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The mission of **Sukkur IBA Journal of Computing and Mathematical Sciences (SJCMS)** is to provide a premier interdisciplinary platform to researchers, scientists and practitioners from the field of computing and mathematical sciences for dissemination of their findings and to contribute in the knowledge domain.

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Prof. Mir Mohammad Shah
Vice Chancellor, Sukkur IBA University
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Editorial

Dear Readers,

It is a pleasure to present to you the Sixth issue of (volume 3, issue 2) of Sukkur IBA Journal of Computing and Mathematical Sciences (SJCMS).

The stunning advances in various fields of science and technology have a profound impact on our lives in almost every sphere of our activity, such as health, agriculture, communication, transportation, and defense. These advances have been driven by an ever-growing volume of exciting discoveries, largely emanating from research community. In order to highlight the future technology challenges, the SJCMS aims to publish cutting-edge research in the field of computing and mathematical sciences for dissemination to the largest stakeholders. SJCMS has achieved milestones in very short span of time and is indexed in renowned databases such as DOAJ, Google Scholar, DRJI, BASE, ROAD, CrossRef and many others. SJCMS is now HEC recognized in Z-Category.

This issue contains the double-blind peer-reviewed articles that address the key research problems in the specified domain The SJCMS adopts all standards that are a prerequisite for publishing high-quality research work. The Editorial Board and the Reviewers Board of the Journal is comprised of renowned researchers from technologically advanced countries. The Journal has adopted the Open Access Policy without charging any publication fees that will certainly increase the readership by providing free access to a wider audience.

On behalf of the SJCMS, I welcome the submissions for upcoming issue (Volume-6, Issue-1, July-December 2021) and looking forward to receiving your valuable feedback.

Sincerely,

Prof. Dr. Javed Ahmed Shahani
Chief Editor

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Mathematical Analysis of Magnetized Rotating Nanofluid Flow Over nonlinear shrinking surface: Duality and Stability

Sumera Dero[1], Ghulam Hyder Talpur[2], Abbas Ali Ghoto[3], Shokat Ali[1]

Abstract:

In this study, the magnetohydrodynamic (MHD) effect on the boundary layer rotating flow of a nanofluid is investigated for the multiple branches case. The main focus of current research is to examine flow characteristics on a nonlinear permeable shrinking sheet. Moreover, the governing partial differential equations (PDEs) of the problem considered are reduced into coupled nonlinear ordinary differential equations (ODEs) with the appropriate similarity transformation. Numerical results based on the plotted graphs are gotten by solving ODEs with help of the three-stage Labatto IIIA method in bvp4c solver in MATLAB. To confirm numerical outcomes, current results have been compared with previously available outcomes and found in good agreement. Skin friction coefficients, Nusselt and Sherwood numbers, velocity profiles, temperature profiles, and concentration profiles are examined. The results show that dual (no) branches exist in certain ranges of the suction parameter i.e., $S \geq S_c$ ($S < S_c$). Further, profiles of velocity decrease for rising values of Hartmann number in the upper branch, while a reverse trend has been noticed in the lower branch. Profiles of temperature and concentration enhance for the increasing values of thermophoresis in both branches. stability analysis of the branches is also done and noticed that the upper branch is a stable branch from both branches. Finally, it is noted that the stable branch has symmetrical behavior with regard to the parameter of rotation.

Keywords: *3D flow; nanofluid; Rotating shrinking surface; Dual Branches; Stability analysis.*

1. Introduction

Recently, scholars are implicated in the analysis of rotational flows within stretching and shrinking boundary layer problems because of their widespread use in the system of rotor-stator, food processing, spinning devices, the architecture of gas turbines, disk cleaners, and many others. Wang [1] examined the flow of rotating fluid through the stretching sheet where momentum boundary layer thickness was observed to decrease as the parameter of the rotational impact increased. Takhar et al. [2] considered a rotating fluid flow on the stretching surface with the characteristics of a magnetic number. Shafique et al. [3] investigated the rotating effect in the Maxwell fluid by considering binary chemical reactions and energy activation characteristics. They have found that the hydrodynamic boundary layer thins when rotation parameter λ is incremented. Oscillatory behavior in both *x*- and *y*-components of velocity is observed when rotation parameter λ is sufficiently large. Rashad [4] used mathematical modeling to check the effect of the non-steady MHD flow of rotating fluid. Recently, Ullah et al. [5] found that

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temperature and concentration were increasing functions of the porosity and the Forchheimer parameters during the examination of the rotating flow of the nanofluid. In addition, Hayat et al. [6] extended the rotational flow model to examine the characteristics of homogeneous-heterogeneous nanofluid reactions. Lund et al., [7] reviewed the 3D flow of rotating nano-fluid on an exponential plane and discovered that the solution was not unique when the value of the rotating parameter was less than 0.1. Some important effects of the various physical parameter on the rotating flow can be found in [7-12].

