky et al., 2004); fifth, “pragmatic motivation”, which comprises elements like “attractive prices, convenience of shopping and ability to do comparative shopping” (Burke, 2002; Evanschitzky et al., 2004); and sixth, “responsiveness”, that includes elements such as “delivery at home, time delivery and ability to contact the seller”.

3. CONCEPTUAL FRAMEWORK: FACTORS THAT MOTIVATE CONSUMERS TO BUY ONLINE

Based on literature review, (Korgaonkar and Wolin, 1999; Suki et al., 2001; Foucault and Scheufele, 2002; Parsons, 2002; Joines et al., 2003; Monsuwe et al., 2004; Rajamma et al., 2007), a model is proposed that delineates the factors that motivate people to buy online. These works have been undertaken under different contexts and environments, and are multidimensional. An attempt has been made to conceptualize a framework that has been tested empirically in the subsequent phase of this study (see Figure 1).

Figure 1: Conceptual Framework: Factors that Motivates Consumers to Buy Online



3.1 Determinants of Consumer Motivation to buying Online:

3.1.1 Pragmatic Motivations

Convenience acts as a primary motive to make purchases online. This convenience may be in terms of convenience of time, place, and the complete buying process (Nielson, 1999; Suki et al., 2001; Foucault and Scheufele, 2002; Alreck and Settle, 2002); it enhances the flexibility with respect to time and place and that in turn motivates consumers to buy online. Consumers can enjoy window-shopping on the Internet without the pressure to purchase. Swaminathan et al., (1999) and Bhatnagar et al. (2000) have concluded from their study that consumers who are primarily motivated by 'convenience' as a factor are more likely to make purchases online. The Internet provides current and detailed information for the pre-purchase search activity (Sorce et al., 2005). Korgaonkar and Wolin (1999) and Joines et al., (2003) have found that 'information; motivation is positively related to online buying. Services tend to be more information oriented than products (Rajamma et al., 2007). Online buying brings along with the availability of a wide range of products thus, enabling easy comparison. Consumers can compare product variants, product features and prices of different brands with just a click of a mouse (Alba et al., 1997; Shankar et al., 2003).

Easy access to specific, detailed and current information of products and services helps consumers to make decisions quickly (Suki et al., 2001). Searching for information and products and making comparisons is related to information motivation, which in turn affects time spent online purchasing items (Korgaonkar and Wolin 1999; Joines et al., 2003). The perception that online buying is easier and involves minimum effort also motivates consumer to buy online. According to the Technology Acceptance Model, the easier and useful a technology is, the more likely are consumers to get motivated to use online technology (Davis et al., 1989; Dabholkar, 1996; Monsuwe' et al., 2004). Ease of use is related to experience of an individual with the technology and system which provides him an easy online buying experience. Underlying dimensions of ease of use are site characteristics like navigation, search functions and downloading speed. The Internet provides a platform to view products with detailed information from international locations and thereby help consumers in learning about new trends. Consumers can also interact with user groups and find out about latest fads and fashions.

3.1.2 Product Motivations

The availability of products that cannot be found locally motivates consumers to buy online. Product motivations such as availability of products, quality and variety of products encourage consumer to indulge in online buying (Rajamma et al., 2007). Certain kind of products such as CDs and books, and services such as buying air tickets are more suitable for online buying. With no fears and apprehensions about the need to feel, try, smell or touch the product, the consumer gets motivated to buy such products and services online (Monsuwe' et al., 2004). Another factor that encourages online buying is the option of customization of certain products such as greeting cards, personal computers, T-shirts proclaiming one's own tastes and fashion. The online market for personalized goods in India is over Rs 200 crores.

3.1.3 Economic Motivations

Competitive prices and good discounts are the two main economic factors that induce Internet users to shop online. Korgaonkar and Wolin (1999) found that economic motivation is directly related to time spent online and purchases made online. This is further supported by the research done by Joines et al., (2003). Competitive prices influence online buying as consumers want to get the best deal. They compare prices, quality, delivery, discount offered etc., reward points earned etc., through online search which is cost effective (Rajamma et al, 2007).

3.1.4 Service Excellence Motivations

Service excellence is a value based perception for buying on the Internet (Monsuwe' et al., 2004). It is based on the consumers' approval of delivered promises in terms of price and timely delivery of products in good condition. Quick home delivery of products in good condition encourages consumers to buy online (Rajamma et al., 2007). Prompt replies to email queries and smooth transactions also inspire consumer to buy online (Rajamma et al., 2007).

3.1.5 Hedonic Motivations

A consumer's motivation to shop online may be either due to an utilitarian motive as a "problem solver" or a hedonic motive in terms of "fun, fantasy.....and enjoyment" (Hirschman and Holbrook, 1982). Some customers prefer to shop and browse on the Internet due to the fun, enjoyment and excitement involved,

that is the emotional and hedonic pleasures, either as individuals or as social groups (Bloch and Richins, 1983; Hirschman, 1983; Childers et al., 2001; Menon and Kahn, 2002; Parsons, 2002). Enjoyment derives from the fun and playfulness of the online shopping experience, rather than from shopping task completion. The underlying dimensions of online enjoyment are escapism, pleasure and arousal. Escapism acts as a diversion from the normal routine day to day traditional shopping mode and activities without any time constraint and physically moving out (Parsons, 2002). In fact Parsons (2002), states that online buying provides many sensory benefits such as background music and visual stimulations. Enjoyment and recreation is also derived in going through search pages, impulsive shopping and fun of shopping and this leads self gratification.

3.1.6 Demographic Motivations

Demographic parameters such as gender, age, income level, education level influence the online buying behavior of consumers (Foucault and Scheufele, 2002). Consumers with a higher education level and income level are more likely to buy online (Li et al. 1999). The study done by Monsuwe' et al., 2004, suggest that young adults are more inclined towards online shopping and more interested in having fun while buying.

3.1.7 Social Motivations

Supportive social environment, perceived norms, family and friends influence the decision to buy online (Limayem 2000, Kraut et al. 1996). Human beings acquire new behavior by observing others. Though, not much research is done on effects of social learning on online buying behavior, research done by Foucault and Scheufele, (2002) on buying books online suggests that through social learning, a consumer does get to know about the online retailer which increases the likelihood of a person indulging in online buying. Being online enables discussion on number of topics through chatting and blogging, without any restriction (Korgaonkar and Wolin, 1999; Joines et al., 2003). While social escapism is also directly related to online buying (Korgaonkar and Wolin, 1999), research by Joines et al., 2003, found that it does not have a significant effect on online buying. Online buying provides an opportunity to command attention (receiving personal emails from online store) and respect. Membership of desired virtual community can provide elevated status and feeling of being important. Online buying provides a time and place for social interaction and social contacts through interactive sites (Parsons, 2002). Online buying offers an opportunity to interact with others having a similar interest through online store-sponsored chat rooms, search engines, links with other sites of interest, user groups. Online buyers can expand their network of connections without feeling conscious in contacting complete stranger.

3.1.8 Hassle Reduction Motivations

Hassle reduction motivations inspire consumers to buy online because it is comparatively trouble free (Burke, 2002; Foucault and Scheufele, 2002; Evanschitzky et al., 2004; Lee and Overby, 2004; Rajamma et al., 2007). Online buying is free from hassles of taking out time for marketing, dressing up to go to market, driving, traffic jams, crowd and finding a place for parking. There is also no hassle of transporting the goods purchased as Internet vendors provide home delivery of products purchased online.

3.1.9 Situational Motivations

Situational factors such as time pressure, geographical distance, lack of mobility, attractiveness of alternatives and need for special items positively influence online buying of consumers (Monsuwe' et al., 2004). The need for special items which are generally not available in local markets also drives consumers to buy online (Wolfenbarger and Gilly, 2001).

3.1.10 Exogenous Motivations

Exogenous factors such as previous online shopping experiences, lifestyle, trust and maintaining consumers' anonymity influence online buying behavior of consumers. If the previous online shopping experience in terms of payment, delivery terms, and service offered, risk involved, privacy, security, personalization, visual appeal, navigation, entertainment and enjoyment are satisfactory then there is more likely hood of the consumer to indulge in online buying (Mathwick et al., 2001; Burke, 2002; Parasuraman and Zinkhan, 2002). Since consumer cannot check the quality of the product and insecure about the privacy

and safety of information provided in online buying, trust in online medium for shopping plays a major role in motivating consumers toward online buying (McKnight and Chervany, 2001-2002).

4. EMPIRICAL STUDY

4.1. Objectives:

The study was conducted with the objective of tapping the consumers' online buying motivational profile. The ultimate objective is that of identifying those factors and design characteristics that can help to develop motivational forces in consumers towards online purchasing. The objectives may be summarized as follows:

1. To establish the impact of convenience based pragmatic motivational factors on online purchase intention
2. To establish the impact of time and efforts based pragmatic motivational factors on online purchase intention
3. To establish the impact of search and information based pragmatic motivational factors on online purchase intention
4. To establish the impact of product based motivational factors on online purchase intention
5. To establish the impact of economic motivational factors on online purchase intention
6. To establish the impact of service excellence motivational factors on online purchase intention
7. To establish the impact of situational and hassle reducing motivational factors on online purchase intention
8. To establish the impact of demographic motivational factors on online purchase intention
9. To establish the impact of social and exogenous motivational factors on online purchase intention
10. To assess the differences across sample on demographics, gender and age.

4.2 Methodology

The study undertaken is descriptive, diagnostic, and causal in nature. It is aimed at identifying the critical motivational parameters of users in online booking of railway tickets in India (through usage of the registered railway website of Indian Railway Catering and Tourism Corporation, www.irctc.com). A pilot study was conducted on a total of 100 sample respondents. The results of the pilot study established the reliability of a total of 38 items, which got grouped under 9 factors / components viz., Convenience based Pragmatic Motivation, Time and Efforts based Pragmatic Motivation, Search and Information based Pragmatic Motivation, Product Motivation, Economic Motivation, Service Excellence Motivation, Situation and Hassle Reducing Motivation, Demographic Motivation, and Social and Exogenous Motivation.

The items drawn from previously tested scales that were modified for this study were validated by factor loadings on their respective constructs.

The statistical method used in these scales was principal component factor analysis. The sample size recommended for this statistical method is at least 50 responses. The guideline used was a factor loading of 0.5 or above (Hair et al. 1995). The recommended guidelines for principal component factor analysis are at least 50 responses, and a ratio of 5 responses for every variable in each scale being measured (Hair et. al., 1995). This sample size met both the criteria. The following Tables (see Tables 1 to 9) illustrate the results of the pre – test in detail.

Reliability concerns the extent to which a measurement of a phenomenon provides stable and consistent result. In assessing measurement reliability, Fornell and Larcker (1981), stress the importance of the reliability of each measure (individual item), and the internal consistency or composite reliability of each construct (Cronbach, 1951). The reliability score and factorial loading of each item were found to be well above the acceptable criterion of 0.50 (see Table 1).

Table 1: Analysis of Factorial Validity and Construct Reliability

| Variable | Measured | Factor Loading | Composite Reliability |
|--|----------|----------------|-----------------------|
| Convenience based Pragmatic Motivation (CPM) | M11 | 0.754 | 0.8937 |
| | M12 | 0.805 | |
| | M13 | 0.814 | |
| | M14 | 0.761 | |
| | M15 | 0.741 | |
| | M16 | 0.752 | |
| | M17 | 0.598 | |
| | M18 | 0.612 | |
| | M19 | 0.545 | |
| | M0 | 0.756 | |
| Time and Efforts based Pragmatic Motivation (TEPM) | M21 | 0.703 | 0.8928 |
| | M22 | 0.718 | |
| | M23 | 0.914 | |
| | M24 | 0.634 | |
| Search and Information based Pragmatic Motivation (SIPM) | M31 | 0.630 | 0.8254 |
| | M32 | 0.529 | |
| | M33 | 0.602 | |
| Product Based Motivation (PDM) | M41 | 0.758 | 0.6491 |
| | M42 | 0.624 | |
| | M43 | 0.554 | |
| Economic Motivation (EM) | M51 | 0.613 | 0.5579 |
| | M52 | 0.590 | |
| | M53 | 0.512 | |
| | M54 | 0.754 | |
| Service Excellence Motivation (SEM) | M61 | 0.502 | 0.7011 |
| | M62 | 0.626 | |
| | M63 | 0.639 | |
| | M64 | 0.531 | |
| Situation and Hassle Reducing Motivation (SHRM) | M71 | 0.678 | 0.8689 |
| | M72 | 0.618 | |
| | M73 | 0.514 | |
| | M74 | 0.528 | |
| Demographic Motivation (DM) | M81 | 0.841 | 0.7908 |
| | M82 | 0.742 | |
| | M83 | 0.692 | |
| Social and Exogenous Motivation (S & EM) | M91 | 0.755 | 0.6665 |
| | M92 | 0.652 | |
| | M93 | 0.508 | |

[Note: Acceptable factor loadings and reliabilities (guidelines used $\lambda > 0.5$ and reliability > 0.5 respectively.)]

The questionnaire for the final study comprised two parts; the first part comprised questions related to basic demographic information about the user (age group, gender, income level, educational qualification, regional location, frequency of online ticket booking, etc.); the second part was intended to measure the users' relative preferences and experiences about critical motivational attributes that induce them to book online the railway tickets. The study was thus aimed at identifying parameters with respect to motivational inclination towards online railway ticket booking and thereby establishes critical motivational factors in the online buying behavior of users of railway ticket reservation.

4.3 Research Hypotheses

The following hypotheses were developed from the objectives of the study mentioned above. A series of multiple regressions was conducted to test each of the hypotheses in the subsequent section of this study.

Hypothesis 1: Convenience based pragmatic motivational factors have a significant impact on users' intention to reserve railway tickets online in India.

Hypothesis 2: Time and efforts based pragmatic motivational factors have a significant impact on users' intention to reserve railway tickets online in India.

Hypothesis 3: Search and information based pragmatic motivational factors have a significant impact on users' intention to reserve railway tickets online in India.

Hypothesis 4: Attributes of online ticket booking transaction (product based motivational factors) have a significant impact on users' intention to reserve railway tickets online in India.

Hypothesis 5: Economic motivational factors have a significant impact on users' intention to reserve railway tickets online in India.

Hypothesis 6: Service excellence motivational factors have a significant impact on users' intention to reserve railway tickets online in India.

Hypothesis 7: Situational and hassle reducing motivational factors have a significant impact on users' intention to reserve railway tickets online in India.

Hypothesis 8: Demographic motivational factors have a significant impact on users' intention to reserve railway tickets online in India.

Hypothesis 9: Social and exogenous motivational factors have a significant impact on users' intention to reserve railway tickets online in India.

4.4 Data Collection

The final questionnaire was developed to capture quantitative data was administered to a cross-section of respondents. The sample was heterogeneous consisting of educated middle and upper class people, who were users of the registered Indian railway website (IRCTC) and had used the service to reserve their travel tickets online at various points of time. A total of 327 questionnaires were found to be complete and valid for analysis.

4.5 Analysis of Data

The responses were subjected to various empirical analyses through using 10.0 version of SPSS. The findings were finally presented with a set of conclusions and recommendations. The statistical analyses were descriptive as well as causal, and included multivariate statistical techniques for testing of the hypotheses and analyzing the demographics to arrive at the research findings.

The factor analysis had grouped the items into 9 constructs with 38 items (see Tables 1). For analytical purposes, descriptive statistics were used through measures of central tendency and dispersion (see Table 2). The users of the railway website were asked to rate the parameter based statements on a scale of 1 to 5, based on their level of agreement or disagreement to each statement. The sum total produced a consolidated score. The means and standard deviations were calculated construct wise. The mean scores for various constructs ranged between 3.1873 and 3.5023, with 'Economic Motivation' having the least score and 'Situation and Hassle Reducing Motivation' have the highest score. This clearly indicates that in India, the economic motivational factors of online railway ticket booking in terms of service charges, speedy refund on cancellation, cost of accession, and travel agent fees (while online booking is done through agency services) do not act as factors that are favorable enough to induce people to go for online reservation of railway tickets. While this is a factor that needs improvement, what really impacts online booking transaction is the hassle free mechanism in the process (see Table 2).

Table 2: Descriptive Statistics for Motivational Constructs on Online Buying Behavior

| S. No. | Constructs | No. of | Mean | Std. Deviation | N |
|--------|--|--------|--------|----------------|-----|
| 1 | Convenience based Pragmatic Motivation (CPM) | 10 | 3.4257 | 0.8815 | 327 |
| 2 | Time and Efforts based Pragmatic Motivation | 4 | 3.4625 | 1.0955 | 327 |
| 3 | Search and Information based Pragmatic | 3 | 3.4271 | 1.0401 | 327 |
| 4 | Product Based Motivation (PDM) | 3 | 3.3629 | 0.9777 | 327 |
| 5 | Economic Motivation (EM) | 4 | 3.1873 | 0.7573 | 327 |
| 6 | Service Excellence Motivation (SEM) | 4 | 3.2528 | 0.8694 | 327 |
| 7 | Situation and Hassle Reducing Motivation | 4 | 3.5023 | 1.1514 | 327 |
| 8 | Demographic Motivation (DM) | 3 | 3.3874 | 0.9316 | 327 |
| 9 | Social and Exogenous Motivation (S & EM) | 3 | 3.2528 | 0.8694 | 327 |

Having calculated the descriptive statistics, the linear relationships were established among the various constructs using correlation analysis so as to measure the strength and direction of linear relationship between them. Each construct was correlated with its individual measuring items to establish the linear relation between them. Also, the various constructs were correlated with each other to establish the strength of association between them (see Table 3).

Table 3: Correlation Analysis of Motivational Constructs on Online Buying Behavior

| Constructs | CPM | TEPM | SIPM | PDM | EM | SEM | SHRM | DM | S & |
|------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| CPM | 1 | | | | | | | | |
| TEPM | .831** | 1 | | | | | | | |
| SIPM | .775** | .781** | 1 | | | | | | |
| PDM | .634** | .648** | .659** | 1 | | | | | |
| EM | .631** | .595** | .633** | .576** | 1 | | | | |
| SEM | .627** | .594** | .540** | .455** | .513** | 1 | | | |
| SHRM | .809** | .823** | .761** | .626** | .582** | .577** | 1 | | |
| DM | .503** | .442** | .438** | .362** | .383** | .493** | .478** | 1 | |
| S & EM | .627** | .594** | .540** | .455** | .513** | 1.00** | .577** | .493** | 1.00** |

** Correlation is significant at 0.01 level (2 tailed)

A series of multiple regressions was conducted to test the hypotheses in order to assess the causal relationships between the various motivational constructs of user groups and their impact on the online reservation of railway tickets in India. The procedure used for these analyses involved a study of the p-value, which indicated whether or not the regression model explained a significant portion of the variance of the dependent variable and the independent variable.

4.6. Hypotheses Testing

Hypothesis 1: Convenience based pragmatic motivation significantly influences the intention of the people to reserve railway tickets online in India.

Regression analysis was performed with the convenience based pragmatic motivation as the dependent variable, and popularity of the railway website, ease of clarity and usage, ease of access, ease of the process, saving of time, ease of cancellation, ease of payment, and time taken for loading of the web page as independent variables. On entering the variables in a single block, it was found that 99.8% of the variance in convenience based pragmatic motivation is explained by all the other constructs ($R^2 = .998$, F Value = 46.078, $p < 0.01$). All the ten dimensions offered significant contributions with their respective t values and the associated level of significance (see Table 4).

Table 4: Model Summary for Convenience based Pragmatic Motivation on Online Buying Behavior

| <i>Model 1</i> | R | R Square | F | Sig. |
|---|------------------------|---------------------------|---------|-------|
| | .999 | .998 | 46.078 | .000 |
| <i>Items Measuring Convenience based Pragmatic</i> | Item Total Correlation | Standardized Coefficients | t | Sig. |
| Constant | | | .000 | 1.000 |
| The IRCTC web site is well known. (CPM1) | .822** | 0.143 | 113.027 | 0 |
| It is easy to get the website to do what I want (CPM2) | .811** | 0.132 | 53.677 | 0 |
| The website is easy to understand and use. (CPM3) | .847** | 0.134 | 42.298 | 0 |
| I feel free/ comfortable to access online ticket booking site. (CPM4) | .844** | 0.14 | 34.046 | 0 |

| | | | | |
|---|--------|-------|---------|---|
| It is easy to purchase ticket online. (CPM5) | .845** | 0.145 | 211.408 | 0 |
| Online ticketing saves time. (CPM6) | .834** | 0.164 | 71.895 | 0 |
| The Internet speed does not create problem while online ticketing. (CPM7) | .260** | 0.14 | 58.025 | 0 |
| The cancellation of online ticket is easy. (CPM8) | .696** | 0.143 | 86.095 | 0 |
| The ticket transaction for payment is simple and easy. (CPM9) | .758** | 0.133 | 101.703 | 0 |
| Web pages take too long to load. (CPM10) | .389** | 0.121 | 76.069 | 0 |

a) **Predictors:** (Constant), CPM1, CPM2, CPM3, CPM4, CPM5, CPM6, CPM7, CPM8, CPM9, CPM10

b) **Dependent Variable:** Convenience based Pragmatic Motivation (CPM)

The hypothesis failed to get rejected. Convenience based pragmatic motivational factors of people in India, who intend to book railway tickets online, significantly impact the online transaction. Hence, the factors mentioned above have to be managed properly and improved in the desired direction to induce people more into buying railway tickets online in India.

Hypothesis 2: Time and efforts based pragmatic motivational factors significantly influence the intention of the people to reserve railway tickets online in India.

Regression analysis was performed with the time and efforts based pragmatic motivation as the dependent variable, and ease and convenience of online booking process, ease of filling up online reservation form, facility of getting the booking done on one's own, and no requirement of following up with others as independent variables. On entering the variables in a single block, it was found that 73.0% of the variance in time and efforts based pragmatic motivation is explained by all the other constructs ($R^2 = .730$, F Value = 112.017, $p < 0.01$). All the four dimensions offered significant contributions with their respective t values and the associated level of significance (see Table 5).

Table 5: Model Summary for Time and Efforts based Pragmatic Motivation on Online Buying Behavior

| <i>Model 1</i> | R | R Square | F | Sig. |
|---|------------------------|----------------------------------|---------|-------|
| | .769 | .730 | 112.017 | .000 |
| <i>Items Measuring Time and Efforts based Pragmatic Motivation (TEPM)</i> | Item Total Correlation | Standardized Coefficients (Beta) | t | Sig. |
| Constant | | | .000 | 1.000 |
| I understand that online ticketing is easy and convenient. (TEPM1) | .867** | .304 | 52.011 | .000 |
| It is easy to fill up online reservation form for ticket. (TEPM2) | .876** | .279 | 222.077 | .000 |
| I need not take the help from others while buying ticket online. (TEPM3) | .872** | .284 | 46.721 | .000 |
| I do not need any interaction with others while buying ticket online. (TEPM4) | .864** | .281 | 119.121 | .000 |

a. Predictors: (Constant), TEPM1, TEPM2, TEPM3, TEPM4

b. Dependent Variable: Time and Efforts based Pragmatic Motivation (TEPM)
The hypothesis failed to get rejected. Time and efforts based pragmatic motivational factors of people in India, who intend to book railway tickets online, significantly impact the online transaction.

Hypothesis 3: Easy searching and access to information based pragmatic motivation significantly influences the intention of the people to reserve railway tickets online in India.

Regression analysis was performed with the search and information based pragmatic motivation as the dependent variable, and display of adequate information about all trains, schedule, availability of berth, station code, and guidance to fill up the online reservation form by the railway website as independent variables. On entering the variables in a single block, it was found that 79.8% of the variance in search and information based motivation is explained by all the other constructs ($R^2 = .798$, F Value = 422.786, $p < 0.01$). All the three dimensions offered significant contributions (see Table 6).

Table 6: Model Summary for Search and Information based Pragmatic Motivation on Online Buying Behavior

| <i>Model 1</i> | R | R Square | F | Sig. |
|--|------------------------|---------------------------|---------|-------|
| | .863 | .798 | 422.786 | .000 |
| <i>Items Measuring Search and Information based</i> | Item Total Correlation | Standardized Coefficients | t | Sig. |
| Constant | | | .000 | 1.000 |
| This web site is user friendly and gives adequate information about all trains, schedule and availability of seat, class, berth and easy guidance to fill up form. (SIPM1) | .878** | .398 | 67.763 | .000 |
| I can find the station code easily. (SIPM2) | .850** | .389 | 119.121 | .000 |
| Searching for particular/alternative trains and schedule is easy. (SIPM3) | .856** | .374 | 46.595 | .000 |

- a) Predictors: (Constant), SIPM1, SIPM2, SIPM3
- b) Dependent Variable: Search and Information based Pragmatic Motivation (SIPM)

The hypothesis failed to get rejected. Search and information based pragmatic motivational factors of people in India, who intend to book railway tickets online, significantly impact the online transaction. Hence, the factors mentioned above have to be managed properly and improved in the desired direction to induce people more into buying railway tickets online in India.

Hypothesis 4: Availability of various online purchase facilities as the basic product based attributes motivates people to reserve railway tickets online in India.

Regression analysis was performed with the basic product motivation based on the availability of service facilities in online reservation as the dependent variable, and iterative booking facilities, combination of tickets across places, and availability of online booking facility during the business hours as independent variables. On entering the variables in a single block, it was found that 57.8% of the variance in availability of service facilities based on online product motivation is explained by all the other constructs ($R^2 = .578$, F Value = 297.002, $p < 0.01$). All the three dimensions offered significant contributions (see Table 7).

Table 7: Model Summary for Product based Motivation on Online Buying Behavior

| <i>Model 1</i> | R | R Square | F | Sig. |
|---|------------------------|---------------------------|---------|-------|
| | .692 | .578 | 297.002 | .000 |
| <i>Items Measuring Product based Motivation</i> | Item Total Correlation | Standardized Coefficients | t | Sig. |
| Constant | | | .000 | 1.000 |
| I can buy tickets for my iterative journey. (PDM1) | .656** | .471 | 76.115 | .000 |
| I can buy various combinations of tickets from any place. (PDM2) | .847** | .429 | 118.211 | .000 |
| Online ticket booking is favored because one can buy ticket online at any time (24/7). (PDM3) | .814** | .402 | 102.111 | .000 |

- a) Predictors: (Constant), PDM1, PDM2, PDM3

b) Dependent Variable: Product based Motivation (PDM)

The hypothesis failed to get rejected. Availability of various online purchase facilities motivates the people in India, who intend to book railway tickets online, and thus significantly impacts the online transaction. Hence, all the above factors as basic product attributes specific to online booking that are not otherwise easily available for booking physically over the counter, have to be maintained properly and improved in the desired direction to induce people more into buying railway tickets online in India.

Hypothesis 5: Various factors related to economic motivation significantly influence the intention of the people to reserve railway tickets online in India.

Regression analysis was performed with the economic motivation in online reservation as the dependent variable, and speedy refund after cancellation, reasonable service charges, commission of travel agents, and the cost of accessing online information as independent variables. On entering the variables in a single block, it was found that 81.9% of the variance in economic motivation related to online purchase transaction is explained by all the other constructs ($R^2 = .819$, F Value = 730.013, $p < 0.01$). All the four dimensions offered significant contributions (see Table 8).

Table 8: Model Summary for Economic Motivation on Online Buying Behavior

| <i>Model 1</i> | R | R Square | F | Sig. |
|---|------------------------|----------------------------------|---------|-------|
| | .886 | .819 | 730.013 | .000 |
| <i>Items Measuring Economic Motivation (EM)</i> | Item Total Correlation | Standardized Coefficients (Beta) | t | Sig. |
| Constant | | | .000 | 1.000 |
| To get the refund money after canceling of the online ticket is trouble free. (EM1) | .780** | .374 | 152.315 | .000 |
| Service charge is reasonable. (EM2) | .775** | .384 | 151.684 | .000 |
| I do not have to pay extra to travel agent. (EM3) | .686** | .403 | 187.444 | .000 |
| The process is expensive due to cost of access. (EM4) | .375** | .363 | 124.471 | .000 |

a) Predictors: (Constant), EM1, EM2, EM3, EM4

b) Dependent Variable: Economic Motivation (EM)

The hypothesis failed to get rejected. Various factors related to economic motivation thus significantly impact the intention of people to reserve railway tickets online in India.

Hypothesis 6: Motivation based on excellence in service delivery significantly influences the intention of the people to reserve railway tickets online in India.

Regression analysis was performed with the motivation based on excellence in service delivery in online reservation as the dependent variable, and prompt home delivery of i-ticket, reduction in processing errors, customer care service, and technical security of online transaction as independent variables. On entering the variables in a single block, it was found that 48.4% of the variance in service excellence motivation related to online purchase transaction is explained by all the other constructs ($R^2 = .484$, F Value = 24.649, $p < 0.01$). One out of the four dimensions offered significant contribution (see Table 9).

Table 9: Model Summary for Service Excellence Motivation on Online Buying Behavior

| <i>Model 1</i> | R | R Square | F | Sig. |
|--|------------------------|----------------------------------|--------|------|
| | .501 | .484 | 24.649 | .000 |
| <i>Items Measuring Service Excellence Motivation (SEM)</i> | Item Total Correlation | Standardized Coefficients (Beta) | t | Sig. |
| Constant | | | 9.000 | .000 |
| The delivery of online i-ticket is prompt. (SEM1) | .800** | .339 | 5.369 | .000 |

| | | | | |
|--|--------|------|-------|------|
| Online ticket buying reduces processing errors. (SEM2) | .750** | .079 | 1.331 | .184 |
| Customer care service for online ticket booking is adequate enough. (SEM3) | .695** | .105 | 1.905 | .058 |
| Technical foul-ups prevent transaction from going through. (SEM4) | .664** | .086 | 1.619 | .106 |

a. Predictors: (Constant), SEM1, SEM2, SEM3, SEM4 b. Dependent Variable: Service Excellence Motivation (SEM)

The hypothesis failed to get rejected. Prompt home delivery of I-ticket as part of excellence in service delivery thus significantly impacts the intention of people to reserve railway tickets online in India. Hence, this particular factor has to be maintained and strengthened properly to induce people more into buying railway tickets online in India.

Hypothesis 7: Motivation based on situational and hassle reducing factors significantly influences the intention of the people to reserve railway tickets online in India.

Regression analysis was performed with the motivation based on situational and hassle reducing factors in online reservation as the dependent variable, and booking through convenient online access, saving of physical efforts, avoidance of traveling the distance, and comfort issues in online transaction as independent variables. On entering the variables in a single block, it was found that 67.1% of the variance in situational and hassle reducing motivation related to online purchase transaction is explained by all the other constructs ($R^2 = .671$, F Value = 154.152, $p < 0.01$). All the four dimensions offered significant contributions (see Table 10).

Table 10: Model Summary for Situation and Hassle Reduction Motivation on Online Buying Behavior

| <i>Model 1</i> | R | R Square | F | Sig. |
|---|------------------------|----------------------------------|---------|-------|
| | .714 | .671 | 154.152 | .000 |
| <i>Items Measuring Situation and Hassle Reduction Motivation (SHRM)</i> | Item Total Correlation | Standardized Coefficients (Beta) | t | Sig. |
| Constant | | | .000 | 1.000 |
| I do not need to travel physically to buy ticket. (SHRM1) | .907** | .315 | 96.001 | .000 |
| Online ticket booking is really effort saving. (SHRM2) | .908** | .308 | 124.276 | .000 |
| I prefer to buy ticket online because railway station is far away from my residence. (SHRM3) | .668** | .252 | 153.892 | .000 |
| Online ticket buying removes the hassle of travel and of standing and waiting in the queue and hassle of parking car etc. (SHRM4) | .883** | .301 | 211.113 | .000 |

a) Predictors: (Constant), SHRM1, SHRM2, SHRM3, SHRM4

b) Dependent Variable: Situation and Hassle Reduction Motivation (SHRM)

The hypothesis failed to get rejected. Various factors related to the situation and hassle reduction thus significantly impact the intention of people to reserve railway tickets online in India.

Hypothesis 8: Factors of demographic motivation significantly influences the intention of the people to reserve railway tickets online in India.

Regression analysis was performed with the various factors related to consumer demographics in online reservation as the dependent variable, and level of education, level of income, and level computer operating knowledge as independent variables. On entering the variables in a single block, it was found that 48.1% of

the variance in various demographic factors related to online purchase transaction is explained by all the other constructs ($R^2 = .481$, F Value = 961.236, $p < 0.01$). All the three dimensions offered significant contributions (see Table 11).

Table 11: Model Summary for Demographic Motivation on Online Buying Behavior

| <i>Model 1</i> | R | R Square | F | Sig. |
|---|------------------------|----------------------------------|---------|-------|
| | .519 | .481 | 961.236 | .000 |
| <i>Items Measuring Demographic Motivation (DM)</i> | Item Total Correlation | Standardized Coefficients (Beta) | t | Sig. |
| Constant | | | .000 | 1.000 |
| Higher education motivated me to buy ticket online. (DM1) | .873** | .403 | 116.621 | .000 |
| Income level motivated me to buy ticket online. (DM2) | .814** | .376 | 98.117 | .000 |
| Proficient Computer Knowledge encourages me to buy ticket online. (DM3) | .833** | .411 | 192.215 | .000 |

a) Predictors: (Constant), DM1, DM2, DM3

b) Dependent Variable: Demographic Motivation (DM)

The hypothesis failed to get rejected. Various factors related to the consumer demographics thus significantly impact the intention of people to reserve railway tickets online in India. Hence, all the above factors have to be considered and analyzed properly over various periods of time and across the geographical regions of the national territory. The same will help take appropriate strategies related to identifying the existing customer segmentation and development of potential online customers, who would be buying railway tickets online in India.

Hypothesis 9: Social and exogenous motivation significantly influences the intention of the people to reserve railway tickets online in India.

Regression analysis was performed with the motivation based on social and exogenous factors in online reservation as the dependent variable, and privacy of the transaction, influence of peer group, and social status as independent variables. On entering the variables in a single block, it was found that 70.3% of the variance in social and exogenous motivation related to online purchase transaction is explained by all the other constructs ($R^2 = .703$, F Value = 1002.004, $p < 0.01$). All the three dimensions offered significant contributions (see Table 12).

Table 12: Model Summary for Social and Exogenous Motivation on Online Buying Behavior

| <i>Model 1</i> | R | R Square | F | Sig. |
|--|------------------------|----------------------------------|---------|-------|
| | .781 | .703 | 1002.00 | .000 |
| <i>Items Measuring Social and Exogenous Motivation (S & EM)</i> | Item Total Correlation | Standardized Coefficients (Beta) | t | Sig. |
| Constant | | | .000 | 1.000 |
| Money refunded on cancellation goes directly to my bank account. (S&EM1) | .792** | .416 | 271.346 | .000 |
| I buy online ticket because people around me used to buy online tickets. (S&EM2) | .806** | .425 | 511.789 | .000 |
| My friends/family members influenced me to start buying ticket online. (S&EM3) | .729** | .449 | 146.299 | .000 |

a) Predictors: (Constant), S&EM1, S&EM2, S&EM3

b) Dependent Variable: Social and Exogenous Motivation (S & EM)

The hypothesis failed to get rejected. Various factors related to the social and exogenous motivation thus significantly impact the intention of people to reserve railway tickets online in India. Hence, all the above factors have to be considered and analyzed properly over various periods of time and across the various groups of consumers. The same will help take appropriate strategies related to identifying the existing customer segmentation and development of potential online customers, who would be buying railway tickets online in India.

4.7 Analysis of Demographics

Based on the analysis of background information of the survey respondents, the samples were further classified on the basis of gender and age groups. Then suitable statistical techniques were applied to capture the cross – sectional comparisons of buyers' / users' motivational attributes imperative to online buying intention of railway tickets in Indian context.

4.7.1. Analysis based on Gender

Out of a total number of 327 respondents covered in the survey, 234 were male and 93 were female. The analysis of descriptive and dispersions were calculated in addition to independent t – test to examine gender wise differences of motivational attributes on online buying intention, if any (see Table 13). The results of independent t – tests showed that for all the critical motivational parameters of buyers / users namely Convenience based Pragmatic Motivation, Time and Efforts based Pragmatic Motivation, Search and Information based Pragmatic Motivation, Product Motivation, Economic Motivation, Service Excellence Motivation, Situation and Hassle Reducing Motivation, Demographic Motivation, and Social and Exogenous Motivation had no significant differences among male and female respondents.

Table 13: Comparative Analysis of Motivational Attributes Based on Gender

| Constructs | Age Group | df | Mean Square | F | Sig. |
|--|----------------|-----|-------------|-------|------|
| Convenience based Pragmatic Motivation (CPM) | Between Groups | 4 | 3.793 | 5.149 | .000 |
| | Within Groups | 322 | .736 | | |
| | Total | 326 | | | |
| Time and Efforts based Pragmatic Motivation (TEPM) | Between Groups | 4 | 5.397 | 4.749 | .000 |
| | Within Groups | 322 | 1.137 | | |
| | Total | 326 | | | |
| Search and Information based Pragmatic Motivation (SIPM) | Between Groups | 4 | 5.868 | 5.740 | .000 |
| | Within Groups | 322 | 1.022 | | |
| | Total | 326 | | | |
| Product Based Motivation (PDM) | Between Groups | 4 | 3.015 | 3.246 | .012 |
| | Within Groups | 322 | .929 | | |
| | Total | 326 | | | |
| Economic Motivation (EM) | Between Groups | 4 | .915 | 1.606 | .172 |
| | Within Groups | 322 | .570 | | |
| | Total | 326 | | | |
| Service Excellence Motivation (SEM) | Between Groups | 4 | 3.352 | 6.050 | .000 |
| | Within Groups | 322 | .554 | | |
| | Total | 326 | | | |
| Situation and Hassle Reducing Motivation (SHRM) | Between Groups | 4 | 5.665 | 4.488 | .002 |
| | Within Groups | 322 | 1.262 | | |
| | Total | 326 | | | |
| Demographic Motivation (DM) | Between Groups | 4 | .674 | .775 | .542 |
| | Within Groups | 322 | .870 | | |
| | Total | 326 | | | |

| | | | | | |
|---|----------------|-----|-------|-------|------|
| Social and Exogenous Motivation (SEM1) | Between Groups | 4 | 1.253 | 1.672 | .156 |
| | Within Groups | 322 | .749 | | |
| | Total | 326 | | | |

Therefore, it can be inferred that as far as these critical motivational attributes are concerned in the context of online reservation of railway tickets in India, they stand equally important and given due importance by both male and female buyers of long distance railway tickets. The univocal importance of buyers' motivational attributes has to be considered accordingly as because it implies that all these motivational attributes to online buying intention are of generic significance irrespective of gender (see Table 13).

4.7.2. Analysis based on Age Group

The total number of 327 respondents was classified under five different categories namely 15 – 20 age group, 20 – 30 age group, 30 – 40 age group, 40 – 50 age group, 50 – 60 age group, and 60 + age group. Analysis of variance (ANOVA) was applied to find out age group wise differences on critical motivational attributes of online buying intention (see Table 14). The results of ANOVA analyses showed that for some of the motivational attributes there were significant differences, whereas for others the differences were not found significant.

For Convenience based Pragmatic Motivation, a significant difference was found among the various age groups with $F(4, 322) = 5.149$, $p < 0.001$. For Time and Efforts based Pragmatic Motivation, a significant difference was found among the various age groups with $F(4, 322) = 4.749$, $p < 0.001$. For Search and Information based Pragmatic Motivation, a significant difference was found among the various age groups with $F(4, 322) = 5.740$, $p < 0.001$. For Service Excellence Motivation, a significant difference was found among the various age groups with $F(4, 322) = 6.050$, $p < 0.001$. For Situation and Hassle Reducing Motivation, a significant difference was found among the various age groups with $F(4, 322) = 4.488$, $p < 0.005$.