The influence of MHD has attracted a lot of attention from researchers because of its extensive range of uses in various fields of science. It was introduced by Hannes Alfvén (1908-1995) who was a famous Swedish physicist. In 1970, he received the Physics Nobel prize for his pioneering work in MHD and major applications in numerous portions of plasma physics. In general, the presence of the magnetic field and the electrically conductive flow of the fluid give rise to the induced electrical current. More interest in MHD flow began in 1930 when Hartmann invented an electromagnetic pump. After that, many researchers considered MHD in their studies such as William [13-14], Eastman et al. [15], and Hossain [16] due to its extensive uses. Moreover, magnetic fields have an impact on numerous artificial and natural flows, which are essential elements used in some industries like pumping, heating, and levitating metals in the core of the earth. For example, solar flares and sunspots are generated by the solar magnetic field [17-18]. For medical and other applications, the ideal properties of the finished product are determined by drawing these strips or filaments into an electrically conductive liquid under the influence of a magnetic field. Hsiao [19] investigated numerical solutions for MHD two-dimension steady flow of boundary layer in a micropolar nanofluid. The author considered Buongiorno's model [20] with a viscous dissipation effect on a linear non-permeable stretching surface. The linear non-permeable stretching surface was used because only one solution was considered. Further, it was discovered that an upsurge in the magnetic field decreases in the magnitudes of Nusselt number and velocities. Recently, Dero et al. [21] used the MHD effect on nanofluid of micropolar where the effect of the thermal radiation had been studied. The shooting method was then adopted to solve the resultant ODEs and triple solutions were obtained. Some important effects of the MHD on fluid flow can be seen in these articles [22-28].

In view of the development of new technologies over the last few decades, the use of convective fluids for heat transfer, such as oil, ethylene glycol, and water minerals, has increased significantly. These kinds of fluids are an essential part of numerous industrial sectors including air-conditioning, transportation, and power generation [29]. It seems that these convection fluids could not meet the requirements of the rate of heat transfer and cooling. In this regard, different fluid upgrade procedures have been applied as there is a necessity to make novel kinds of fluid that are extra viable in relation to heat transfer act to meet the increasing demands of modern technology and innovation in miniaturization and process intensification of equipment [30]. Keeping in mind the final goal to attain such, it has recently been anticipated to mix insignificant amounts of nanometers from 10 nm to 50 nm of nanoparticles in convectional fluids, subsequent in nanofluids [31-33]. Studies have shown that the fraction of particle volume, that is the concentration of volumetric of the nanoparticle in nanofluid is related to the nanofluid thermal conductivity [34-35]. As associated with convectional fluid, the results of experiments on nanofluid noted that the expressively of thermal conductivity expanded with little changes in nanoparticle volume fractions. The nanofluids' thermal conductivity with the base fluid of water containing nanoparticles TiO_2 (27 nm), SiO_2 (12 nm), and Al_2O_2 (13 nm) have been measured by Masuda et al. [36]. Abareshi et al. [37] and Das et al. [38] suggested that there is a significant rise in temperature with an increase in thermal conductivity. CuO (28.6 nm)/water and Al_2O_2 (38.4 nm)/water nanofluids at different temperatures fluctuating from 21°C to 51°C were studied by

Das et al. [39]. Theoretically, due to an increase in Brownian motion along with nanoparticles and nanofluid's bulk temperature *T*, it is expected that more energy can be exchanged from one region to the next as time increased.

The flow of boundary layer idea on an incessant stretched sheet along constant velocity was initially presented by Sakiadis [40-41]. Ever since, frequent research on boundary layer flow through a stretched sheet had been carried out because of its extensive applications in industries such as the production of glass fiber, hot rolling, paper production, and polymer sheets extrusion [42]. Crane [43] was the first who consider a fluid flow problem on a stretched surface and presented a solution in an analytical form. In recent years, Awaludin et al. [44] investigated heat transfer of a stagnation point flow with the effect of heat sink/source on a stretched/shrunk parameter. They observed that dual solutions existed indefinite ranges of stretching/shrinking parameters. Recently, Raza et al. [45] studied the three-dimensional boundary layer flow of a rotating nanofluid in the presence of suction/injection. The numerical results revealed two solutions existed which depended on the values of magnetic, stretching/shrinking, porosity, and suction parameters.

Based on the literature review conducted and published, there is no such study in which a rotational nanofluid model with Brownian motion and thermophoresis effect on the stretching surface has been considered for multiple branches with their stability analysis. Due to this research gap, this study is conducted numerically as the nanofluid rotational flow has important applications in industry, engineering, and so on. In light of this fact, the Buongiorno model was considered to be preparing a nanofluid model in the hope that our findings will provide valuable help and reduce the cost of experiments.

2. Mathematical Formulation

The steady three-dimensional flow of nanofluid along with heat transfer has been considered over the shrinking surface as presented in Figure 1. Sheet at $z = 0$ in the direction of x-axis i.e, $u_w(x) = -cx^n$ and velocity of mass flux is $w_w(x) = S\sqrt{c\vartheta}x^{(n-1)/2}$. Moreover, the temperature at the wall (ambient) is T_w (T_∞). The sheet is supposed to rotate with velocity Ω_0 about the z-axis that is vertical to the sheet. A uniform field of external magnetic $B = B_0$ has been used to act with the z-axis. Taking into account the momentum, temperature, and concentration boundary layers, the flow of nanofluid can be presented in the form of PDEs as follows [45]:

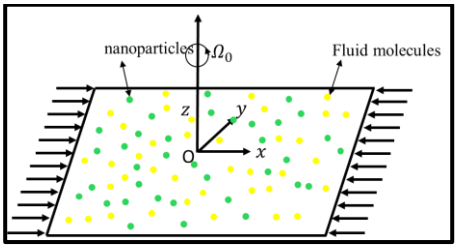

Figure 1. Physical model.

$$\frac{\partial u}{\partial x} = -\left(\frac{\partial w}{\partial z} + \frac{\partial v}{\partial y}\right) \tag{1}$$

$$u\frac{\partial u}{\partial x} - 2\Omega_0 v = \vartheta\frac{\partial^2 u}{\partial z^2} - \frac{\sigma B^2 u}{\rho} - v\frac{\partial u}{\partial y} - w\frac{\partial u}{\partial z} \tag{2}$$

$$u\frac{\partial v}{\partial x} + 2\Omega_0 u = \vartheta\frac{\partial^2 v}{\partial z^2} - \frac{\sigma B^2 v}{\rho} - v\frac{\partial v}{\partial y} - w\frac{\partial v}{\partial z} \tag{3}$$

$$u\frac{\partial T}{\partial x} - \alpha\frac{\partial^2 T}{\partial z^2} = -v\frac{\partial T}{\partial y} - w\frac{\partial T}{\partial z} + \tau_1\left[D_B\frac{\partial C}{\partial z}\frac{\partial T}{\partial z} + \frac{D_T}{T_\infty}\left(\frac{\partial T}{\partial z}\right)^2\right] \tag{4}$$

$$u\frac{\partial C}{\partial x} + v\frac{\partial C}{\partial y} + w\frac{\partial C}{\partial z} = D_B\frac{\partial^2 C}{\partial z^2} + \frac{D_T}{T_\infty}\frac{\partial^2 T}{\partial z^2} \tag{5}$$

The related boundary conditions (BCs) (1-5) are

$$\begin{cases} v = w_w(x)\,, u = u_w(x), v = 0, \text{at } z = 0 \\ T = T_w, C = C_w \ \text{at } z = 0 \\ u \to 0, v \to 0, T \to T_\infty, \text{as } z \to \infty \\ C \to C_\infty \text{ as } z \to \infty \end{cases} \quad (6)$$

Note that respective velocities in directions of x, y, and z-axes are u, v, and w. Further, $\vartheta, \sigma, \alpha, T, \tau_1, D_B, D_T$, and C are the corresponding kinematics viscosity, electrical conductivity, thermal diffusivity, temperature, the ratio between heat capacitances of the nanoparticles and base fluid, Brownian diffusion, thermophoresis diffusion, and nanoparticle fraction or concentration of nanofluid.