These findings can be attributed to the fact that the above motivational attributes have got different implications for various age groups of people/buyers, who reserve long distance railway tickets online in India. People belonging to lower age brackets are more techno savvy, and hence prefer to reserve rail tickets online to avoid the physical hassle and distance. On the other hand, buyers belonging to middle age brackets are people in the working category, and hence they might prefer to book railway tickets online to save time and efforts of their busy professional schedule.

Whereas people in the higher age brackets, may not feel comfortable operating computers and hence might not be so inclined to buy railway tickets online in India. Moreover the retired people can afford to travel and spend time for over the counter booking, many of them might still not be convinced about the integrity of online booking, and again some of them might try to avoid taking the service of any travel agents to reserve tickets online because of excessive fees charged or harassment by such agents. So keeping in mind all such distinct possibilities, the concerned Indian railway authority can go for segmented analysis to decide promotional strategies for online reservation of long distance tickets in order to induce buyers in various age groups with their matching motivational drivers to online buying intention.

Whereas for other motivational parameters like Product Based Motivation, Economic Motivation, Demographic Motivation, and Social and Exogenous Motivation there were no significant differences found among the various age groups. These findings can be attributed to the fact that these kind of motivational drivers are important enough for all types of buyers belonging to various age groups, who reserve/intend to reserve railway tickets online in India. Hence, all such factors have to be considered with due importance while deciding the marketing, promotion, and customer relationship strategies by the Indian railway to induce people more to go for online buying of long distance railway tickets (see Table 14).

Table 14: Comparative Analysis of Motivational Attributes Based on Age Group

| Constructs | Age Group | df | Mean Square | F | Sig. |
|--|----------------|-----|-------------|-------|------|
| Convenience based Pragmatic Motivation (CPM) | Between Groups | 4 | 3.793 | 5.149 | .000 |
| | Within Groups | 322 | .736 | | |
| | Total | 326 | | | |
| Time and Efforts based Pragmatic Motivation (TEPM) | Between Groups | 4 | 5.397 | 4.749 | .000 |
| | Within Groups | 322 | 1.137 | | |
| | Total | 326 | | | |
| Search and Information based Pragmatic Motivation (SIPM) | Between Groups | 4 | 5.868 | 5.740 | .000 |
| | Within Groups | 322 | 1.022 | | |
| | Total | 326 | | | |
| Product Based Motivation (PDM) | Between Groups | 4 | 3.015 | 3.246 | .012 |
| | Within Groups | 322 | .929 | | |
| | Total | 326 | | | |
| Economic Motivation (EM) | Between Groups | 4 | .915 | 1.606 | .172 |
| | Within Groups | 322 | .570 | | |
| | Total | 326 | | | |
| Service Excellence Motivation (SEM) | Between Groups | 4 | 3.352 | 6.050 | .000 |
| | Within Groups | 322 | .554 | | |
| | Total | 326 | | | |
| Situation and Hassle Reducing Motivation (SHRM) | Between Groups | 4 | 5.665 | 4.488 | .002 |
| | Within Groups | 322 | 1.262 | | |
| | Total | 326 | | | |
| Demographic Motivation (DM) | Between Groups | 4 | .674 | .775 | .542 |
| | Within Groups | 322 | .870 | | |
| | Total | 326 | | | |
| Social and Exogenous Motivation (SEM1) | Between Groups | 4 | 1.253 | 1.672 | .156 |
| | Within Groups | 322 | .749 | | |
| | Total | 326 | | | |

5. A BI FRAMEWORK FOR ONLINE BUYING BEHAVIOUR BASED ON MOTIVATION DRIVEN DECISION PROCESS

In the proposed BI framework a Knowledge Management (KM) approach is used for effective decision support system.

5.1 Link between BI, KM and Data Mining (DM)

There is a link between BI, KM and DM. BI is a broad category of applications and technologies of gathering, accessing, and analyzing a large amount of data for the organization to make effective business decisions (Cook and Cook, 2000; Williams and Williams, 2006). Typical BI technologies include business rule modeling, data profiling, data warehousing and online analytical processing, and DM (Loshin, 2003). The central theme of BI is to fully utilize massive data to help organizations gain competitive advantages.

KM is a set of practices of the creation, development, and application of knowledge to enhance performance of the organization (Wiig, 1999; Buckman, 2004; Feng and Chen, 2007; Lee and Change, 2007; Smoliar, 2007; Wu et al., 2007; Paiva and Goncalo, 2008; Ramachandran et al., 2008). Similar to BI, KM improves the use of information and knowledge available to the organization (Sun and Chen, 2008). However, KM is distinct from BI in many aspects. Generally, KM is concerned with human subjective knowledge, not data or objective information (Davenport and Seely, 2006). The majority of models used in the KM field, such as the tacit and explicit knowledge framework for a dynamic human process of justifying personal belief toward the truth (Nonaka, 1994; Nonaka and Takeuchi, 1995), are typically non-technology oriented. Although KM has not evolved out of a set of formal methodologies, KM competently deal with unstructured information and tacit knowledge which BI fails to address (Marwick, 2001).

DM (sometimes called Knowledge Discovery in Databases process or KDD) is the process of discovering new patterns from large structured data sets as well as unstructured dataset. DM is the computer-assisted process of digging through and analyzing enormous sets of data and then extracting the meaning of the data. DM tools predict behaviors and future trends, allowing businesses to make proactive, knowledge-driven decisions.

5.2 Integrating Motivation Driven Decision Making and DM

DM is considered to be useful for business decision making, especially when the problem is well defined. Because of this, DM often gives people an illusion that one can acquire knowledge from computers through pushing buttons. The danger of this misperception lies in the over-emphasis on “knowledge discovery” in the DM field and de-emphasis on the role of user interaction with DM technologies in developing knowledge through learning. There is a lack of attention on theories and models of DM for knowledge development in business. Conventional theories and models in this area ought to be re-examined and developed in such a way that a distinction is made between two important variables: DM centered information and business centered knowledge.

The primary limitation in traditional data mining theory is its limited real world application in two aspects. First, people often find that “knowledge” gained from DM does not always lead to an action in all situations, particularly when the piece of “knowledge” is hard to apply. It fails to recognize the roles of business insiders in developing their knowledge for coordination of actions for business.

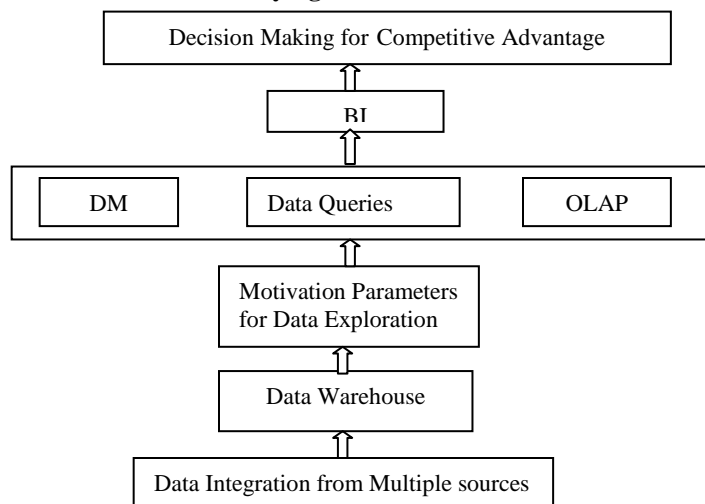
The proposed behavioural BI framework is an attempt to overcome the limitation of traditional data mining by integrating it with motivation driven decision making of online buyer. Factors that motivate online buyer are empirically tested, DM can be done these factors and decision makers can use the information for competitive advantage. The integration of motivation drives decision making of online buyer with data exploration and query makes data mining relevant to genuine BI.

The knowledge work done by motivation parameters can be generally described in the perspective of unstructured decision making. To be ready for action, a decision maker searches appropriate information, evaluates alternative actions pertinent to this information, and choose the action that is best supported by the information. In the DM context, DM results can be a set of information for the decision maker in making unstructured decisions.

5.3 A BI Framework for Online Buying Behaviour Based on Motivation Driven Decision Making

The technical view of BI usually centers on the process of or applications and technologies for gathering, storing, analyzing and providing access to data to help make better business decisions. Business Intelligence software (figure 2) queries and analyzes, information from data warehouse using techniques such as data mining (DM), data query and online analytical processing (OLAP) based on factors which motivate online buyer. Data ware house integrates and transforms data pulled from multiple sources such as operational data base, customer database, market research database, legacy system, customer relationship management (CRM), enterprise resource planning (ERP), online transaction data processing (OLTP), web server, mail server, call logs, emails, surveys, consumer forums, consumer feedback etc.

Figure 2: A BI Framework for Online Buying Behaviour Based on Motivation



6. CONCLUSION

Although the number of individuals buying products and services online continues to increase in India, managing the dynamics of this behavior has often been a research question. What motivates a buyer to shop online is a matter that has evoked a lot of interest although the findings from research are loose, fragmented and disintegrated. Similarly present BI models do not give attention on theories and models of DM for knowledge development in business. Online transactions are characterized by anonymity, lack of physical interaction, lack of control, great deal of uncertainty and potential opportunism.

Based on the analysis of data, this study reached a logical conclusion that the motivation to buy online exhibits positive correlation to Convenience based Pragmatic Motivation, Time and Efforts based Pragmatic Motivation, Search and Information based Pragmatic Motivation, Product Based Motivation, Economic Motivation, Service Excellence Motivation, Situation and Hassle Reducing Motivation, Demographic Motivation, and Social and Exogenous Motivation have a significant influence on people's intention to reserve railway tickets online in India.

This paper is an attempt to conceptualize 'motivation' as a concept paramount for online buying. The paper starts with the concept of motivation, thereafter, factors that motivate online buyer tested. Finally a framework for BI based on motivation driven decision making in online buying is proposed.

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Characterizing the Maximum Queuing Delay of a Packet Switch

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ABSTRACT

The queuing delay which is suffered by a packet that is transiting a packet switch has the most adverse effect on the delay performance of the switch. Being able to estimate the maximum queuing delay which any packet may suffer in a packet switch will make it possible to design upper bounded end-to-end delay switched networks, which are very important in today's delay sensitive networks. In this paper, we have characterized the maximum queuing delay of a packet switch; a characterization, which is in consonance with the definition of maximum queuing delay in literature.

KEYWORDS: *Maximum Queuing Delay, Packet switch, End-To-End Delay*

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1. INTRODUCTION

Queuing delay is the time between when a packet is assigned to a queue for transmission and when it starts being transmitted; during this time, the packet waits while other packets in the queue are transmitted. (Bertsekas and Gallager, 1992, p.150) The queuing delay has the most adverse effect on packet delay in a switched network. According to Song (2001), any frame traveling through the switches in its path from origin node to destination node without experiencing any buffering (queuing) has the minimum end-to-end delay. Queuing delay builds up at the output port of a switch because the port may receive packet from several input ports, that is, packets from several input ports that arrive simultaneously may be destined for the same output port. (Anurag, Manjunath and Kuri, p.121) If input and output links are of equal speed, and if only one input link feeds an output link, then a packet arriving at the input will never find another packet in service and hence, will not experience queuing delay. Message buffering occurs whenever the output port cannot forward all input messages at a time and this corresponds to burst traffic arrival; the analysis of buffering delay therefore, depends on knowledge of the input traffic patterns. (Song, 2001; Song et al., 2002) Because of the adverse effect which the queuing delay of a packet switch can have on the delay performance of the switch, there is the need to characterize the maximum queuing delay which a packet may suffer in a packet switch. This will make the designs of upper bounded end-to-end delay switched networks possible. In the work of Georges, Divoux, and Rondeau (2005), an expression for the maximum

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queuing delay of a packet switch was obtained; but the expression is not a reflection of the definition of a packet switch's maximum queuing delay in literature. Taking a cue from this work, we have characterized the maximum queuing delay of a packet switch; a characterization, which is in consonance with the definitions of queuing (maximum queuing) delay in literature.

2. DERIVATION OF AN EXPRESSION FOR THE MAXIMUM QUEUING DELAY OF A PACKET SWITCH

The output port of a packet switch can be modeled as a FIFO (first-in-first-out) queue. The FIFO queue can be viewed as a degenerate form of FCFS (first-come-first-served) multiplexer (the multiplexer on the other hand, has two or more input links and a single output link; its function is to merge the streams arriving on the input links onto the output link). (Cruz, 1991) The FIFO queue has one input link and one output link. The input link has transmission capacity C_{in} and the output link has transmission capacity C_{out} . The FIFO is defined simply as follows. Data that arrives on the input link is transmitted on the output link in FCFS order as soon as possible at the transmission rate C_{out} . (Georges, Divoux, and Rondeau, 2005; Cruz, 1991) For example, if a packet begins to arrive at time t_0 and if no backlog exists inside the FIFO at time t_0 , then the packet also commences transmission on the output link at time t_0 . It is assumed that $C_{in} \geq C_{out}$ so that this is possible; if C_{in} were less than C_{out} , then this would be impossible to do, as the FIFO would 'run out' of data to transmit immediately following time t_0 , before the packet could be transmitted at rate C_{out} . (Cruz, 1991)

Suppose that the rate of the input stream to the FIFO queue is given as $R_{in}(t)$; if the size of the backlog inside the FIFO at time t is given by $W_{C_{out}}(R_{in})(t)$, the j^{th} packet which arrives at time S_j must wait for all the current backlog, and this backlog gets transmitted at rate C_{out} . It follows that the j^{th} packet commences exit from the FIFO queue at time $t_j = S_j + d_j$, where d_j is given by Eq. (1).

$$d_j = \frac{1}{C_{out}} W_{C_{out}}(R_{in})(S_j). \quad (1)$$

and $t_j = S_j + d_j$

S_j = time at which the j^{th} packet starts arriving at the FIFO queue
 d_j = time spent by the j^{th} packet in the FIFO queue before being transmitted at rate C_{out}
 = maximum delay of the j^{th} packet in the FIFO queue
 t_j = time at which the j^{th} packet commences exit from the FIFO queue

The FIFO queue is illustrated in Figure 1.

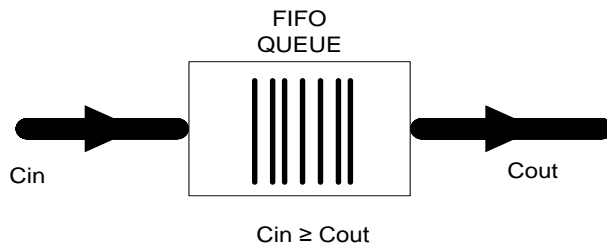


Fig. 1. Illustration of a FIFO queue

If $R \sim (\sigma, \rho)$, where R = the rate function of a traffic stream,
 $\rho > 0$ is an upper bound on the long-term average rate of the traffic flow,
 $\sigma \geq 0$ is the burstiness constraint of the traffic stream (the maximum amount of data that can arrive in a burst), then the function $W_{\rho}(R)$ was defined for all times by Cruz (1991) as follows:

$$W_{\rho}(R)(t) = \max_{s \leq t} \left[\int_s^t R - \rho(t-s) \right]. \quad (2)$$

Where $W_p(R)(t)$ = size of the backlog in a system (that is, the amount of unfinished work) at time t in a work-conserving system which accepts data at a rate described by the rate function R , and transmits data at the rate p while there is work to be done (data to be transmitted).

The presentation in this paper of course implies the assumption of output buffering, which is what is implemented in switches, as it eliminates head-of-line (HOL) blocking (Georges, Divoux, and Rondeau, 2005; Song, 2001), and since buffering delays occur in switches during burst traffic arrival periods when the output port cannot forward all arrived packets in a particular time period in the same time period (Sven, Ales, and Stanislav, 2008; Ryousei et al., 2006; Song, 2001), it may therefore, be necessary to have a knowledge of the input traffic pattern. (Song et al., 2002; Song, 2001)

An arriving packet to a FIFO queue has to wait for the backlog in the queue to be zero before it will be forwarded on the output link at rate C_{out} , where, C_{out} = bit rate of the output link (switch port).

From Eq. (2), the backlog inside the queue at time t is given as:

$$W_{C_{out}}(R)(t) = \max_{s \leq t} \left[\int_s^t R_{in}(t) dt - C_{out}(t-s) \right] \quad (3)$$

Where, $R_{in}(t)$ = rate function of the incoming traffic stream at time t .

Putting Eq. (3) into Eq. (1), we have:

$$d_j = \frac{1}{C_{out}} \times \max_{s \leq s_j} \left[\int_s^{s_j} R_{in}(t) dt - C_{out}(s_j - s) \right] \quad (4)$$

Since our intention is to provide a maximum bound on this delay (d_j), the challenge here is, how do we determine the interval $[s, s_j]$ for which d_j is maximum? This will have to correspond to the maximum burst traffic arrival period of the incoming traffic. But C_{out} is fixed, this is because, the FIFO queue is a degenerate FCFS MUX (Cruz, 1991), and we assume that the FCFS MUX is work-conserving; that is, if $B(t)$ is the backlog at time t , and $B(t) > 0$ at any instant of time t , then, $R_{out}(t) = C_{out}$ (Cruz, 1991). So definitely, the interval $[s, s_j]$ where d_j is maximum only depend on the arrival process of the traffic $R_{in}(t)$.

To determine a possible traffic arrival interval where, d_j would be, maximum, recall that, R_{in} is the rate function of the incoming traffic stream;

$\forall s_j \geq s$, $\int_s^{s_j} R_{in}(t) dt$ is the amount of traffic that has arrived in the closed interval $[s, s_j]$.

Given $\sigma \geq 0$, and $\rho \geq 0$, we write $R_{in} \sim (\sigma, \rho)$, if and only if for all s, s_j satisfying $s_j \geq s$, there holds:

$$\int_s^{s_j} R_{in}(t) dt \leq \sigma + \rho(s_j - s) \quad (5)$$

Where σ = the maximum amount of traffic that can arrive in a burst, and,
 ρ = the long term average rate of traffic arrivals

Similarly, if b is any function defined in the non-negative reals, and $R_{in} \sim b$, we can write (Georges, Divoux, and Rondeau, 2005; Cruz, 1991):

$$b(t) = \sigma + \rho t \quad (6)$$

Where $b(t)$ is an affine arrival curve.

In consonance with the description of the physical layer switch system in (US Patent No. 5889776, 2008), that the switching circuit of a switch establishes a link between two ports specified by the source address and the destination address that is received from the status look-up table, we can then take into account, the internal bus capacity (transfer rate), say C bits/sec; then the affine function (Eq.(6)) can be completed with an inequality constraint (this inequality constraint idea was introduced by Georges, Divoux and Rondeau (2005) in relation to the communication link feeding a switch):

$$b(t) \leq Ct \quad (7)$$

(7), means that, the arrival of data to the output buffers of a switch cannot be greater than the internal bus capacity through which the data will flow. Eq. (6) can now be completed with the inequality constraint (7) as:

$$b(t) = \min\{Ct, \sigma + \rho t\} \quad (8)$$

We can now write out the amount of data that have arrived in the interval $[s_j, s]$ for all $s_j \geq s$ as:

$$\int_s^{s_j} R_{in}(t) dt \leq \min\{C(s_j - s), \sigma + \rho(s_j - s)\} \quad (9)$$

From Eq. (8), if $Ct < \sigma + \rho t$, then

$$b(t) = Ct \text{ and } t < \frac{\sigma}{C - \rho} \quad (10)$$

$$\frac{db(t)}{dt} = C \quad (11)$$

and if $\sigma + \rho t < Ct$, then

$$b(t) = \sigma + \rho t \text{ and } t > \frac{\sigma}{C - \rho} \quad (12)$$

$$\frac{db(t)}{dt} = \rho \quad (13)$$

Eqs. (11) and (13) then gives us two possible arrival rates: C , the internal bus capacity and ρ , a long term average rate (both are in bits/sec).