Lund et al. [46]'s similarity variables are employed as follows:

$$\begin{cases} u = cx^n f'(\eta), v = cx^n g(\eta) \\ w = -\sqrt{\dfrac{c\vartheta(n+1)}{2}}\, x^{(n-1)/2} \\ \quad \left[f + \dfrac{n-1}{n+1}\eta f'\right] \\ \eta = z\sqrt{\dfrac{c(n+1)}{2\vartheta}}\, x^{(n-1)/2} \\ \emptyset(\eta) = {(C-C_\infty)}/{(C_w-C_\infty)} \\ \theta(\eta) = {(T-T_\infty)}/{(T_w-T_\infty)}, \end{cases} \quad (7)$$

where prime shows the derivative with respect to η and c is a positive constant. By putting Equation (7) in (2-5) leads to

$$f''' + ff'' - \frac{2n}{n+1}f'^2 + \frac{4\Omega}{n+1}g - \frac{2n}{n+1}Mf' = 0 \quad (8)$$

$$g'' + fg' - \frac{2n}{n+1}f'g - \frac{4\Omega}{n+1}f' - \frac{2n}{n+1}Mg = 0 \quad (9)$$

$$\frac{1}{Pr}\theta'' + \theta' f + Nb\emptyset'\theta' + Nt(\theta')^2 = 0 \quad (10)$$

$$\emptyset'' + Scf\emptyset' + \frac{Nt}{Nb}\theta'' = 0 \quad (11)$$

Along with BCs

$$\begin{cases} f'(0) = -1, \theta(0) = 1, \emptyset(0) = 1 \\ f(0) = -S\sqrt{\dfrac{2}{n+1}} \\ g(\eta) \to 0, f'(\eta) \to 0 \ as\ \eta \to \infty \\ \theta(\eta) \to 0, \emptyset(\eta) \to 0 \ as\ \eta \to \infty \end{cases} \quad (12)$$

Here $\Omega = \frac{\Omega_0}{c}$ is rotation parameter, $Pr = \frac{\vartheta_f}{\alpha_f}$ is Prandtl, $Nb = \frac{\tau_1 D_B(C_w - C_\infty)}{\vartheta}$ is Brownian motion parameter, $Nt = \frac{\tau_1 D_T(T_w - T_\infty)}{\vartheta T_\infty}$ is thermophoresis parameter, and S is the injection parameter ($S > 0$) and suction parameter ($S < 0$).

The skin friction coefficients, local Nusselt, and Sherwood numbers can be defined as

$$\begin{cases} C_{fx} = \dfrac{\mu}{\rho u_w^2}\left(\dfrac{\partial u}{\partial z}\right)|z = 0 \\ C_{fy} = \dfrac{\mu}{\rho v_w^2}\left(\dfrac{\partial v}{\partial z}\right)|z = 0 \\ Nu_x = -\dfrac{x}{(T_w - T_\infty)}\left(\dfrac{\partial T}{\partial z}\right)|z = 0, \\ Sh_x = -\dfrac{x}{(C_w - C_\infty)}\left(\dfrac{\partial C}{\partial z}\right)|z = 0 \end{cases} \quad (13)$$

Putting Equation (7) in Equation (13) gives

$$\begin{cases} \sqrt{Re_x}C_{fx} = \dfrac{n+1}{2}f''(0) \\ \sqrt{Re_y}C_{fy} = \dfrac{n+1}{2}g'(0) \\ \sqrt{\dfrac{1}{Re_x}}Nu_x = -\theta'(0), \\ \sqrt{\dfrac{1}{Re_x}}Sh_x = -\emptyset'(0) \end{cases} \quad (14)$$

where $Re_x = \frac{xu_w}{\vartheta}$ and $Re_y = \frac{yv_w}{\vartheta}$ are the local Reynold numbers.

3. Temporal Stability Analysis

In the previous section, dual solutions of Equations (8-11) with BCs (12) are noted; these branches are important as BCs (12) are also fulfilled in the lower branch. It is critical, however, to obtain a solution that can maintain its stability when subjected to minor disturbances. The stability of two solutions is so evaluated in order to identify a branch that is perfectly appropriate to the actual natural situation. The first step for stability is to transform Eqs (2-5) to the unsteady form as per the stability criteria as follows [47]:

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}-2\Omega_0 v=\vartheta\frac{\partial^2 u}{\partial z^2}-\frac{\sigma B^2 u}{\rho}-v\frac{\partial u}{\partial y}-w\frac{\partial u}{\partial z} \quad (15)$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+2\Omega_0 u=\vartheta\frac{\partial^2 v}{\partial z^2}-\frac{\sigma B^2 v}{\rho}-v\frac{\partial v}{\partial y}-w\frac{\partial v}{\partial z} \quad (16)$$

$$\frac{\partial T}{\partial t}+u\frac{\partial T}{\partial x}-\alpha\frac{\partial^2 T}{\partial z^2}=-v\frac{\partial T}{\partial y}-w\frac{\partial T}{\partial z}+\tau_1\left[D_B\frac{\partial C}{\partial z}\frac{\partial T}{\partial z}+\frac{D_T}{T_\infty}\left(\frac{\partial T}{\partial z}\right)^2\right] \quad (17)$$

$$\frac{\partial C}{\partial t}+u\frac{\partial C}{\partial x}+v\frac{\partial C}{\partial y}+w\frac{\partial C}{\partial z}=D_B\frac{\partial^2 C}{\partial z^2}+\frac{D_T}{T_\infty}\frac{\partial^2 T}{\partial z^2} \quad (18)$$

where t indicates the time. As a result, a new variable, $\tau=cx^{n-1}t$, is established. Equation (7) is articulated as follows:

$$\begin{cases} u=cx^n f'(\eta,\tau), v=cx^n g(\eta,\tau) \\ w=-\sqrt{\dfrac{c\vartheta(n+1)}{2}}x^{(n-1)/2}\left[f+\dfrac{n-1}{n+1}\eta f'\right], \tau=cx^{n-1}t \\ \eta=z\sqrt{\dfrac{c(n+1)}{2\vartheta}}x^{(n-1)/2} \\ \emptyset(\eta,\tau)=\left.(C-C_\infty)\right/(C_w-C_\infty) \\ \theta(\eta,\tau)=\left.(T-T_\infty)\right/(T_w-T_\infty), \end{cases} \quad (19)$$

Substituting Equation (19) in Equations (15-18) leads to

$$f_{\eta\eta\eta}+ff_{\eta\eta}-\frac{2n}{n+1}f_\eta^{\,2}+\frac{4\Omega}{n+1}g-\frac{2n}{n+1}Mf_\eta-\frac{2n}{n+1}f_{\tau\eta}=0 \quad (20)$$

$$g_{\eta\eta}+fg_\eta-\frac{2n}{n+1}f_\eta g-\frac{4\Omega}{n+1}f_\eta-\frac{2n}{n+1}Mg-\frac{2n}{n+1}g_\tau=0 \quad (21)$$

$$\frac{1}{Pr}\theta_{\eta\eta}+f\theta_\eta+Nb\emptyset_\eta\theta_\eta+Nt(\theta_\eta)^2-\theta_\tau=0 \quad (22)$$

$$\emptyset_{\eta\eta}+Scf\emptyset_\eta+\frac{Nt}{Nb}\theta_{\eta\eta}-Sc\emptyset_\tau=0 \quad (23)$$

Along with BCs

$$\begin{cases} f'(0,\tau)=-1,\theta(0,\tau)=1,\emptyset(0,\tau)=1 \\ f(0,\tau)=-S\sqrt{\dfrac{2}{n+1}} \\ g(\eta,\tau)\to 0, f'(\eta,\tau)\to 0 \ as\ \eta\to\infty \\ \theta(\eta,\tau)\to 0,\emptyset(\eta,\tau)\to 0 \ as\ \eta\to\infty \end{cases} \quad (24)$$