But the maximum burst size has been defined as the maximum length of time that a data traffic flows at the peak rate (Forouzan, 2008, p.762; Alberto and Widjaja, 2004, p.551); we therefore, ignore Eq. (13) which deals with average rate. Eq. (9) can then be written (taking the upper bound of the inequality) as:

$$\int_s^{s_j} R_{in}(t) dt = C(s_j - s) \quad (14)$$

Eq. (4) now becomes:

$$d_j = \frac{1}{C_{out}} \max_{s \leq s_j} [C(s_j - s) - C_{out}(s_j - s)] \quad (15)$$

To determine the maximum length of time or $\max [s_j - s]$ that the incoming traffic flows at the peak rate, we note that, the upper bound of the inequality of (9) implies,

$$\text{either } \int_s^{s_j} R_{in}(t) dt = C(s_j - s) \quad (16)$$

$$\text{or } \int_s^{s_j} R_{in}(t) dt = \sigma + \rho(s_j - s) \quad (17)$$

$$\text{that is, } C(s_j - s) = \sigma + \rho(s_j - s) \quad (18)$$

$$\text{or } s_j - s = \frac{\sigma}{C - \rho} \quad (19)$$

= maximum length of time at which the traffic flows at the peak rate.

We can now re-write Eq. (15) as:

$$\begin{aligned} dj &= \frac{1}{C_{out}} \left[C \left(\frac{\sigma}{C - \rho} \right) - C_{out} \left(\frac{\sigma}{C - \rho} \right) \right] \\ &= \frac{1}{C_{out}} \left[\frac{(C - C_{out})\sigma}{C - \rho} \right] \end{aligned} \quad (20)$$

= maximum delay in seconds suffered by the j^{th} packet in crossing the FIFO queue.

We note here again that σ is the maximum burst size (in bits) of the input traffic stream to the FIFO Queue. But we had earlier stated that ρ is the rate at which a work-conserving system that accepts data at a rate described by the rate function R transmits the data while there is data to be transmitted. (Cruz, 1991) We can explain this concept in this simple way. Consider a work-conserving system which receives data at a rate described by $R(t)$, and issues out the data at a constant rate C_{out} . It is easy to see that C_{out} also represents the average rate of traffic arrivals to the work-conserving system. This idea was amply illustrated by Sven, Ales, and Stanislav (2008) as is shown in Figure 2. And in the words of Costa, Netto and Pereira (2004), the queuing delay experienced by packets in arriving at a switch varies, since the packets that might have arrived in the output queue before any arriving packet, is not fixed; it depends on the patterns of arrivals at any time.

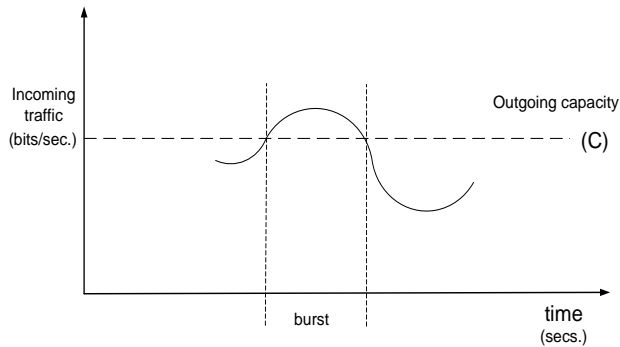


Fig. 2 Illustration of traffic arrivals to and departures from a queuing system with constant output rate, C .
source : [10]

Therefore, taking ρ as C_{out} , Eq. (20) becomes:

$$d_j = \frac{\sigma}{C_{out}} \quad (21)$$

where:

d_j = maximum delay in seconds suffered by the j^{th} packet in crossing the FIFO Queue,

σ = maximum amount of data traffic that can arrive in a burst in bits,

C_{out} = bit rate of the output link (switch port) in bits per second (bps).

Eq. (21) is in agreement with the assertion (with respect to a router) by Sven, Ales and Stanislav (2008), that, since the output queue of a router is emptied at the nominal link capacity, an hypothesis can be made that, the size of a packet burst in bits measured on a router output port divided by the nominal physical link capacity is the upper limit of delay added to the queue build-up by the packet burst. We have, however, shown beyond this hypothesis that Eq. (21) actually characterizes the maximum delay suffered by a packet at the output queue of the output port of a switch (since a router is a switching device).

3. CONCLUSION

The queuing delay which is suffered by a packet that is transiting a packet switch has the most adverse effect on the performance of the packet switch. Being able to estimate the maximum queuing delay which any packet may suffer in a packet switch will make the designs of upper bounded end-to-end delay switched networks possible. In this paper, we have shown in consonance with literature definitions that the maximum queuing delay of a packet switch is the maximum size of traffic that can arrive to the switch in a burst divided by the nominal link capacity of the output port through which the arrived traffic will exit the switch.

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Individual Characteristics as Correlates of Use of ICT in Makerere University

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ABSTRACT

This survey sought to investigate links between use of ICT with six individual characteristics, namely interaction with ICT change agents, ICT training, cosmopolitanism, age, gender and income level. The study was a co-relational and cross-sectional survey biased to the quantitative approach, involving 145 teaching staff, 124 senior administrators and 175 graduate students. Primary data were collected using a self-administered questionnaire, and analysed using summary statistics (e.g. means and standard deviations), t-test, Analysis of Variance and Pearson correlation. Results indicated fair levels of use of ICT, although all individual characteristics but gender significantly related with use of ICT. Appropriate recommendations toward putting in place ICT change agents in all units in the University, training leading to possession of ICT qualifications, and special ICT help (including ICT training) for the less cosmopolitanism and the ageing and aged plus provision of institutional ICT so that the financially less able can also access and hence use the same, were accordingly suggested.

General terms: Higher education, ICT, individual characteristics, innovation adoption, Makerere University

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1. INTRODUCTION

Organizations wishing to survive have to foster use of innovations among their members (Mullins, 2002). One innovation that is particularly important for stakeholders in an academic institution these days is information and communication technology (ICT), given its innumerable benefits such as enhancing speed, efficiency and effectiveness of the user (Mullins, 2002). Unfortunately however, low levels of use of ICT in Makerere University have received increasing attention of recent (Agaba, 2003; Makerere University, 2000; Nakaye, 1998; Niwe, 2000; Nsobya, 2002; Nyakoojo, 2002) but the reasons why use of ICT in the University is low are not yet clear. This paper reports on a survey on use of ICT in Makerere University carried out with the purpose of linking use of ICT, an innovation with six individual characteristics, as suggested by Kibera (1997). The six individual characteristics were interaction with ICT change agents, ICT training, cosmopolitanism, age, gender, and income level. Taking ICT as an innovation, literature is hence reviewed on how each of the said individual characteristics relates with use of innovations.

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1.1 Interaction with change agents and use of innovations

Osuji (1988) gives some six definitions or conceptions of a change agent including that of Lippitt, Watson and Westley (1958), who according to Osuji (1988), first used the term change agent to refer to all helpers, no matter what system they work with; and that of Beckhard (1969) who defined change agents as those people, either inside or outside the organisation, providing technical, specialist or consulting assistance in the management of a change effort. Kibera (1997) asserts that a potential adopter who has more contacts with a change agent is more likely to benefit from the technological or technical knowledge of the agent and therefore to be more ready to use innovations than those with fewer contacts.

1.2 Training and use of innovations

Ntulume (1998) defines training as “the systematic modification of behavior through learning which occurs as a result of education, instruction, development and planned and unplanned experience” (P.11). Training is directed at changing people’s knowledge, experience, skills and attitudes. It enables employees to be more adaptable, and as technological advances continue it is training that enables employees to cope with the changes (Wamala, 1996). In particular, ICT literacy defined as the degree to which an individual possesses mastery over ICT symbols in their written form and contributes to the process of adopting new technology by providing the means for ICT print media exposure and facilitating the retrieval of ICT print messages for later use (Kibera, 1997) among others.

1.3 Cosmopolitanism and use of innovations

Cosmopolitanism refers to the degree to which an individual is oriented outside the immediate social system or has urban influence is positively related to innovativeness (Kibera, 1997). Cosmopolitanism which is the rural or urban divide is theorized to relate to adoption of educational and agricultural innovations, health and/ or demographic innovations such as contraception because urban residents have more education than rural dwellers and have better accessibility to the services and have better access to media like television and internet, which are useful in communicating innovation gospels (Rogers, 2003).

1.4 Age and use of innovations

Schiffman and Kanuk (2004) observe that age of the consumer innovator is related to the specific product category in which the consumer innovates, with consumer innovators tending to be younger than either late adopters or innovators because many of the products selected for research attention (e.g. fashion, automobiles) are particularly attractive to young consumers. Age is also theorized to be important in adoption of health and/ or demographic innovations such as family planning, contraception and health service utilization. Age is also theorized to be important in the adoption of agricultural innovations, although there are two conflicting explanations for this. For example Basisa (1999) points out that while older farmers may have more experience, education and farm resources which factors can be an incentive to try out a technology, young farmers tend to have more schooling and exposure to new ideas that may help to adopt a technology, which suggests an inconclusive debate and hence gap on this issue.

1.5 Gender and use of innovations

Gender comprises a range of differences between men and women extending from the biological to the social roles a woman has to play like caring for the children, cooking, fetching water and firewood, in addition to cultivation. Ssekiboobo (1995 cited in Basisa, 1999) argues that such roles may hinder her from easily adopting to technology use. According to Kato (2000), the marginalization of women in regard to technology adoption and transfer is reinforced by the African cultural system which requires women to remain at home while husbands attend seminars, yet they do not always teach women what they have learnt in extension meetings. Women do not have access to the key productive resources such as capital, as well as being underprivileged in education and knowledge. Mwebesa (1997) observes that technological changes are not usually aimed at women at all, and that large scale development projects and their attendant technology rarely include policy regarding women; that sexist bias was the most important factor explaining the inability of women to take advantage of new technology offered. He further contends that appropriate technology programmes reveal that many projects do not achieve positive results for women’s lives; that in many projects, even technology introduced for the benefit of women has been co-opted by men for their own use.

1.6 Income level and use of innovations

On the importance of income in innovation adoption, Schiffman and Kanuk (2004) observe that “consumers innovators have... higher personal or family incomes, and are more likely to have higher occupational statuses... than late adopters or non-innovators” (p. 538). According to Morales-Gomez and Melesse (1998), access to Internet and other ICTs is only open to a small fraction of the population, a phenomenon which is a function of income; Internet users tend to have above average income. They further assert that the situation is even more dramatic in developing countries where the income gap is exorbitant; where literacy rates are remarkably lower; and where the users of telecom technologies are likely to belong to modern elite.

1.7 Hypotheses

From the literature, the research hypothesized that each of interaction with ICT change agents, ICT training, cosmopolitanism and income level, significantly positively correlated with use of ICT. However, age was hypothesized to be inversely related to use of ICT, while gender was postulated to relate to use of ICT, in such a way that males were better.

2. METHODOLOGY

Using a quantitative correlational survey design, data were collected using a self-administered questionnaire with questions of relevance in this paper, namely interaction with ICT change agents (one question on whether a given respondent's unit in the University had a noticeable ICT change agent); on ICT training (one question on whether a respondent possessed any ICT qualification); on cosmopolitanism (five questions: $\alpha = 0.8107$); and one question on each of three demographic factors, namely age, gender and income level. The questionnaire had six questions or items on use of personal computer (PC) applications software ($\alpha = 0.8174$) and eight questions or items on use of internet applications ($\alpha = 0.8864$). According to Cronbach's Alpha Coefficient Test (Cronbach, 1971), the questionnaire was reliable for the study as all alpha coefficients were above 0.5. Using the said questionnaire, data were collected from a sample of 145 teachers, 124 senior administrators and 175 postgraduates, and analysed using summary statistics (means and standard deviations), t-test, analysis of variance (ANOVA) and correlation analyses.

3. FINDINGS AND DISCUSSION

3.1 Background of respondents

Other details about the 444 respondents were as follows: according to age, 39% were aged between 30 and 40 years, followed by those below 30 years (35.8%), and the rest (25.2%) were above 40 years of age. Males (66.1%) dominated the sample, and regarding perceived income level, the medium income (63.8%) took a lion's share, followed by 31.1% of low income and only 5.2% of high income.

3.2 Use of ICT

Use of ICT was conceptualized in terms of use of PC applications software (six questions) and internet applications (eight questions), each question scaled using the five-point Likert scale where 1 = Very rarely or never, including never heard of it; 2 = Rarely use; 3 = Neither rarely nor regularly; 4 = Regularly; and 5 = Very regularly. Tables 1 and 2 give summary statistics on the respective two concepts:

Table 1. Statistics on use of PC software

| Indicator of use | Mean | Standard deviation |
|---------------------------------------|------|--------------------|
| Word processing software | 4.04 | 1.25 |
| Spread sheet software | 3.15 | 1.45 |
| Database management software | 2.33 | 1.39 |
| Graphics software | 2.51 | 1.33 |
| Desktop publishing | 1.73 | 1.13 |
| Statistical or data analysis software | 2.00 | 1.34 |

According to Table 1, only word processing had a reasonably high sample mean, implying very rare or no use of PC software by the majority of respondents. An average index (“Usepcsw” from Table 1) registered a mean = 2.63, which further suggested that overall, the majority of respondents were only fair users of ICT that is neither rare nor regular users of the same.

Table 2. Statistics on use of internet facilities

| Indicator of use | Mean | Standard deviation |
|---|------|--------------------|
| Email | 4.21 | 1.19 |
| Web surfing | 4.00 | 1.27 |
| Bulletin board, mailing lists and discussion groups | 2.49 | 1.46 |
| Computer conferencing systems | 1.67 | 1.06 |
| Video conferencing systems | 1.48 | 0.90 |
| Electronic journals and newsletters | 2.43 | 1.41 |
| Electronic databases | 2.23 | 1.35 |
| On-line library catalogs | 2.17 | 1.33 |

According to Table 2, only E-mail and web surfing in that order, recorded reasonable levels of use, suggesting that respondents very rarely or never used Internet facilities. An average index (“Useint” from Table 2) scored a mean = 2.57, which suggested that the majority of respondents were only fair users of internet facilities. An average index (“UseICT” from the two indices, “Usepcsw” and “Useint” from Tables 1 and 2), had a mean = 2.60, which suggested that the majority of respondents only fairly used ICT, that is neither rare nor regular users of the same. This finding corroborated earlier researchers. For example, both Agaba (2003) and Niwe (2000) found teachers in Makerere poor at utilisation of the Internet as source of information. Nyakoojo (2002) found teachers in the University poor at utilisation of ICT as a pedagogical tool. Nakaye (1998) and Zziwa (2001) found that administrators in the University hardly utilized computers in the management of students’ information such as in the area of admissions, while Nassanga (2001) found that students in the University hardly participated in usage and management of ICT.

3.3 Hypothesis testing

3.3.1 Interaction with ICT change agents and use of ICT

The first hypothesis in the study was that interaction with ICT change agents was a positive correlate of use of ICT. Respondents were thus prompted to state whether or not, in their observation, their department had at least one ICT change agent; that is a person promoting the cause of ICT. Table 3 gives pertinent summary statistics and Fisher’s ANOVA results:

Table 3. Statistics and ANOVA on use of ICT by interaction with ICT change agents

| Any departmental ICT change agents? | Count | Mean | Std dev | F | p |
|-------------------------------------|-------|------|---------|-------|-------|
| No | 85 | 2.56 | 0.83 | 6.547 | 0.002 |
| Yes | 202 | 2.72 | 0.88 | | |
| Not observant | 77 | 2.32 | 0.74 | | |

Sample means in Table 3 suggested that those who interacted with ICT change agents (Mean = 2.72) tended to be better at using ICT than those who did not (Mean = 2.56) or were not observant about presence of ICT change agents (Men = 2.32). This was indeed supported by the very big F- value ($p < 0.01$), leading to acceptance of the research hypothesis that interaction with ICT change agents did significantly positively relate with use of ICT at the one percent level of significance. The finding corroborated earlier researchers (e.g. Kato, 2000) but was inconsistent with others (e.g. Luwedde, 1997). The finding thus strengthened theoretical assertions such as that by Kibera (1997) to the effect that a potential adopter who has more contacts with a change agent is more likely to benefit from the technological or technical knowledge of the agent and therefore to be more ready to use the innovation than those with fewer contacts. The finding led to one major conclusion namely that ICT change agents were necessary in all units in Makerere University, if only to enhance use of ICT by staff and graduate students. Hence the recommendation that ICT change agents be put in all units in the University by Top Management and Directorate of ICT Support.

3.3.2 ICT training and use of ICT

The second study hypothesis was that ICT training, proxied by possession of ICT qualification, positively related with use of ICT. Respondents were thus prompted using one item to state whether or not they possessed any ICT qualification. Pertinent summary statistics and t test results are given in Table 4:

Table 4: Statistics and t-test on use of ICT by possession of ICT qualification

| Hold any ICT qualification? | Count | Mean | Std dev | T | P |
|-----------------------------|-------|------|---------|-------|-------|
| No | 185 | 2.36 | 0.80 | 5.406 | 0.000 |
| Yes | 181 | 2.83 | 0.86 | | |

According to sample means in Table 4, holders of ICT qualifications were more frequent users of ICT than those who did not. This was supported by the very big t value ($p < 0.01$), which led to acceptance of the research hypothesis to the effect that possession of an ICT qualification and/ or training was a significant positive correlate of use of ICT at the one percent level of significance. The study finding was at par with such past studies as Fedorowicz and Gelinas (1998). It was in line with theoretical assertions such as that one by Kibera (1997) who argues that adaptability to technological advances is a factor of training. And contextually, the study concluded that perhaps low levels of formal ICT training in Makerere University are contributory to low levels of use of ICT in the University. It was thus recommended that for this to be reversed, then all stakeholders in the University deserve training, exposure and/ or encouragement with respect to ICT resources, in order to raise their propensity to use ICT. The University's Top Management and Directorate of ICT Support are called upon to offer the same.

3.3.3 Cosmopolitanism and use of ICT

The third hypothesis in the study was that cosmopolitanism directly correlated with use of ICT. Cosmopolitanism was taken as ranging from the worst case scenario of "rural poor" to the best case scenario of "urban elite". Thus respondents were asked to do self-rating as to the places where they were, at different levels in life, using a scale ranging from a minimum of 1 = rural poor, through 2 = rural but elite, 3 = urban poor, to a maximum of 4 = urban elite, and the resulting summary statistics are in Table 5:

Table 5. Statistics on cosmopolitanism at different levels in life

| Level in life | Mean | Standard deviation |
|-------------------------|------|--------------------|
| Childhood place | 2.16 | 1.13 |
| Primary schooling place | 2.27 | 1.09 |
| O-level schooling place | 2.81 | 1.02 |
| A-level schooling place | 3.09 | 0.96 |
| Current place of abode | 3.61 | 0.70 |

Table 5 reveals that on average, respondents' cosmopolitanism rose with education level. An overall average index ("Cosmop", acronym for "cosmopolitanism" from the five items in Table 5) had a mean = 2.79, which suggested that overall, respondents rated themselves as "urban poor". Pearson linear correlation between the cosmopolitanism and use of ICT indexes ("Cosmop" from Table 5 and "UseICT" from Tables 1 and 2) gave $r = 0.226$, $p = 0.000$, which suggested a positive ($r > 0$) and very significant relationship ($p < 0.01$) between cosmopolitanism and use of ICT at the one percent level of significance.

The study finding was in agreement with some other studies (e.g. Nafuna, 2002), and supported the theoretical assertion that cosmopolitanism positively related with use of innovations because urban residents have more education than rural dwellers and have better accessibility to the services and have better access to media like television and Internet, which are useful in communicating innovation gospels (Rogers, 2003). The study thus concluded that the less cosmopolitan teachers, senior administrators and postgraduates in the University needed extra training, exposure and/ or encouragement with respect to ICT facilities. Hence the recommendation those relevant stakeholders such as the University's Top management and Directorate of ICT Support (DICTS) give them that preferential treatment.