Now, obtain the solutions of steady flow from (8-11) as $f(\eta)=f_0(\eta), g(\eta)=g_0(\eta)$, $\theta(\eta)=\theta_0(\eta)$,and $\emptyset(\eta)=\emptyset_0(\eta)$, it is assumed

$$\begin{cases} f(\eta,\tau)=f_0(\eta)+e^{-\varepsilon\tau}F(\eta,\tau) \\ g(\eta,\tau)=g_0(\eta)+e^{-\varepsilon\tau}G(\eta,\tau) \\ \theta(\eta,\tau)=\theta_0(\eta)+e^{-\varepsilon\tau}H(\eta,\tau) \\ \emptyset(\eta,\tau)=\emptyset_0(\eta)+e^{-\varepsilon\tau}J(\eta,\tau) \end{cases} \quad (25)$$

where the unidentified eigenvalue is ε where its value needs to fix a stable branch. In addition, $F(\eta,\tau), G(\eta,\tau), H(\eta,\tau)$, and $J(\eta,\tau)$ all their derivatives are assumed small relative to $f_0(\eta), g_0(\eta)$, $\theta_0(\eta)$, and $\emptyset_0(\eta)$. Now, substituting the correlation (25) in Equations (20-24), we get the following resultant Linearized Eigenvalue Problem (LEVP) system as follows:

$$F_0''' + f_0F_0'' + F_0f_0'' - \frac{4n}{n+1}f_0'F_0' + \frac{4\Omega}{n+1}G_0 \frac{2n}{n+1}MF_0' + \frac{2n}{n+1}\varepsilon F_0' = 0 \quad (26)$$

$$G_0'' + g_0'F_0 + G_0'f_0 - \frac{2n}{n+1}(f_0'G_0 + F_0'g_0) - \frac{4\Omega}{n+1}F_0' + \frac{2n}{n+1}\varepsilon G_0 = 0 \quad (27)$$

$$\frac{1}{Pr}H_0'' + \theta_0'F_0 + H_0'f_0 + Nb(\emptyset_0'H_0' + J_0'\theta_0') + 2Nt\theta_0'H_0' + \varepsilon H_0 = 0 \quad (28)$$

$$J_0'' + Sc\emptyset_0'F_0 + J_0'f_0 + \frac{Nt}{Nb}H_0'' + Sc\varepsilon J_0 = 0 \quad (29)$$

subject to BCs

$$\begin{cases} F_0(0) = 0, F_0'(0) = 0, G_0(0) = 0, \\ \quad H_0(0) = 0, J_0(0) = 0 \\ F_0'(\eta) \to 0, G_0(\eta) \to 0 \; as \; \eta \to \infty \\ H_0(\eta) \to 0, J_0(\eta) \to 0 \text{ as } \eta \to \infty \end{cases} \quad (30)$$

All feasible eigenvalues would be acquired (ε) by solving the LEVP system. In Equation (30), a relaxed boundary condition requires being used to achieve the sequence of eigenvalues. The boundary condition $F_0'(\eta) \to 0$ as $\eta \to \infty$ is now restrained to $F_0''(0)$.

4. Results and Discussions

Non-linear Equations (8-11) subject to BCs (10) has been numerically solved with bvp4c solver in MATLAB. We have compared the values of $\sqrt{Re}C_{fx}$ and $\sqrt{Re}C_{fy}$ with the results of Zaimi et al. [48] over the stretching surface (i.e, $f'(0) = 1$) in Table 1. From these results, we notice that the numerical outcomes signify good a correlation with the earlier findings. Henceforth, the code of MATLAB can be employed with full conviction to investigate the problem under discussion. The effect of numerous physical parameters such as magnetic number ($0 \le M < 0.5$), rotation parameter ($\Omega \le 0.04$), positive number ($2 \le n \le 3$), Brownian motion parameter ($0.1 \le Nb \le 0.5$), thermophoresis parameter ($0.1 \le Nt \le 0.5$), and suction parameter ($S \ge 3.5$) are conversed and illustrated in figures.

Table 1. Values of $\sqrt{Re}C_{fx}$ and $\sqrt{Re}C_{fy}$ are compared when $f'(0) = 1 = n$ and $M = S = 0$.

		$\sqrt{Re}C_{fx}$		$\sqrt{Re}C_{fy}$	
Ω	[48]	Present results		[48]	Present results
0	-1.00	-1.000		0.0000	0.0000
0.5	–1.1384	-1.1384		–0.5128	-0.5128
1	–1.3250	-1.3250		–0.8371	-0.8371
2	–1.6523	-1.6523		–1.2873	-1.2873
3	–1.9289	-1.9289		–1.6248	-1.6248
4	–2.1716	-2.1716		–1.9054	-1.9054
5	–2.3901	-2.3901		–2.1506	-2.1506

The existence of multiple solutions enables one to explore those parameters lead to the existence of two branches. The reduced skin friction variants $f''(0), g'(0)$, heat transfer $-\theta'(0)$, and $-\emptyset'(0)$ are shown in Figures 2-5 for various values of n. Moreover, $S_c = -2.40392, -2.6249, -2.8285$ is the

equivalent critic of $n = 2,2.5,3$ where S_c is the critical point where all solutions exist at $S = S_c$. Dual branches are noted as $S \geq S_c$ and when $S < S_c$ there is no solution. The estimation of boundary layers beyond such critical values is no longer justified. Reduced skin friction ($f''(0)$) reduces when n is increased in the upper branch. Further, $g'(0)$ decreases when n increases in the lower branch. On the other hand, $g'(0)$ rises when values of n are increased in the upper branch. In addition, the behavior of $g'(0)$ and S are inversely proportional in the lower branch. Nature of reduced heat transfer ($-\theta'(0)$) can be seen in Figure 4 in which $-\theta'(0)$ enhances in both branches when the effect of S reduces, while the opposition movement has been examined in both branches for the rising values of n. Similarly, the effects of suction and positive constant were drawn in Figure 5 in order to examine their effects on the nanoparticle fraction of nanofluid. As previously noticed in Figure 4, the same behavior is noted.

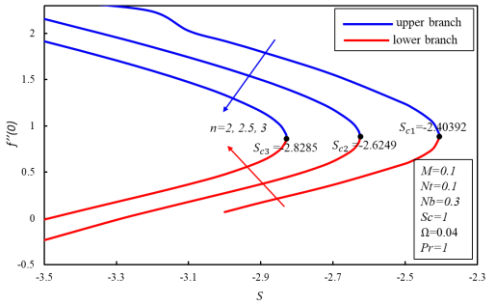

Figure 2. $f''(0)$ for numerous values of S and n.

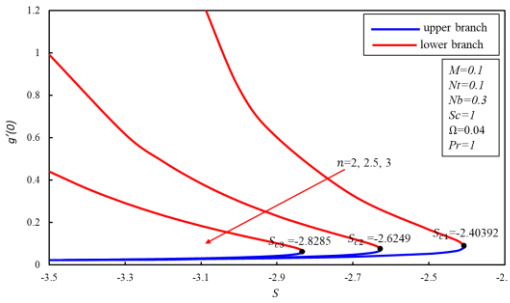

Figure 3. $g'(0)$ for numerous values of S and n.

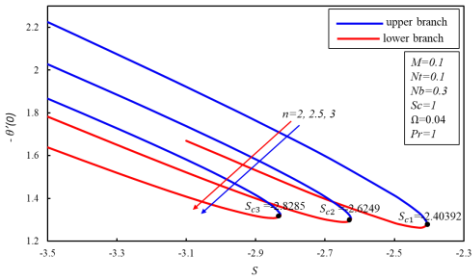

Figure 4. $-\theta'(0)$ for numerous values of S and n.

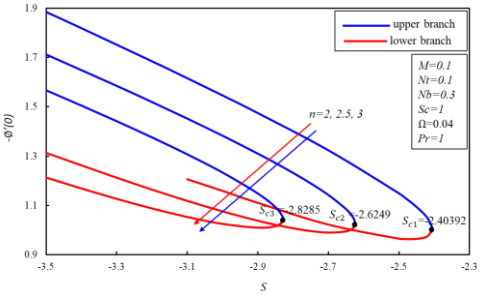

Figure 5. $-\emptyset'(0)$ for numerous values of S and n.