3.3.4 Age and use of ICT

The fourth hypothesis in the study was that age was inversely related to use of ICT. Respondents were thus prompted to state their ages to the nearest year, yielding a mean and median of 36.1 and 35 years respectively. Age had a range of 47 years that is from a minimum of 22 to a maximum of 69 years. Pearson's Linear Co-relation between age and use of ICT index ("UseICT" from Tables 1 and 2), yielded $r = -0.144$, $p = 0.006$, leading to acceptance of the research hypothesis to the effect that age was significantly inversely related with use of ICT ($r < 0$) at the one percent level of significance ($p < 0.01$). The study

finding was consistent with several past studies (e.g. Byarugaba, 1998) but inconsistent with others (e.g. Ehikhamenor, 1999). The finding concurred with theoreticians such as Schiffman and Kanuk (2004) who observe that age is an important correlate of use of innovations, with consumer innovators tending to be younger than late adopters. In conclusion, aged and ageing teachers, senior administrators and graduate students needed extra encouragement and/ or special training with respect to ICT, which assistance relevant stakeholders such as Top Management and Directorate of ICT Support (DICTS) are called upon to offer.

3.3.5 Gender and use of ICT

The fifth hypothesis was that gender related to use of ICT, with males being better. Summary statistics and t-test results there from, are given in Table 6:

Table 6. Statistics and t-test on use of ICT by Gender

| Gender | Count | Mean | Standard deviation | t | p |
|--------|-------|------|--------------------|---------|-------|
| Female | 128 | 2.59 | 0.83 | - 0.266 | 0.791 |
| Male | 253 | 2.61 | 0.87 | | |

Means in Table 6 suggest that females and males were almost at par as far as use of ICT was concerned. The small t value ($p > 0.05$) supported this observation. Thus at the five percent, the null hypothesis to the effect that gender was not significantly related to use of ICT, was accepted. The study finding contrary to what was hypothesized, was similar to that of Ehikhamenor (1999), but disagreed with others (e.g. Mburu, Massimo and Mutua, 2000).

The possible explanation for the study finding is that levels of use of ICT may be so low among teachers, senior administrators and postgraduates in the University that they cut across the gender divide. In other words, both male and female teachers, senior administrators and postgraduates in the University may be equally poor at use of ICT. The study thus concludes that both male and female teachers, senior administrators and postgraduates in the University need the same treatment as far as the use of ICT is concerned. Hence the recommendation that the relevant stakeholders such as the top management and Directorate of ICT Support accord both the male and female in the University equal training, exposure and/ or encouragement with respect to ICT resources.

3.3.6 Income level and use of KMS

The sixth hypothesis in the study was that income level was positively related to use of ICT. Respondents were thus prompted to rate themselves on income on a scale where 1 = Low; 2 = Medium; and 3 = High. Table 7 gives pertinent summary statistics and ANOVA results:

Table 7. Statistics and ANOVA on use of ICT by income level

| Income level | Count | Mean | Standard deviation | F | P |
|--------------|-------|------|--------------------|-------|-------|
| Low | 111 | 2.44 | 0.86 | 3.254 | 0.040 |
| Medium | 244 | 2.65 | 0.85 | | |
| High | 20 | 2.83 | 0.80 | | |

Means in Table 7 suggested that use of ICT rose with income, which was indeed supported by the big F-value ($p < 0.05$), leading to acceptance of the research hypothesis that income level was a significant positive correlate of use of ICT at the five percent level of significance. In addition to being consistent with the hypothesis in the study, the finding also collaborated findings of other studies (e.g. Matovu, 2003). The finding thus strengthened the theoretical assertion that the higher the income, the easier it is for an individual to acquire personal ICT facilities, and to get informal exposure to ICT through ICT magazines and newspapers (Moralez-Gomez and Melesse, 1998). The study then concluded that income was a significant positive correlate of use of ICT by teachers, senior administrators and postgraduate students in Makerere University. Hence, the recommendation that the stakeholders like the Directorate of ICT Support provide institutional ICT and other computers so that the financially less able can also access and hence use ICTs irrespective of ability to own the same.

4. CONCLUSION

This survey sought to investigate links between use of ICT in Makerere University with six individual characteristics, namely interaction with ICT change agents, ICT training, cosmopolitanism, age, gender and income level. The study which was a co-relational and cross-sectional survey biased to the quantitative approach, indicated only fair levels of use of ICT. Furthermore, all individual characteristics but gender significantly related with the use of ICT. Appropriate recommendations toward putting in place ICT change agents in all units of the University, training leading to possession of ICT qualifications, and special ICT help (including ICT training) for the less cosmopolitanism and the ageing and aged plus provision of institutional ICT so that the financially less able can also access and hence use the same, were accordingly suggested. Because gender was an insignificant correlate of use of ICT, it was concluded that both male and female teachers, senior administrators and postgraduates in the University needed same treatment as far as use of ICT was concerned. Hence the recommendation that the relevant stakeholders accord both males and females in the University equal training, exposure and/ or encouragement with respect to ICT resources.

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Key Issues in Information Communication Technology Policy Review Process: The Case of Tanzania

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ABSTRACT

Developing a National Information Communication Technology Policy (NICTP) of a country is vital for the development of a nation. Tanzania recognized that Information and Communication Technology (ICT) sector is a key accelerator to development, that is why NICTP was enacted by parliament in 2003, and what followed was its implementation. So far tremendous progress has been made including liberalisation of the sector. Although it is more than 7 years the ICT sector has changed quite significantly; there is a need to review all stages of the policy and finally come up with suggestions for improvements. This paper looks into the process of reviewing the Tanzania NICTP by applying the benchmarking process as a supporting tool for policy-making. The paper illustrates the analysis carried out and the results from five relatively successful countries, namely Australia, Estonia, Malaysia, Mauritius and Singapore in ICT policy formulation, policy focus areas and policy implementation. Besides the policy process and stakeholder's involvement, the ICT policy goals, objectives and mission are discussed. The institutional arrangements for driving the ICT policy at regional and international dimensions, as well as the implementation processes, policy review and monitoring are elaborated. The paper concludes with a set of recommendations on how the policy review processes should be carried out.

Categories and Subject Descriptors: K.4.1 [**Computers and Society**]: Public Policy Issues
General Terms: Human Factors

Keywords and Phrases: ICT, NICTP, Benchmarking, Policy

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1. INTRODUCTION

The National Information Communication Technology Policy (NICTP) development process for Tanzania started in the year 2000 as a result of the perceived lack of guidance on ICT. The lack of ICT Policy and existence of isolated initiatives led to random adoption of different systems and standards, resulting in unnecessary duplication of effort hence wastage of resources. Benefits of effective adoption of ICT are likely to result not only in an increase in connectivity or access, but more importantly benefits acquired from the facilitation of new types of development solutions and economic opportunities that the utilization

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of ICT makes it possible. These opportunities are envisaged in the National Strategy for Growth and Poverty Reduction and the Country's Vision 2025. The said NICTP was essential and necessary to guide the ICT development in Tanzania.

The NICTP development took the following action steps:

- a. Lobbying at the initial stages through government machinery
- b. Drafting and reviewing of the policy
- c. Approval process through the government machinery
- d. Permission to make digital/hard copy of part of this work for personal or classroom use is granted without fee provided that the copies are not made or distributed for profit or commercial advantage, the copyright notice, the title of the publication, and its date of appear, and notice is given that copying is by permission of the ACM, Inc. To copy otherwise, to republish, to post on servers, or to redistribute to lists, requires prior specific permission and/or a fee. © 2011
- e. Publication of the NICTP
- f. Implementation and
- g. Policy implementation, monitoring and review

The policy was approved and published in 2003, this was the first phase. Some of the weaknesses in the implementation of this phase were the top-down model of implementation, non-involvement of stakeholders during the developing process and non-integration and harmonization of regional ICT policies.

The publishing of the policy was to be followed by a sector by sector development of an integrated implementation strategy as a second phase of the ICT Policy development process. This phase was however faced by various challenges that eventually made this phase less effective in delivering the objectives stated in the policy document. Some of the challenges experienced included ownership of the process, institutional and governance structure, capacity and coordination at the Ministry of Infrastructure development and competition for resources among ministries, departments and agencies [Lishan, 2008].

From these weaknesses and challenges, there is a need of reviewing the policy to address the observed weaknesses and challenges, synergies and regional cooperation in ICT policies and harmonise regional policy framework in order to achieve economies of scale. The recent interest in broadband connectivity within the region and the development of a single market provide an opportunity for Tanzania to review its national ICT policy so as to reflect regional and global needs.

This paper underlines the need and effective process of NICTP review suitable for Tanzania, and the analysis of the key success factors that need to be considered during undertaking of the task.

2. METHODOLOGY

ICT is dynamic and therefore the processes and activities keep changing within very short time scales. These rapid changes in the ICT sector affect key decisions made and essentially call for a contemporary environmental scan. Owing to this dynamic nature of ICT, benchmarking appears to be the suited tool for policy review. In this case, review of the ICT Policy formulation of fast growing countries in recent years is considered effective. In the final phase, an analysis on how the Tanzanian ICT Policy was developed and implemented is made and thus elucidating the commonalities and differences.

2.1 Source of Information

In this study, key documents reviewed and analysed included the following: National ICT policies for Tanzania, Estonia, Australia, Mauritius and Malaysia. Other documents reviewed included:

- a. Fact Finding Mission Report by Lishan Adam concerning EAC ICT policy review – 2008.
- b. Harmonization of the East African Communications Regulatory Regime report by Professor David Souter - 2008.
- c. Stakeholders' recommendation report for ICT policy review in Tanzania by Lishan, 2008 EAC report.
- d. Key stakeholders from Tanzania were consulted in order to gather ideas and recommendation on the review of the ICT policy. The following stakeholders were consulted:

- e. The Permanent Secretary and the Director of ICT in the Ministry of Communication, Science and Technology (MCST)
- f. Director of Information, Commission for Science and Technology (COSTECH)
- g. Members of the Tanzanian ICT Policy formulation of 2003
- h. Director of Managements of Information Systems of the Bank of Tanzania (BOT)
- i. Director of Legal and Regulatory Framework of Tanzania Communication Regulatory Authority (TCRA)
- j. The private sector and the civil society specifically advocacy groups.

Resources for environmental scan are presented in Table I.

Table I: Resources reviewed during the environmental scan

| Source Type | Number Reviewed |
|--|-----------------|
| ICT Policies | 7 |
| Articles (Conference/Journal) | 10 |
| Reports (technical , fact finding and research reports) | 3 |
| Physical visits | 6 |
| Total | 26 |

The desk survey was used to review the existing policies of the mentioned countries. In the final stage, the Benchmarking analysis of the ICT policy cycle (formulation, implementation and review process) in Tanzania was considered against experiences of five relatively successful countries namely Australia, Estonia, Malaysia, Mauritius and Singapore. The emanating aspects of this work are discussed within the context of:

- a. The policy development process and stakeholders involvement
- b. The ICT policy goals, objectives and mission
- c. ICT policy focal areas
- d. Institutional arrangements driving the ICT policy development and implementation
- e. Regional and international dimensions
- f. Implementation processes
- g. Policy monitoring, evaluation and review.

3. BENCHMARKING AS A POLICY REVIEW TOOL

Benchmarking has different meaning depending on the institutional and organization set-up in which it is applied. It can be used to measure the success factors of a policy towards developing an ICT society. There are several regional benchmarking options that includes the bottom-up approach, top down approach, horizontal approach etc. In the bottom-up approach, regions get together and agree among themselves on a set of common indicators. Since the region has different policy framework, it is not possible to apply the method initially. The choice of indicators is a result of a compromise among different regions without top-bottom coordination. This implies that the same indicator can measure different parameter in different regions for example a measure of policy output, results, and impacts, or a simple framework of readiness indicator could be adopted [Osimo and Gareis, 2005].

In this work it is important to consider the position of indicators into the policy-review process and benchmarking as indicated in Figure 1.

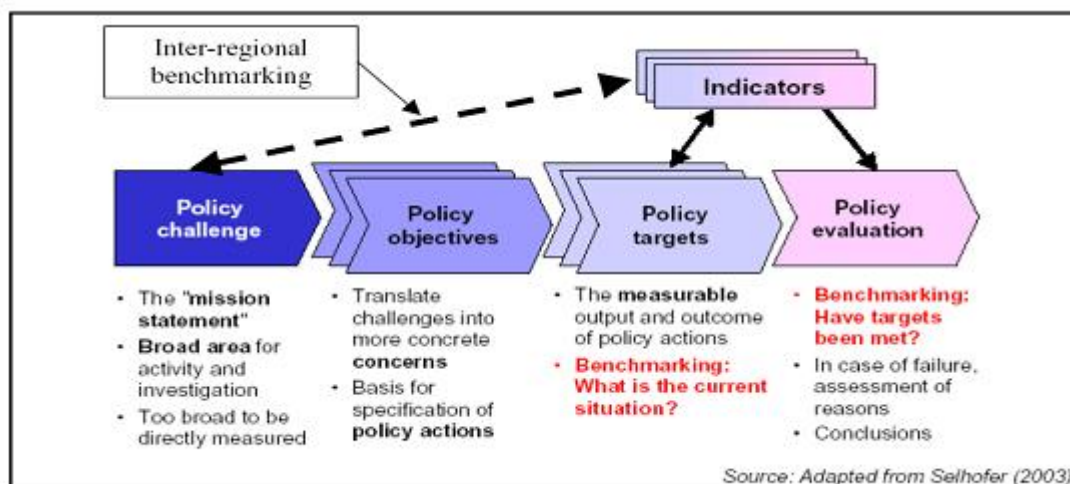


Figure 1: The different roles of benchmarking in policy-making

From the figure, the role of benchmarking is not simply to measure the attainment of policy objectives through policy evaluation, but have a direct impact on the policy review process.

3.1 Policy Development, Review Process and Stakeholders Involvement

The policy formulation of five selected countries demonstrates several advantages of involving stakeholders like the private sector, academia and civil society organizations such as professional bodies in the policy processes. The process for development of Australian, Estonian, and Singapore and Mauritius ICT policies had consultative meetings with a range of stakeholders. Of interest is the case of Australia where the stakeholders were approached by e-mail regarding their discussions on effective use of ICT by citizens and consumers across civil society [Australia Gov. ICTP].

The Tanzanian policy development emerged as a need from the government and gather experts on ICT to develop or rather draft the policy. This team used their expertise and developed the policy without involving the stakeholders. In principle this draft lacked ownership of the majority of the stakeholders. The consequence of this process is the lack of clear harmonized approach to its implementation strategies.

3.2. Benchmarking ICT Policy Vision, Missions and Objectives of selected countries compared to the Tanzania's

The policy vision, mission and objectives of Estonia, Singapore and Mauritania emphasizes addressing citizen problems which are similar to those of Tanzania. Furthermore, countries like Singapore [Singapore ICTP] and Malaysia [Malaysia ICTP] have provided milestones in the policy. In Malaysia, the State has a vision to utilize ICT to transform successively to an information society, a knowledge society and finally a values-based knowledge society [Malaysia ICTP]. In Mauritius, the policy vision on making use of the ICT as the fifth pillar of the economy and transforming the country to a regional ICT hub [Mauritius ICTP].

The Tanzania NICTP is aligned to the following vision statement: "Tanzania to become a hub of ICT Infrastructure and ICT solutions that enhance sustainable socio-economic development and accelerated poverty reduction both nationally and globally." This vision statement has the following limitation;

The vision statement is directed towards the utilization of ICT for accelerating poverty reduction nationally and globally. The global focus of poverty reduction shouldn't be among the elements of the national vision. Rather the vision should focus on full participation of the country in the global information society.

No emphasis of universal access in the vision statement as the success of becoming the ICT hub depend much on the accessibility issues that includes the concept of digital divide between access in urban/rural and national/international relations.

3.3. Strategic ICT Leadership

The objective of the Strategic ICT leadership involves an increase in the use of ICT for equitable and sustainable socio-economic and cultural development of Tanzania, aiming at improving the awareness on the role and potential of ICT. In so doing, creating an authoritative national organization to effect, coordinate and review the ICT policy. The role of prioritizing ICT investment in development assistance policies and programmes, enhancing synergy, economies of scale and productivity in all ICT matters and create a favorable environment for cooperation and partnership in ICT among public and private sectors, civil society became an important ingredient to its development. This is consistent with best-practice in Estonia, Singapore and Malaysia picking a few supporting examples. The review process has to follow this definitive focus.

3.4 ICT Infrastructure

Infrastructure covers both national and institutional levels. At national levels a system to ensure usefulness of the installed infrastructure has to be assured of. In Tanzanian case for example, building the broadband infrastructure is the main agenda. Achievements realized in Mauritius and Singapore is a result of broadband deployment. Both countries based on the objectives of the respective Act, targets were set which include:

- a. An increase in penetration rate from 25 to 50 for every 100 population for the whole country and rural areas respectively by 2020. An interim target of 30 per 100 persons had been set for Malaysia by the year 2005.
- b. Quality of service at affordable costs.
- c. Infrastructures development communications and multimedia infrastructures with adequate and effective plans for supporting overall economic development.
- d. Creation of a hub to serve the global hub of communications and multimedia industry in this region.

The Tanzania NICTP has several objectives concerning broadband issues including the objective of providing special incentives for investors to deliver broadband connectivity to hitherto disenfranchised and isolated populations in the country [Statement 3.10.2 (c) of the National ICT policy (2003)]. The fact finding report revealed that, the private sector especially the mobile operators have invested substantially in developing an efficient infrastructure (Lishan 2008 EAC). However, interoperability, reliability and rural access are challenges to the initiative. Infrastructure sharing has been recommended as the most sustainable and efficient way of rolling out infrastructure, although it is facing internal resistance from the operators who consider their infrastructure as a business differentiation tool.

3.5 The ICT Industry and Human Resource

The ICT industry is service- or hardware manufacturing- or assembly-based. It is imperative that companies are involved in all aspects of the business. A national ICT policy could stimulate the establishment, development and growth of ICT businesses through incentives and support provision. Incentives could include encouraging foreign partnerships or joint ventures, foreign direct investment or empowering local businesses and tax incentives.

In Mauritius for example, several strategies to enhance productivity and efficiency across economic sectors and SMEs through the use of ICT were set and it worked. Besides, Mauritius established an Export Development Fund in order to extend the foreign market for ICT.

NICTP on the other hand, intend to make Tanzania a producer and not a mere consumer of ICT products and services. It is thus clear that the ICT Policy is expected to create conducive environment for a vibrant and sustainable ICT industry, making the country a more competitive developer and producer of ICT products and services. The policy lacks support to entrepreneurship and emphasis on small and medium enterprises (SMEs).

On human resource development, Mauritius, Estonia and Malaysia defined it clearly in their ICT policies. Malaysia set several objectives to improve the human resource capacity that stimulates improving science and technology courses, the use of e-learning and training teachers on ICT skills.

Tanzanian NICTP provides for the development of an ICT ready workforce with the objective of increasing human resource ICT skills, support ICT training for political decision-makers, community and civil society leaders, as well as private and public sector executives, expand and develop the teaching of ICT at all levels of the national system of formal and informal education and training, to foster interest among scientists. The policy does not address regional linkages in the development of human capacity development.

3.6 ICT Productive and Service Sectors

The inception and diffusion of ICT in the production sectors forms an important basis for exploitation of the ICT muscles at the full-scale. The ICT policy needs to strengthen the competitive and comparative advantage of hardware and ICT service providers locally, regionally and internationally. Policies of some countries have focused on local companies over foreign-owned companies just as is the case with Mauritius ICT policy's priority, "*Enhanced productivity and efficiency across economic Sectors and SMEs through ICT*" is evident [Mauritius National ICTP].

The Tanzanian NICTP basically was to bring a facilitative role of ICT within the production sector so as to improve efficiency and productivity. It had an objective of contributing to the reduction of poverty and improve the quality of life of Tanzanians, fostering enterprise, entrepreneurship and innovativeness for sustainable socio-economic and cultural development.

Correct policies have to recognize the opportunities and services so that they could be included in the policy implementation strategies. This is evident in Australia, which recognizes e-commerce as a service to ICT [Australia NICTP]. ICT policies of Estonia, Singapore and Australia recognize economic reforms that are necessary. Thus, the Tanzanian service sector needs to aim at improving the economy by boosting production, ensuring growth and living standards.

3.7 ICT Legal and Regulatory Framework

Many of the leading countries in ICT policy formulation and implementation formulated regulatory and legal frameworks for easy implementation of the ICT policy. In this case, Singapore created several acts and regulations that provide legal recognition of electronic contracts and electronic signatures. Malaysia on the other hand, developed Digital Signature Act. 1997 to give a digital signature the same legal status as an ordinary signature, thumbprint or other binding mark in use. Above all, Singapore and Malaysia have enacted binding laws dealing with cyber crime while Mauritius intends to improve cyber security culture. Deployment of the necessary infrastructure to support secure electronic transactions for e-business and e-government need be implemented. Other entailing key issues include measures to protect the confidentiality and privacy of citizens, increase the level of awareness on information security threats and best practices to safeguard data.

Singapore established cabinet agencies to oversee ICT policy-development as shown in Table II. The key question here is whether there is one best institutional model for policy-development and implementation. However, it is important that agency or commission is given a leading role in ICT planning and development.

Table II. Policy-making and Regulatory Bodies: Apex ICT Policy-making Bodies

| S/N | Country | Details |
|-----|-----------|---|
| 1. | Singapore | Ministry of Information, Communications and the Arts (MITA) Formulates and administers policies to regulate and develop the Infocomm industry (which includes telecoms/IT/Postal Service) through the Infocomm Development Authority. MITA also supervises Singapore Broadcasting Authority (SBA), the agency responsible for regulating broadcasting and Internet content. |
| 2: | Malaysia | National IT Council (NITC) established in 1994, chaired by the Prime Minister, and composed primarily of government ministers with private sector participation |

Technological development to significantly regulate is of important. Digital technology has enables the use of one digital network to distribute services that used to require a number of different analogue networks. Thus, broadcasting, telephony and internet can be delivered using one network. A number of countries have created one regulatory agency to handle telecommunications and IT, owing to the convergence of information and communication technologies. Malaysia's Communications and Multimedia Commission and Singapore's Infocomm Development Authority are good examples as shown in Table III.

Table III. Policy-making and Regulatory Bodies and the Regulatory Environment

| S/N | Country | Details |
|-----|-----------|---|
| 1. | Singapore | Infocomm Development Authority (IDA) Regulator of telecommunication and postal services. Media Development Authority of Singapore (MDA) Responsible for regulating broadcasting and Internet content. |
| 2: | Malaysia | Malaysian Communications and Multimedia Commission (MCMC) The Malaysian Communications and Multimedia Commission Act 1998 (Act 589) provides for the establishment of the MCMC with powers to supervise and regulate communications and multimedia activities in Malaysia. |

Tanzania Communication Regulatory Authority (TCRA) is a convergence regulator bringing the convergence concept in communication sector to reality in Tanzania. TCRA is a merger of the former Tanzania Communication Commission (TCC) which used to regulate communication, the Tanzania Postal Commission (TPC) which was regulating postal services and the Tanzania Broadcasting Commission (TBC) which used to regulate broadcasting industry [<http://www.tcra.go.tz>]. The merger concluded the evolution of the regulatory environment from the Tanzania Post and Telecommunication Corporation. Nevertheless an emphasis is needed on confidentiality and privacy, formulation of the National Information Security Strategy and promoting the adoption of Information Security Standards at national level.

3.8 Public Service and Local

Many developed and developing countries focus on the use of ICT to enhance service delivery to the public. Remarkable efforts have been shown in many of these countries including Singapore and Malaysia. Mauritius has set out goals for the use of ICT for delivering government services. Specifically, the government of Mauritius stipulated strategies for comprehensive business process re-engineering in departments and ministries, launch a special initiative to cater for delivery of e-government applications through other electronic channels other than Internet, implementation of information systems and shared databases, introduce policies and procedures to safeguard the privacy of citizen data, encourage the use of smart cards and biometrics in e-government applications and will enhance the current ID card to one based on smart card technologies.

This pillar (Public service) in the Tanzania NICTP focuses on effective delivery of services to the public. The specific objectives of e-government outlined in NICTP are to increase the productivity of both the public and private sectors, empowering the public by building an e-Government platform that facilitates their relationship and interactions with the Government, and enhances the range and delivery of more effective public services at both central and local levels, while also generating accurate and timely information to better shape policies, strategic plans and tactical decisions for developing and enhancing the delivery of affordable public services. Moreover the policy also has outlines strategies for promoting good corporate and public governance by furthering information sharing, transparency and accountability.

Compared to infrastructure development, content development has not received as much attention from governments worldwide. Already we see that lack of local content has driven Internet traffic in many countries to foreign sites. There are countries such as Singapore that have initiatives to develop local content. Singapore and Malaysia have laws and rules regarding objectionable Internet content Table IV. Singapore is unique in combining government rules with industry self-regulation in managing content. While most prohibit content that are deemed pornographic, a number also regulate political content. In some countries, governments are nervous about content, especially that which is seen to be challenging the political and economic interests of the State or its allies. Content that has the potential for political

mobilization also comes within the orbit of the State's surveillance, which is provided for by the laws enacted in these countries.

Table IV. Content Management

| | |
|-----------|---|
| Singapore | MDA's Class License Scheme Under which the Internet Code of Practice was issued. Internet Code of Practice Drafted by the Singapore Broadcasting Authority in 1997. Establishes the guidelines for acceptable content that can be published over the Internet. |
| Malaysia | Communications and Multimedia Act of 1998 makes it an offence to provide content that is indecent, obscene, false, menacing or offensive in character with intent to annoy, abuse, threaten or harass any person. Other laws (including the Penal Code, Sedition Act, and Internal Security Act) apply to content regulation of the Internet. |

Source: Singapore & Malaysia NICTP

While other countries have developed laws governing the management of local content, The Tanzania NICTP focuses on supporting the local creation and development of ICT applications and multi-media content for productivity, as well as for social interactions, culture and entertainment, encouraging the development of local content and promoting the development of local content to support e- activities. Thus, the role of the government in providing support and resources in the development and deployment of content in local language need to be enhanced by developing adequate policies to re-enforce government commitment to broaden dissemination and use of local content in local languages.

Mauritius has strategies for harnessing ICT for Social Development. These include the specific targets of increasing ICT integration in society, by providing access to ICTs to all communities including those who are isolated geographically or economically, provide access to ICTs 3.12 Universal Access through the enhancement of existing Public Internet Access Points (PIAPs), reducing the digital divide, by encouraging the youth to set up computer clubs with the aim to encourage their interest in IT-related fields and to provide online for so that they can express their needs.

The study found that commitment to universal access is the cornerstone of efforts to reach out to include everyone in the information economy and is a first step in bridging the digital divide. A funding mechanism to meet the cost of universal access has to be discussed and negotiated by the telecoms regulator and/or the government department/ministry responsible for this. Operators should contribute to the cost of rolling out access as part of their obligations under the licensing agreements they have signed with the local regulatory authority of the government.

3.9 Institutional Arrangements for driving the ICT policy

Similarly to Singapore, Tanzania has established TCRA as the sector ICT regulator. The regulator is an independent, credible, and effective quasi-government body whose functions are to regulate and monitor the ICT sector and foster competition through the issuance of licenses to operators and franchise holders. The regulator is a statutory body that was established as part of the Government Policy reforms in the communication sector with the aim of improving the availability of the info-communications services to the public as well as to allow new players into the market. TCRA reports to the line Ministry (Ministry of Communication Science and Technology) established February 2008.

Contrary to Singapore, the above two organs are not featuring in the ICT policy for Tanzania, thus the policy should clearly outline the roles for TCRA and MCST. Moreover, identification of the various players, their specific roles and relationship should be defined clearly in the policy framework. Furthermore, institutional arrangements for ICT policy implementations should consider the participation of both public sector and private sector and functional linkages between different key institutions should feature clearly in the revised policy.

4. FORMULATION OF TANZANIA NICTP

4.1 Tanzanian National ICT Policy Formulation Process

The efforts for developing a policy to support the deployment of ICT for social-economic development in Tanzania began in the mid nineties. Two National workshops were organized by the then planning Commission and facilitated by the UNECA under its NICI Projects initiatives. It was however the interests of the general public, under the Tanzania e-ThinkTank [<http://www.ethinktank.org>] group - a fraternity supported by the United Nations Development Programme (UNDP) that made further push for the articulation of the policy. The actual drafting of the policy was undertaken by a broad based Task-force under the Ministry of Communications and Transport which was mandated to be a focal point for ICT and the policy was adopted in 2003. The broad objectives of the ICT policy were to [TNICTP]:

- a. Provide a national framework that will enable ICT to contribute towards achieving national development goals
- b. Transform Tanzania into a knowledge-based society through the application of ICT
- c. Provide a national framework to accommodate the convergence of information, communication and technology including media.

Despite the broad participation of multiple stakeholders in its development, the ICT policy in Tanzania did not translate into action plans. The establishment of the Ministry of Communications, Science and Technology in 2008 created a new impetus for updating the policy framework and implementing flagship projects.

Table V. shows the state of ICT for policy and key milestones in Tanzania

| | | |
|------|---|--|
| 1999 | <p>ICT policy spearheaded by loose informal group – eThinkTank but latter overtaken by government.</p> <p>The ICT policy implementation plan was not developed.</p> | <p>1993- Tanzania Communications Act and establishment of Tanzania Communications Commission</p> <p>1997 -National Telecommunication Policy</p> <p>2003 - Adoption of a national ICT policy</p> <p>2003- Tanzania Communications Regulatory Act</p> <p>2003- Establishment of TCRA as a converged regulator combining Tanzania Communications Commission and Tanzania Postal Commission (TPC) and the Tanzania Broadcasting Commission (TBC)</p> <p>2005- TCRA converged licensing framework</p> <p>2005- ICT backbone study</p> |
|------|---|--|

Source: TCRA www.tcra.org.tz

The above snapshot, Table V, is the ICT policy processes in Tanzania. It indicates that in all cases telecommunications policies precede the development of broad-based national ICT policy. However, there has been limited connection between efforts to liberalize the sector and the broader national ICT policy that were aimed at addressing ICT application for social and economic development. Consequently there has been a major disconnection between communication policies that address access issues and broad based ICT policies that focus on the exploitation of ICTs as instrument of development. A consequence of the disconnection between communication sector reform and ICT for development policy was that although access to communication was improved through cellular services, progress with regards to fixed lines and broadband network that underpin ICT application has remained very low. Increasing access to affordable communication and the development of human capacity are prerequisites for the success of ICT policy in Tanzania.

4.2. Policy Priorities and Internet Regulation

Although Tanzania has started internal process of governance over the Internet by developing her own set of National ICT Strategies, infrastructure, technological and regulatory frameworks, there is wide gap between national policy and the regulation of online environment, particularly in the aspects of international communications infrastructure, content access and development, electronic trade and on-line applications. The policy process didnot pay particular attention to the governance of the Internet except efforts by civil society organizations that raised the issues of domain registration and participation in the full range of Internet governance debate. Awareness around Internet governance issues is very low and consistent legal framework to address consumer and data protection legislation against identity theft,

unauthorized access of information, e-commerce fraud and other forms of cyber crime are generally absent. There is a need to establish a committee to address Internet issues discussed above.

The review of the ICT policy shows that there is an overlap in the priority areas, a reflection of the common social and economic challenges in the country. The overlap is evident particularly in the areas of:

- a. Human resources development
- b. Infrastructure in particular broadband infrastructure development
- c. Policy, legislative and regulatory framework
- d. ICT sector development
- e. ICT applications and content

Main areas of focus of ICT policy Include: ICT Leadership, ICT Infrastructure, ICT Industry, Human Capital, Legal and Regulatory Framework, Productive Sectors, Service Sectors, Public Service, Local Content and Universal access. Furthermore, the vision and mission expressed in the policy document remain consistent - an indication of a degree of convergence in adopting common vision to harness information and communication technologies for development.

The review of the policy indicates that; there is under emphasis of the need for highly skilled human resources and ICT research and development that could have long term economic and social benefits to the country. The smart use of ICTs in the universities, public and private sector is critical for national as well as regional competitiveness.

The application of ICTs in agriculture and health has not been given equal attention as compared to the number of workforce and amount resources devoted to these sectors in the country.

4.2 Institutional Arrangement and Participation of Stakeholders

Institutional arrangement and the participation of various stakeholders particularly the media, civil society, private sector and the academia provide a good indication of the maturity of ICT policy. The review of institutional arrangement shows that the more the ICT function is sponsored by the highest political leadership (the President), the better the chance of its success. Similarly, the higher the involvement of major stakeholders in the policy process (formulation, implementation and review of policy), the higher the ownership and the better the success in implementing ICT programmes.

Although Tanzania had a relatively developed broad consultation process in the ICT sector, the participation of civil society in ICT policy issues has not been that consistent due to lack of a strong ICT civil society with a national coverage. Table VI shows institutional framework for policy formulation and implementation.

Table VI. Institutional Framework for ICT for Development Policy

| Governance institutions | Governance features | Participation |
|--|--|--|
| New Ministry for Communication, Science and Technology Tanzania Communications Regulatory Authority | Ministry expected to promote with strong civil society participation Lack of coordination and ownership New ministry expected to alleviate coordination challenges | Tradition of civil society participation Strong and competitive private sector facilitated by good regulatory framework |

Source: NICTP document

Evaluation of the governance framework shows that various sectors and institutions continue to compete for external resources to meet their needs and concerns independently, rather than creating a favourable framework applicable to all. It is evident that, the ICT policy was developed by experts. Where as one could have expected to it be developed by professionals. Neither the policy build on government computerization initiatives, no facilitation on further sector reforms to expand access to communication networks. The main lessons that can be drawn from the ICT policy can be summarized as follows:

Streamline institutional arrangements. The establishment of the directorate of ICT at the Ministry of Communication Science and Technology has a high chance of success in the implementation of ICT programmes and mobilization of resources.

Since the Ministry to champion ICT among other things exists, the established directorate will drive the policy process, develop priority and flagship projects and implement projects through public and private partnerships. The minister or the permanent secretary should act as key champions and sponsors for the ICT policy process.

The separation of policy (political) and regulatory (procedural) function has been a key governance challenge. There is no one size fit strategy for the separation of policy and regulatory functions; however it is essential that the regulator is insulated from day-to-day interference of policy makers and secure its financial autonomy. The legitimacy of the regulator can be improved by enhancing its competence and improving its interaction with the public.

A good coordination among institutions requires a champion Minister or Permanent Secretary, trust and flexibility within the ICT policy.

4.3 Implementation of ICT Policy

In general terms, the ICT policy leads to an implementation plan benchmarked by flagship projects, although the presence of an implementation plan may not guarantee the success of policy. A review of the situation of Tanzania shows that the implementation of the ICT policy is driven by external funding than a well thoughtout plan that addresses the key building blocks like infrastructure, regulatory functions and human resources development as envisaged and monitored.

Although NICTP existed, Tanzania did not develop the implementation strategy. Various projects targeted to the policy have been implemented with support from external donor agencies. The national fiber backbone network, Universal Access, Post Coding and Addressing System and the e-government projects are among the current flagship projects for the implementation of the national ICT policy. The main objective of the national backbone project is to establish a telecom backbone transmission network to satisfy domestic and regional ICT requirements in the long term. It intends to provide long-distance telephone networks, data backbone networks and extend Internet bandwidth countrywide by offering sufficient capacities, network resiliency and guaranteed quality of service provision to meet the needs of voice, data, mobile, internet, leased circuit and more.

5. KEY FACTORS ON THE DEVELOPMENT OF NICTP

By using the benchmarking principals the NICTP for Tanzania was analyzed and compared to other countries. The emerging issues from the work and the entailing findings are categorized in the following key elements summarized as:

- a. The policy process and stakeholders involvement
- b. The ICT policy goals, objectives and mission
- c. ICT policy focus areas
- d. Institutional arrangements for driving the ICT policy
- e. Regional and international dimensions
- f. Implementation processes
- g. Policy review and monitoring

Institutional framework for implementing the national policy implementation and monitoring was not described adequately in the policy, hence some roles were left hanging. It is observed that all the stakeholders consulted strongly feel that the policy left a serious governance gap. Most of the stakeholders interviewed agreed that, coordination of the implementation strategy was inadequate and therefore created confusion on what have to be done and what should be the source of funding for the proposed activities.

6. CONCLUSION

The analysis of the current NICTP development and implementation has been carried out. Weaknesses were identified through the Benchmark approach taken to analyze and compare the Tanzania NICTP from other countries of similar nature but in different regions. It is evident that from the start of the initiatives, drafting and development of the policy stakeholders took a backbencher role, thus leading to:

- a. Lack of ownership and operational institutional framework
- b. Poor participation of key stakeholders
- c. Poor coordination during implementation
- d. Lack of coherent but integrated implementation strategies

In order to correct the situation, the policy review process has to consider changes in technology, new national and regional developments and recognize the evolving of new acts and policies. A good policy with its implementation strategies and institutional framework has the potential of making ICT an effective tool in achieving countries development goals.

For an effective policy review process it is recommended that:

- a. The review of the NICTP should involved stakeholder emphasizing a multi-stakeholder participatory approach involving key ministries.
- b. Policy vision and mission to address universal access and infrastructural developments and sharing with key role players.
- c. The policy has to appreciate such other laws and regulations like cyber usage, e-transaction, confidentiality and privacy.
- d. The reviewed policy has to emphasize downstream issues like ICT Incubator to promote local entrepreneurial culture.

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Use of Concept Map Scaffolds to Promote Adaptive E-Learning in Web-Based System

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ABSTRACT

Scaffolds are a good method of implementing self-regulated learning. Use of prior knowledge makes the learner to understand a topic better. Learner adaptation enables a learner to be presented with content that matches his/her level of understanding.

The main aim of this project is to use the adaptive scaffolds in form of concept maps in web-based e-learning systems to play the role of learner guide. The learner creates a concept map from prior knowledge to show how he/she understands a certain domain of knowledge. The concept map takes into account the knowledge of the learner in that topic, and uses it to adapt to the user level. This is done by integrated evaluation where the learner is presented with a concept map that matches his level of understanding as he/she draws the concept map. The scaffolding and the adaptation are implemented using production rules.

Categories and Subject Descriptions: H.5.2 [Information Interfaces and Presentation]: User Interfaces – *User Centered Design*; H.5.4 [Information Interfaces and Presentation]: Hypertext/Hypermedia – *Navigation, User issues*; I.2.6 [Artificial Intelligence]: Learning – *Concept learning; Induction*; K.3.1 [Computers and Education]: Computer Uses in Education – *Distance Learning, Computer Assisted Instruction (CAI)*; J.4 [Social and Behavioral sciences]: Psychology

General Terms: Algorithms, Human Factors, Experimentation, Measurement, Performance

Additional Key Words: Scaffold, adaptation, prior knowledge, learner evaluation, concept maps, cognition, adaptive e-learning systems, adaptive scaffolds, integrated assessment.

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1. INTRODUCTION

Cognition is the process of knowing, and includes all the mental processes that may be described as an experience of knowing (including perceiving, recognizing, conceiving, and reasoning). Easy learning takes place when the cognitive load of a learner is greatly reduced.

Cognitive maps are a good way to represent internally represented concepts and relationships among those concepts. Concepts are built from past experiences and an individual can then interpret new events/concepts from prior concepts (Weick, 1979).

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A concept map is a graph in which nodes (points or vertices) represent concepts, and links (arcs or lines) represent the relationships between concepts. The concepts, and sometimes the links, are labeled on the concept map (Novak and Canas, 2008).

Scaffolding refers to a temporary structure on the outside of a building, used by workmen while building, repairing, or cleaning the building to enable them to reach *unreachable* parts of the building.

In learning, scaffolding is defined as the assistance a teacher gives a student in a learning situation (Montet, 2004) to reach levels not possible if the student is working alone.

2. SOME USES OF CONCEPT MAPS IN LEARNING

Effective learning depends on the creation of new schema (concept map), or on existing schema being revised, extended or reconstructed. Concept maps are used in many ways in learning. Among those uses, the ones used in this project include:

1. They make knowledge explicit, thus allow the learners to become aware of what they know (prior knowledge) and as a result be able to modify what they know to create new knowledge.
2. They are used as scaffolds – they enable a learner to reach unreachable areas thorough step by step guidance. Teaching scaffolds may involve breaking a large task into smaller parts. The learner is guided from an easy to a more difficult task.
3. Knowledge evaluation – This is assessment by comparing the concept map drawn by the learner and the expert concept map.

The use of prior knowledge is important in learning. The learner is able to use prior knowledge to build onto new knowledge.

A tutor can use concept maps to identify the key concepts and the relationship between them. The structure of the to-be-learned domain can be presented before or during the learning phase, thus playing the role of advance organizer. They can also be used after the learning episode as an integrative tool (Bruillard & Baron 2000). Guiding the learner from one level of knowledge to another (learning) enables the learner to learn with ease. The learner can start with the more general things (easy) and later move to more specific ones (more difficult), hence progression from one level of knowledge to another (Raleigh, 1997). This approach is naturally achieved implemented using hypermedia as is the case with web-based learning (Hoffman, 1997).

Knowledge assessment can determine the level of understanding of the learner by comparing what the learner knew before learning and what he/she knows after learning. A web-based concept map learning system proposed in this project provides and facilitates the use of the above features to promote learning.

2.1 Use of Concept Maps to realize Adaptation in Web-based Learning

The notable difference in concept maps from other cognitive mapping techniques is their emphasis on prior knowledge when learning about new concepts (Ausubel 1968). This prior knowledge is used as the starting point in drawing a concept map, and later extend the concept map by adding more concepts, thus learning taking place.

The main aim of adaptive systems is to offer *individualized* learning service to each learner (Peña and Sossa 2004). Adaptive Educational Hypermedia (AEH) deals with providing a personalized educational experience by adapting its presentation of content to the learner's needs. An Adaptive Hypermedia System (AHS) may conditionally show, hide, highlight or dim conditional fragments of the system (Brusilovsky 1996).

Ortiz et al (2007) defines a navigable concept map as one that presents additional information when the user selects one of its elements (concepts). If the user is interested in a certain concept, the system visualizes one of more electronic documents of web pages that permit the user to learn about the concept. Basically, concept maps allow the learners to get a lot of course content with structure and coherence, in a non-linear way. They enable the learner choose their interested concepts and then follow the strategy he/she prefers. However, a learner may be overwhelmed by a big or unknown concept map, which may show too

many elements at once or provide material that the student is not prepared to understand leading to helpless and de-motivated student (Ortiz et al. 2007). To reduce these problems, techniques from adaptive hypermedia systems can be applied so that concept maps can be adjusted to learner's features and knowledge (to only information that student is ready to comprehend).

In this study, adaptation was offered by regulating the number of concepts and concept links provided to the learner. The adaptation was guided by the learner's level of knowledge. The level of knowledge was estimated according to the number of correct concepts and relationships between concepts in a concept map presented by a student. This adaptation was implemented using production rules.

2.2 Concept Maps and Learner Evaluation

Comparing the concept map of the learner and that of the instructor ("expert" concept map) was used to evaluate the learner. This comparison was also used to determine the level of the learner and thus important in implementing adaptation. A learner model was made from this evaluation, prompting for the particular adaptation schemes mentioned above.

2.3 Concept maps and Artificial Intelligence

The use of concept maps has not been well incorporated in adaptive systems. The use of intelligent learning approach is one viable way to enhance adaptive systems.

Artificial Intelligence is known to offer the logistic framework and experiences in the educational area through the use of the Intelligent Tutoring Systems – ITS (Peña and Sossa 2004). They described a conceptual proposal for the designing and management of the student model by the use of cognitive maps as a way to deal with the learning process that implies causality.

The student model, being the particular view for each user, could be built from scratch or from a general schema of concepts and fulfilled with the particular properties of the learner. Then, it can be *updated* along the assessments of the learning experiences that reveal the cognitive progress of the student.

Peña and Sossa (2004) suggest an Adaptive Web-Based Education System (AWBES) whose main goal is to provide a flexible and well-fitted education/learning service oriented to the each specific learner from a general framework. AWBES borrows the student model from ITS. AWBES is among the few that have ventured into the use of artificial intelligence in adaptive systems.

3. AIMS AND OBJECTIVES OF THIS STUDY

To develop an adaptive web-based learning software prototype that uses concept maps

- To make use of the student's prior knowledge,
- To provide personalized support for learning according to the student's level of knowledge and
- For evaluating the student's level of knowledge

4. HYPOTHESES

This study used two hypotheses

Hypothesis 1

"Students using the adaptive concept mapping tool will draw a more correct concept map than those who use the non-adaptive concept mapping tool."

This hypothesis was further split into four hypotheses:

Sub-Hypothesis 1.1 – Number of Correct links

The experimental group will score better than the control group in identifying the number of 'correct links'.

Sub-Hypothesis 1.2 – Number of Valid links with wrong labels

The experimental group will score better than the control group in identifying the number of 'valid links with wrong labels'.

Sub-Hypothesis 1.3 – Number of Reversed Links

The experimental group will produce less number of ‘reversed links’ than the control group.

Sub-Hypothesis 1.4 – Number of Invalid Links

The experimental group will produce less number of ‘invalid links’ than the control group.

Hypothesis 2

“The experimental group will be more positive and have a better attitude towards the learning environment than the control group”

5. USE OF CONCEPT MAPS TO REALIZE ADAPTATION IN WEB-BASED LEARNING

Adaptive Educational Hypermedia (AEH) deals with providing a personalized educational experience by adapting its presentation of content according to the learner's needs. Mostly, adaptation is achieved through a user model. The user model is based on each individual user and includes features such as user goals, preferences and knowledge.

An Adaptive Hypermedia System (AHS) will conditionally show, hide, highlight or dim conditional fragments of the system (Brusilovsky 1996). In this study, adaptation is achieved by hiding some concepts and relationships from the student. A student model needs to be constantly updated to reflect the current status of the student, which is used to guide adaptation

The learner's level of knowledge in the learner model was used to guide adaptation of concept maps. The level of knowledge was estimated according to the number of correct concepts and relationships between concepts in a concept map presented by a student, using a rule-based approach. The number of concepts and number of concept links made available to the student were adapted according to the learner's level of knowledge.

6. METHODOLOGY

The following general approach was used:

1. Designing and implementing a web-based adaptive concept maps software prototype.
2. Making a non-adaptive copy of the prototype by disabling the adaptive features of the system
3. Giving the adaptive prototype to the experimental group for concept mapping. Giving the non-adaptive version to the control group for use during concept mapping.
4. Determining whether the learner' using the prototype will learn better or not.

6.1 Experimental Design

An experiment was conducted on two groups; an experimental and a control group. Students were randomly assigned to each group. Both groups were given the same passage (domain) on plants and used it to draw a concept map.

Experimental Group

The experimental group was given the adaptive concept maps software prototype to draw the concept map.

Control Group

This group constructed the concept map using a non-adaptive concept maps software prototype.

Both prototypes provided the students with possible concepts and links (relationships) from that particular domain.

6.2 Experimental variables

There was one independent variable in this experiment (a two-level concept map tool: the adaptive software prototype and the non-adaptive prototype, both for drawing concept maps). There are two dependent variables: concept map production and learning environment.

The main objective of the experiment is studying the effect of the independent variable (software prototype) on the dependent variables (mapping production and learning environment).

6.3 Experimental Subjects

Nineteen (19) third-year BSc. Computer Science students of KUCT participated. The students were randomly allocated to either the experimental or control group. Both used the same passage (domain) to draw the concept map.

6.4 Experimental Procedure

The following procedure was used in conducting the experiment:

1. The students were randomly assigned to either the control or the experimental group.
2. The students were introduced to concept maps, using an example.
3. The students were supplied with a passage on the general topic of plants.
4. The students from both groups were shortly introduced to their respective software prototypes to enable them to develop a concept map without any technical problems.
5. The students were asked to develop a concept map from the supplied paragraph (on plants in step 3), using the supplied web-based concept mapping tools. Each student developed the concept map individually.
6. The students were constantly assessed (ongoing work) on the concept map construction.
7. The students were evaluated based on the concept map produced to determine the final level of understanding on the topic.
8. The students from both experimental and control groups were asked to fill in the questionnaire to assess the learning environment.

7. DESIGNING AND IMPLEMENTING CONCEPT MAPPING TOOL

The concept mapping prototype was for a particular topic (plants in general). A list of concepts (parking lot) was supplied. By supplying all the concepts in the domain, the system assures that the learner not only includes all the concepts in the concept map, but also ensures that the concept map answers the focus question. An expert map, which is the expected and correct concept map, was used for comparing with what the learner will develop. This comparison is used for adaptation and learner guidance (scaffolding).

Scaffolding in the software prototype enabled the learner to reach those areas which might seem difficult or impossible. By the use of link annotation (colouring), the learner is able to get an instant feedback on whether he/she has done the right thing in terms of drawing the correct concept. The following colouring scheme is used in the software prototype:

- **Orange** – This colour shows that a link is valid and has the correct label. For the entire concept map to be correct, all the links must be orange. Such a concept map indicates the highest level of understanding.
- **Blue** – This is a link that is valid between any two concepts, but has a wrong label. It indicates that a link is almost correct.
- **Magenta** – This a reversed link between any two concepts. That is, the link takes the end concept as the begin concept and the begin concept as the end concept. It does not matter whether the link label is correct or not.
- **Red** – This colour indicates that the link is invalid, and thus should not exist between the two concepts.

Adaptation in this software prototype is achieved through the use of the number of correct relationships in the drawn concept map. There are three levels of knowledge of the learner used in this study: beginner, intermediate and expert. There were also three multi-representations of the domain, to match the three levels of knowledge of the learner: level 1, level 2 and level 3. A higher level of difficulty has more concepts and a lower level has fewer concepts. The easier concept map is made of the more general concepts and the difficulty concept map is made of the more specific concepts. Adaptation is realized through adding or removing concepts and their links from the parking lot, depending on the learner's current level of knowledge. Level of knowledge is estimated from the number of correct relationships. The total number of correct relationships enables the learner to move from the current level to the next higher level of concept difficulty or to the lower one (easier one).

8. RESULTS OF THE EXPERIMENT

The statistical procedure used on the collected data is t-test distribution. T-test compares the means of two samples (in this case the experimental and a control group) to determine whether there is a significant difference between the two groups

Hypothesis 1.1 – Number of Correct Links

The experimental group will score better than the control group in identifying the number of 'correct links'.
There was a significant difference between the two groups in terms of the number of 'correct links' - $P(T \leq t)$ two-tail = 0.000039 (Table 1.1)

Number of Correct Links

t-Test: Two-Sample Assuming Equal Variances

| | <i>Adaptive</i> | <i>Non Adaptive</i> |
|------------------------------|-----------------|---------------------|
| Mean | 11.000000 | 8.000000 |
| Variance | 0.888889 | 2.000000 |
| Observations | 10 | 9 |
| Pooled Variance | 1.411765 | |
| Hypothesized Mean Difference | 0 | |
| df | 17 | |
| t Stat | 5.495213 | |
| $P(T \leq t)$ one-tail | 0.000020 | |
| t Critical one-tail | 1.739607 | |
| $P(T \leq t)$ two-tail | 0.000039 | |
| t Critical two-tail | 2.109816 | |

Table 1.1: t-Test analysis for 'number of Correct Links'

Hypothesis 1.2 – Number of Valid links with wrong labels

The experimental group will score better than the control group in identifying the number of 'valid links with wrong labels'

There was a significant difference between the two groups in terms of the number of 'valid links with wrong labels' - $P(T \leq t)$ two-tail = 0.000049 (Table 1.2)

Number of Valid Links with wrong label

t-Test: Two-Sample Assuming Equal Variances

| | <i>Adaptive</i> | <i>Non Adaptive</i> |
|------------------------------|-----------------|---------------------|
| Mean | 0.300000 | 1.888889 |
| Variance | 0.233333 | 0.611111 |
| Observations | 10 | 9 |
| Pooled Variance | 0.411111 | |
| Hypothesized Mean Difference | 0 | |
| df | 17 | |
| t Stat | -5.393347 | |
| $P(T \leq t)$ one-tail | 0.000024 | |

| | |
|---------------------|----------|
| t Critical one-tail | 1.739607 |
| P(T<=t) two-tail | 0.000049 |
| T Critical two-tail | 2.109816 |

Table1.2: t-Test analysis for 'number of Valid Links with Wrong Label'

9. DISCUSSION

The experimental group (the one using the adaptive software prototype) scored significantly higher than the control group (the one using non-adaptive software prototype) in all the sub-variables except one (number of reversed links).

The experimental group was better in identifying the number of 'correct links' than the control group ($P(T \leq t)$ two-tail = 0.000039). This was due to the scaffolding support provided by the adaptive software prototype. A learner in the experimental group could know immediately after drawing a link whether it was correct or not due to link colouring. The learner in the control group was not aware when the link was correct or not. This matched the hypothesis.

Experimental group had a significantly higher number of 'valid links, but wrong label' than the control group ($P(T \leq t)$ two-tail = 0.000049). The scaffolding facility (link annotation) offered by the adaptive system guided the learner as opposed to the non-adaptive system. This again matched the hypothesis.

10. CONCLUSION

The adaptive concept maps software prototype purposed to introduce the concept maps in e-learning web systems. This adaptation was introduced in form of regulating the levels of difficultness of the concept map based on the user understanding. Also, scaffolding is used through link annotations to enable the learner to reach greater height.

This research project provided additional insight into the adaptive use of concept maps in web-based e-learning. The research found that the concept maps scaffolds can be used adaptively in e-learning. The main aim of the experimental validation of the software prototype was to get some quantitative data about the adaptive use of concept maps in web-based e-learning.

Generally, it can be concluded that the software prototype could be an effective tool for adaptive e-learning since:

- It enables the learners to easily reach those areas in a given topic that may seem unreachable (scaffolding).
- It incorporates personalized learning by adaptively presenting the learner with a concept map that matches his/her level of understanding. As the learner improves on the understanding, more concepts are added and as the learner performs poorly the concepts are reduced.
- It enables the use of prior knowledge where the learner can use what he knew from the previous level if he/she moves to the next level of difficulty.
- It evaluates the level of the learner by enabling the learner to do some self-evaluation while drawing the concept map. Evaluation is also done at the end of drawing the concept map, to check the final understanding of the learner in that area.

11. FURTHER WORK

In order to test the reliability of the concept maps in adaptation support, experiments should be carried out using a bigger sample than has been used in this study, which has 19 participants only. This will increase their reliability in this area of adaptation.

Furthermore, many areas of study need to be tested and with different classes of participants. Only one area of plants was used in this study and with a particular group of students from computer science. This will make the approach more acceptable to the other areas of learning.

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Biometrics Verification: a Literature Survey

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ABSTRACT

Biometric verification refers to an automatic verification of a person based on some specific biometric features derived from his/her physiological and/or behavioral characteristics. A biometric verification system has more capability to reliably distinguish between an authorized person and an imposter than the traditional systems that use a card or a password. In biometrics, a person could be recognized based on who he/she is rather than what he/she has (ID card) or what he/she knows (password). Currently, biometrics finds use in ATMs, computers, security installations, mobile phones, credit cards, health and social services. The future in biometrics seems to belong to the multimodal biometrics (a biometric system using more than one biometric feature) as a unimodal biometric system (biometric system using single biometric feature) has to contend with a number of problems. In this paper, a survey of some of the unimodal biometrics will be presented that are either currently in use across a range of environments or those still in limited use or under development, or still in the research realm.

Keywords: Biometrics, Unimodal Biometrics, Multimodal Biometrics, Verification, Identification, Recognition.

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1. INTRODUCTION

Human verification has traditionally been carried out by using a password and/or ID cards. These methods can be easily breached, for password can be guessed and ID card can be stolen, thus rendering them unreliable [Jain et al. 2006]. Biometrics refers to identifying a person based on his or her physiological or behavioral characteristics; it has the capability to reliably distinguish between an authorized person and an imposter. A biometrics system is a recognition system which operates by acquiring biometric data from an individual, extracting feature sets and comparing it with the template set in the database. Depending upon the application context, the identity of a person can be resolved in two ways: verification and identification. In the former, a person to be identified submits a claim; which is

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either accepted or rejected. In the latter, a person is identified without a person claiming to be identified. In literature, however, verification and identification are interchangeably used for biometrics recognition [Jain et al. 1997].

2. BIOMETRICS

There are many biometrics in use today and a range of biometrics that are still in the early stages of development. Biometrics can, therefore, be divided into two categories: those that are currently in use across a range of environments and those still in limited use or under development, or still in the research realm. Here we present literature survey for some of the biometrics of the two categories.

2.1. Biometrics Currently in Use across a Range of Environments

2.1.1. Fingerprint

Fingerprint is the pattern of ridges and valleys on the tip of a finger and is used for personal verification of people. Fingerprint based recognition method because of its relatively outstanding features of universality, permanence, uniqueness, accuracy and low cost has made it most popular and a reliable technique and is currently the leading biometric technology [Jain et al. 2004]. There is archaeological evidence that Assyrians and Chinese ancient civilizations have used fingerprints as a form of identification since 7000 to 6000 BC [Maltoni et al. 2003]. Henry Fauld in 1880 laid the scientific foundation of the modern fingerprint recognition by introducing minutiae feature for fingerprint matching [Maltoni et al. 2003]. Current fingerprint recognition techniques can be broadly classified as Minutiae-based, Ridge feature-based, Correlation-based [Jain and Prabhkar, 2001] and Gradient based [Aggarwal et al. 2008].

Most automatic fingerprint identification systems employ techniques based on minutiae points [Jain and Prabhkar, 2001]. Although the minutiae pattern of each finger is quite unique, noise and distortion during the acquisition of the fingerprint and errors in the minutiae extraction process result in a number of missing and spurious minutiae [Chikkerur et al. 2006]. To overcome the difficulty of reliably obtaining minutiae points from a poor quality fingerprint image, ridge feature-based method is used. A ridge is a pattern of lines on a finger tip. This method uses ridge features like the orientation and the frequency of ridges, ridge shape and texture information for fingerprint matching. However, the ridge feature-based methods suffer from their low discrimination capability [Maltoni et al. 2003]. The correlation-based techniques make two fingerprint images superimposed and do correlation (at the intensity level) between the corresponding pixels for different alignments. These techniques are highly sensitive to non-linear distortion, skin condition, different finger pressure and alignment [Yousiff et al. 2007]. Most of these techniques use minutiae for alignment first.

The smooth flow pattern of ridges and valleys in a fingerprint can be also viewed as an oriented texture [Jain and Prabhkar, 2001]. [Jain et al. 2000] describe a global texture descriptor called 'Finger Code' that utilizes both global and local ridge descriptions for an oriented texture such as fingerprints. A variation to this method is used by [Chikkerur et al. 2006] that use localized texture features of minutiae and another one by [Zhengu et al. 2006] that uses texture correlation matching. Further, [Aggarwal et al. 2008] proposed gradient based approach to capture textural information by dividing each minutiae neighbourhood locations into several local regions of which histograms of oriented gradients are then computed to characterize textural information around each minutiae location. Recently, [Jhat et al. 2011] proposed that Texture feature of Energy of a fingerprint can be used for effecting fingerprint verification.

Face

Face recognition for its easy use and non intrusion has made it one of the popular biometric [Chellappa, 1995]. A summary of the existing techniques for human face recognition can be found in [Chellappa et al. 1995; Zhao et al. 2003]. Further, a survey of existing face recognition technologies and challenges is given [Abate et al. 2007]. A number of algorithms have been proposed for face recognition. Such algorithms can be divided into two categories: geometric feature-based and appearance-based. Appearance-based methods include: Eigenfaces [Turk and Pentland, 1991], Fisherfaces [Belhumeur et al. 1997], Independent Component Analysis (ICA) [Bartlett et al. 2002], Kernel Principal Component Analysis (KPCA) [Scholkopf et al. 1999, Kim et al. 2002], Kernel Fisher Discriminant Analysis (KFDA) [Liu 2004, Yang 2002], General Discriminant Analysis (GDA) [Baudat and Anouar, 2000], Neural Networks [Lawrence et al. 1998], and Support Vector Machine (SVM) [Phillips, 1999; Jonsson et al. 2002].

An inherent drawback of appearance-based methods is that the recognition of a face under a particular lighting and pose can be performed reliably when the face has been previously seen under similar

circumstances. Further, in appearance-based methods the captured features are global features of the face images and facial occlusion is often difficult to handle in these approaches. Geometric feature-based methods are robust against variations in illumination and viewpoints but very sensitive to feature extraction process. The geometry feature-based methods analyze explicit local facial features, and their geometric relationships. The geometry feature-based methods include: Active Shape Mode [Cootes et al. 1995; Yuille, 1991], Elastic Bunch Graph matching [Wiskott et al. 1997] and Local Feature Analysis (LFA) [Penev and Atick 1996].

Recognition of faces from still images or 2D images is a difficult problem, because the illumination, pose and expression changes in the images create great statistical differences and the identity of the face itself becomes shadowed by these factors. To overcome this problem 3D face recognition has been proposed which has the potential to overcome feature localization, pose and illumination problems, and it can be used in conjunction with 2D systems. Research using 3D face data to identify humans was first published by [Cartoux et al. 1989]. The 3D face data encodes the structure of the face and so is inherently robust to pose and illumination variations. Applying HMMs to 3D face verification was first attempted by [Achermann et al. 1997]. A recent advance for 3D face verification has been to show the applicability of the Gaussian Mixture Model (GMM) parts-based approach [Mccool et al. 2008]. The drawbacks of 3D face recognition include high cost and decreased ease-of-use for laser sensors, low accuracy for other acquisition types, and the lack of sufficiently powerful algorithms.

Iris

The iris is a thin circular diaphragm, which lies between the cornea and the lens of the human eye. A survey on the current iris recognition technologies is available in [Bowyer et al. 2008]. [Flom and Ara, 1987] first proposed the concept of automated iris recognition. It was John Daugman who implemented a working automated iris recognition system [Daugman, 1993; Daugman, 2003]. Though Daugman's system is the most successful and most well known, many other systems have also been developed. An automatic segmentation algorithm based on the circular Hough transform is employed by [Wildes, 1997]. [Boles and Boashash, 1998] extracted iris features using a 1-D wavelet transform. [Sanchez-Avila and Sanchez-Reillo, 2002], further developed the iris representation method proposed by Boles et al. [Lim et al. 2001] extracted the iris feature using 2-D Haar wavelet transform and [Park et al. 2003] utilized directional filter banks to extract the normalized directional energy as a feature. [Kumar et al. 2003] employed correlation filters. Recently Ma et al. proposed two iris recognition methods, one using multi-channel Gabor filters [Ma et al. 2002] and the other using circular symmetric filters [Ma et al. 2002]. Later, they proposed an improved method based on characterizing key local variations with a particular class of wavelets, recording a position sequence of local sharp variation points in these signals as features [Ma et al. 2004]. Several other methods have also been developed for iris recognition. [Chen et al. 2006] proposed using Daugman's 2-D Gabor filter with quality measure enhancement. [Du et al. 2006] proposed using 1-D local texture patterns and [Sun et al. 2005] proposed using moment-based iris blob matching.

Hand geometry

Hand geometry refers to the geometric structure of the hand that is composed of the lengths of fingers, the widths of fingers, and the width of a palm, etc. The advantages of a hand geometry system are that it is a relatively simple method that can use low resolution images and provides high efficiency with great users' acceptance [Golfarelli et al. 1997, Jain et al. 1999]. A brief survey of reported systems for hand-geometry verification can be found in [Golfarelli et al. 1997; Jain et al. 1999; Sanchez-Reillo et al. 2000; Pavesic et al.]. An elaborate survey on hand geometry verification is given in [Dutan, 2009]. Geometrical features of the hand constitute the bulk of the hand features adopted in most of the hand recognition systems. One advantage is that geometrical features are more or less invariant to the global positioning of the hand and to the individual planar orientations of the fingers. Among numerous geometrical measures include lengths, widths, areas, and perimeters of the hand, fingers and the palm. [Jain et al. 1999], have shown that hand geometrical features solely are not sufficiently discriminative. Therefore, for more demanding applications one must revert to alternative features such as hand global shape, appearance and/or texture. [Jain et al. 1999] thus use 16 axes predetermined with the aid of five pegs. [Sanchez-Reillo et al. 2000] use a similar set of geometric features, containing the widths of the four fingers measured at different latitude, the lengths of the three fingers and the palm. [Wong and Shi, 2002], in addition to finger widths, lengths and interfinger baselines, employ the fingertip regions. [Bulatov et al. 2002] describe a peg-free system where 30 geometrical measures are extracted from the hand images. In

addition to widths, perimeters and areas of the fingers, they also incorporate the radii of inscribing circles of the fingers.

The other approach in hand geometry verification is contour-based [Jain and Duta, 1999]. The contour is completely determined by the black-and-white image of the hand and can be derived from it by means of simple image-processing techniques. It can be modelled by features that capture more details of the shape of the hand than the standard geometrical features do. Accordingly, various techniques have been proposed to obtain and mathematically represent these hand features [Sanchez-Reillo, 2000; Alexandra et al. 2002]. Recently, [Yoruk et al. 2006] introduced a more accurate and detailed representation of the hand using the Hausdorff distance of the hand contour, and Independent Component Analysis (ICA).

Palmprint

Palmprint is the region between the wrist and fingers. Palmprint features like ridges, singular points, minutia points, principal lines, wrinkles and texture can be used for personal verification [Shu and Zhang, 1998]. There are two types of palmprint verification systems: high resolution and low resolution. High resolution system employs high resolution images, while low resolution system employs low resolution images. In high resolution images, ridges, singular points and minutia points are used as features. In low resolution images, it is principal lines, wrinkles and texture that are used as features. Palmprint verification techniques can be mainly divided into four categories: (1) line based [Zhang and Zhang, 2004; Han et al. 2003; Lin et al. 2005; Wu et al. 2004; Wu et al. 2006; Liu and Zhang, 2005; Liu et al. 2007]; (2) texture based [Zhan et al. 2003, Kong et al. 2006]; (3) orientation based [Kong and Zhang, 2006, Kong et al. 2006]; and (4) appearance based [Wu et al. 2005; Connie et al. 2005; Lu et al. 2003; Wu et al. 2003; Ribaric and Fratric 2005; HU et al. 2007; Yang et al. 2007].

A line in a palmprint is its basic feature. Line based approaches, therefore, play an important role in palmprint verification. Zhang et al. used overcomplete wavelet expansion and directional context modeling technique to extract principal lines-like features [Zhang and Zhang, 2004]. Han et al. proposed using Sobel and morphological operations to extract the line like features from palmprint images [Han et al. 2003]. Lin et al. applied the hierarchical decomposition mechanism to extract principal palmprint features, which includes directional and multi-resolution decompositions [Lin et al. 2005]. Additionally, Wu et al. and Liu et al. proposed two different approaches based on palm lines in which the palm lines were regarded as a kind of roof edge, and extracted according to the zero-cross points of lines' first-order derivative and the magnitude of second derivative [Wu et al. 2004; Wu et al. 2006; Liu and Zhang, 2005; Liu et al. 2007]. The main approaches based on texture extract exploit 2-D Gabor filter [Zhang et al. 2003, Kong et al. 2006]. Zhang and Kong et al. proposed an approach based on texture called as PalmCode for palmprint verification, which exploit zero-crossing information on a palmprint image by using Gabor filter [Zhang et al. 2003]. Subsequently, Kong et al. used fusion rule at feature layer to further improve PalmCode, named as FusionCode [Kong et al. 2006].

Recently, orientation codes have been found to be most promising methods, since the orientation feature contains more discriminative power than other features, and is more robust for the change of illumination. Kong and Zhang were the first who investigated the orientation information of the palm lines for palmprint verification and their approach was defined as Competitive Code [Kong and Zhang, 2004, Kong et al. 2006]. Wu et al. proposed another approach based on orientation named as palmprint orientation code (POC) [Wu et al. 2005]. Moreover, some important appearance based approaches [Connie et al. 2005; Lu et al. 2003; Wu et al. 2003; Ribaric and Fratric 2005; HU et al. 2007; Yang et al. 2007] include such methods as principal component analysis (PCA), independent component analysis (ICA), locality preserving projections (LPP), linear discriminant analysis (LDA), etc., have also been exploited for palmprint verification.

Speaker /voice

Speaker/voice verification combines physiological and behavioral factors to produce speech patterns that can be captured by speech processing technology. Inherent properties of the speaker like fundamental frequency, nasal tone, cadence, inflection etc. are used for speech authentication. Speaker recognition systems are classified as text-dependent (fixed-text) and text-independent (free-text). The text-dependent systems generally perform better than text-independent systems because of the foreknowledge of what is said can be exploited to align speech signals into more discriminant classes. The text-dependent systems, however, require a user to repronounce some specified utterances, usually containing the same text as the training data. A survey of text-dependent verification techniques is given in [Hébert, 2008].

Text-dependent systems are also called Fixed Phrase Verification Systems, where a fixed phrase is used both during the training and the verification time and thus the Dynamic Time Wrapping (DTW) [Furui, 1981] approach has been mostly used for such systems. Nowadays, Text-dependent systems based on Hidden Markov Model (HMM) using Gaussian or multi-Gaussian distributions [BenZeghiba and Bourland, 2006] are more popular. In text independent speaker verification, the users are not restricted to any fixed or prompted phrases. They have the freedom to say whatever they want. To account for the expected freedom of utterances different methods have been proposed such as: Long-term statistics and multidimensional autoregressive [Montacie et al. 1992]; Vector quantization [Soong et al. 1997]; HMMs [Naik et al. 1989]; Artificial Neural Networks(ANN) [Farrell et al. 1994]; Gaussian Mixture Models (GMMs) [Reynolds and Rose 1995; Reynolds et al. 2000]; and SVM [Campbell et al. 2006]. The GMMs are the basis in most of the Speaker verification systems today. Recently, the combined GMM-SVM method [Djemili et al. 2007] has been shown to give slightly better results than the GMM method alone.

Signature

Handwritten signature is one of the first accepted civilian and forensic biometric verification technique in our society [Abuhaiba, 2007]. Human verification is normally very accurate in identifying genuine signatures. Signature verification systems use the distinctive behavioural features of a signature (such as speed, pressure and stroke order) to verify the identity of the user, as opposed to a simple physical crosscheck of one signature and another. The signature verification problem can be classified into two categories: offline and online. Off-line method identifies signatures using an image processing procedure whereby the user is supposed to have written down completely the signature onto a template that is later captured by a CCD camera or scanner to be processed. On-line signature verification involves the capturing of dynamic signature signals such as pressure of pen tips, time duration of whole signature and velocity along signature path. On-line systems use special input devices such as tablets, while off-line approaches are much more difficult because the only available information is a static two-dimensional image obtained by scanning pre-written signatures on a paper; the dynamic information of the pen-tip (stylus) movement such as pen-tip coordinates, pressure, velocity, acceleration, and pen-up and pen-down can be captured by a tablet in real time but not by an image scanner. The off-line method, therefore, needs to apply complex image processing techniques to segments and analyse signature shape for feature extraction. Hence, on-line signature verification is potentially more successful. Nevertheless, off-line systems have a significant advantage in that they do not require access to special processing devices when the signatures are produced. Types of signature verification, methods and performance evaluation can be found in [Plamondon and Lorette, 1989; Leclerc and Plamondon, 1994; Plamondon and Srihari, 2000]. Among the many offline signature verification techniques, HMM-based [Camino et al 1999; Fang et al. 2002], Fuzzy Logic [Hanmandlu et al. 2005; Ismail and Gad, 2000; Simon et al. 1997], Neural Networks (NNs) [Vélez et al. 2003], Neuro-fuzzy [Franke et al. 2002], Genetic Algorithms (GAs) [Ramesh AND Narasimha, 1999], Elastic Graph Matching [Fang et al. 2002], Dynamic Time Warping [Shanker and Tajagopalan, 2007], Optimal Displacements Functions [Muzukami et al. 2002] and Fuzzy Snake Model [Vélez José et al. 2009] are worth noting. Similarly for online signature verification, so far there have been many widely employed methods, for example, Artificial Neural Networks [Martens and Claesen 1996; Wu et al. 1997; KATONA et al. 1995], Dynamic Time Warping [Mautner et al. 2002; Rhee et al. 2001; Quan and Ji, 2005.], and the Hidden Markov Models [Nelson et al. 1994; Bourlard and Morgan, 1998].

2.2. Biometrics in Limited Use or Underdevelopment, or Still in the Research Realm

2.2.1. Earshape

It is known that the shape of the ear and the structure of the cartilagenous tissue of the pinna are distinctive. Although a newcomer in the biometrics field, ears have long been used as a means of human identification in the forensic field. A small literature on ear biometrics is given in [Pun and Moon, 2004; Yan and Bowyer, 2005]. A recent survey on ear biometrics has been provided by [Hurley et al. 2008]. Although ear recognition is a relatively new topic, researchers have already come up with various approaches which drastically differ from each other in terms of acquisition, raw data interpretation and feature extraction. Some of them have been widely used in human verification, e.g. Principal Component Analysis PCA [Victor et al. 2002], Neural Networks [Carreira-Perpinan, 1995] and Force field transformation [Hurley et al. 2005].

Most ear biometric approaches have exploited the ear's planar shape. One of the first ear biometric works utilizing machine vision was introduced by [Burge and Burger, 1998] based on adjacency

graph which was calculated from a Voronoi diagram of the ear curves. [Hurley et al. 2005] used force field feature extraction to map the ear to an energy field. The geometrical properties of ear curves have also been used for recognition [Choras, 2005; Iannarelli, 1989]. The most prominent example of these has been proposed by [Iannarelli, 1989], was based on measurements between a numbers of landmark points, determined manually. [Naseem et al. 2008] have proposed the use of sparse representation, following its successful application in face recognition. The 3D structure of the ear has also been exploited, and good results have been obtained [Yan and Bowyer 2007; Chen and Bhanu, 2007]. [Yan et al. 2007] captured 3D ear images using a range scanner and having segmented the ear, they used Iterative Closest Point (ICP) registration for recognition. [Chen et al. 2007] proposed a 3D ear detection and recognition system using a model ear for detection, and using a local surface descriptor and ICP for recognition. Though using 3D can improve the performance, using 2D images is consistent with deployment in surveillance or other planar image scenarios. In related studies [Akkermans et al. 2005] developed an ear biometric system based on the acoustic properties of the outer and middle ear.

2.2.2. Knuckle crease

The image pattern formation from the finger-knuckle bending is highly unique and makes this surface a distinctive biometric identifier [Woodard and Flynn, 2005]. [Woodard and Flynn, 2005] were the first to exploit the use of finger knuckle surface in biometric systems. However, their work did not provide a practical solution in establishing an efficient system using the outer fingers. Later, [Kumar and Ravikanth, 2007; Kumar and Ravikanth, 2009] proposed another approach to personal authentication using 2D finger-back surface imaging features. In Kumar's later work [Kumar and Zhou, 2009; Kumar and Zhou, 2009] used the robust line orientation code proposed in Jia et al. 2008 to extract the orientation of the finger-back surface images. Few works have also studied use of knuckle print texture on the fingers as a biometric characteristic for recognition. Li et al. 2003 used a hierarchical classification method to study knuckle print based on location and line features [LI et al. 2004]. In Ribaric and Fratric, 2005, principal Component Analysis was employed to project finger images into lower dimensional subspace. Apart from that, [Loris and Alessandra, 2009] also investigated knuckle features by fusing the knuckle print pattern from the middle and ring fingers. Recently, Kumar and Ravikanth, 200] has detailed the usage of finger knuckle surface for online user identification using combination of sub-space features.

2.2.3. Brain/EEG

Using elctroencephalogram (EEG) as a biometric is a new approach. Poulos et al, 1999 have proposed to model the EEG signal using autoregressive (AR) models and then using Kohonen's Vector Quantizer (VQ) for the classification. Paranjape et al, 2001 also proposed to represent the EEG signal using AR models, however, discriminant analysis is employed to perform the classification. Palaniappan and Ravi, 2003 further investigated features based on the spectral power of the signal together with a fuzzy Neural Network for the classification. More recently Gaussian Mixture Models and Maximum a Posteriori model adaptation has been proposed in S'ébastien, 2007.

2.2.4. Heart sound/ECG

The use the electrocardiogram (ECG) as a biometric has been found to give relatively high result for human recognition [Biel et al. 2001; Israel et al. 2005]. Israel et al, 2005 investigated the effect of the state of anxiety of an individual on its ECG features through a series of high and low stress tasks. Test results show that the features extracted from the ECG signal are unique to an individual and invariant to the individual state of anxiety. Israel et al, 2005 also found that the identification performance is independent of the electrode placements. However, ECG for identification is generally cumbersome due to the many electrodes required [Biel et al. 2001].

3. MULTIMODAL BIOMETRICS VERFICATION

Most of the biometric systems that are in use in practical application use a single piece of information for recognition and are as such called unimodal biometric systems. The unimodal biometric recognition systems, however, have to contend with a variety of problems like non-universality, susceptibility to spoofing, noise in sensed data, intra –class variations, inter-class similarities. Some limitations of the unimodal biometric systems can be alleviated by using multimodal system [Brunelli and Falavigna, 1995]. A biometric system that combines more than one sources of information for establishing human identity is called a multimodal biometric system. Combining the information cues from different

biometric sources using an effective fusion scheme can significantly improve accuracy [Hong et al, 1999] of a biometric system.

The information fusion in multibiometrics can be done in different ways: fusion at the sensor level, feature extraction level, matching score level and decision level. Sensor level fusion is rarely used as fusion at this level requires that the data obtained from the different biometric sensors must be compatible, which is seldom the case. Fusion at the feature extraction level is not always possible as the feature sets used by different biometric modalities may either be inaccessible or incompatible. Fusion at the decision level is too rigid as only a limited amount of information is available. Fusion at the matching score level is , therefore, preferred due to presence of sufficient information content and the ease in accessing and combining match scores [Ross, 2007].

A number of works showing advantages of multimodal biometric verification systems have been reported in literature. Brunelli and Falavigna, 1995 have proposed personal identification system based on acoustic and visual features, where they use a HyperBF network as the best performing fusion module. Duc et al, 1997 proposed a simple averaging technique combining face and speech information. Kittler et al, 1998 have experimented with several fusion techniques using face and voice biometrics, including sum, product, minimum, median, and maximum rules and they have found that the best combination results are obtained for a simple sum rule. Hong and Jain, 1998 proposed a multimodal personal identification system which integrates face and fingerprints that complement each other. The fusion algorithm combines the scores from the different experts under statistically independence hypothesis. Ben-Yacoub et al, 1999 proposed several fusion approaches, such as Support Vector Machines (SVM), tree classifiers and multi-layer perceptrons, combining face and voice biometrics. Pigeon and Vandendorpe, 1998 proposed a multimodal person authentication approach based on simple fusion algorithms to combine the results coming from face and voice biometrics. Choudhury et al, 1999 proposed a multimodal person recognition using unconstrained audio and video and the combination of the two features is performed using a Bayes net. Ross and Jain, combine face, fingerprint and hand geometry biometrics combining them under sum, decision tree and linear discriminant- based method. The sum rule is reported to outperform others. Various other biometric combinations have been proposed [Jain et al. 2004; Chen and Chu, 2005; Nageshkumar et al. 2009] that report that combining more than one biometric modalities together result in improved performance than using them alone.

4. CONCLUSION

Biometrics refers to an automatic authentication of a person based on his physiological and/or behavioral characteristics. The usage of biometrics as a reliable means of authentication is currently gaining momentum, though the industry is still evolving and emerging. The unimodal biometric recognition systems have to contend with a variety of problems and thus presently the amount of applications employing unimodal biometric systems is quite limited. Some limitations of the unimodal biometric systems can be alleviated by using multimodal biometric systems, which integrate information at various levels to improve performance. The future of biometrics can thus be envisaged to perhaps belong to multimodal biometric systems.

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