Figures 6-9 allude to the impacts of rising magnitudes of M on profiles of velocity $f'(\eta), g(\eta)$, temperature profiles $\theta(\eta)$, and concentration profiles $\emptyset(\eta)$. Figures 6 and 9 show that $f'(\eta)$ and $g(\eta)$ decline for the rising magnitudes of M in the upper solution, but the opposite movement is noticed in the lower solution. It is apparent from these estimates that for significant values of M, the thickness of momentum boundary layers of $f'(\eta)$ and $g(\eta)$ are decreased in the stable branch. Physically, the decreasing behavior is due to the magnetic field effect on the nanofluid experience of the force induced by the electrical current. This electrically conductive nanofluid interacts with a transverse magnetic field that induces the Lorentz forces. The Lorentz's force reduces the velocity flow and thus reduces the thickness of layer. The temperature and concentration of nanofluid enhance in both branches when the magnetic effect increases (see Figures 8-9).

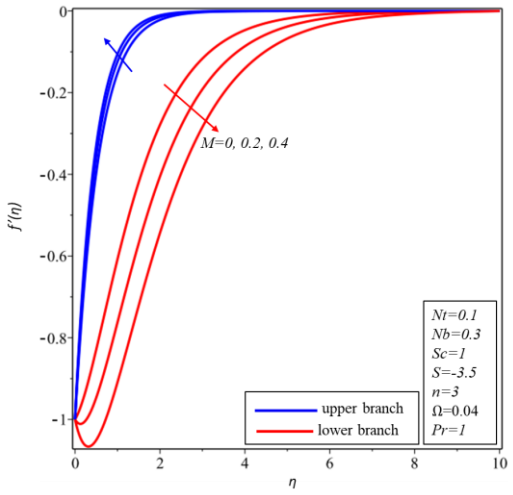

Figure 6. $f'(\eta)$ for different values of M.

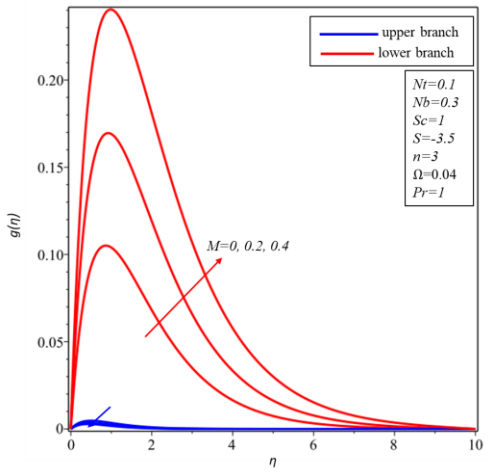

Figure 7. $g(\eta)$ for different values of M.

The space is intentionally left blank to adjust the fingers.

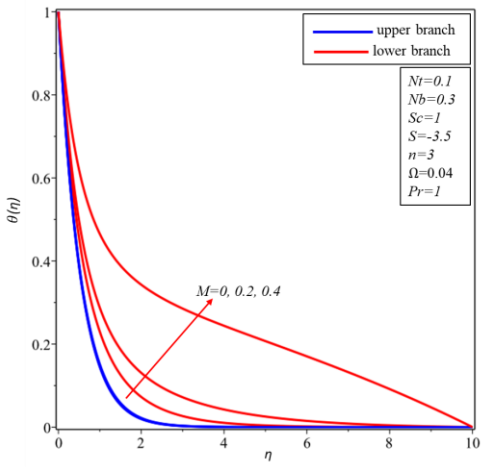

Figure 8. $\theta(\eta)$ for different values of M.

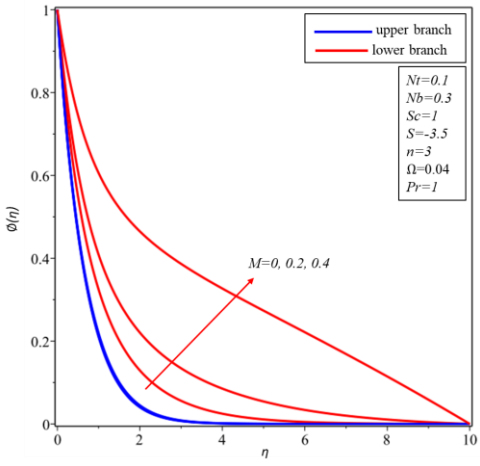

Figure 9. $\emptyset(\eta)$ for different values of M.

Figures 10-11 display the effect of increasing values of Nt on the dimensionless temperature profiles $\theta(\eta)$ and concentration profiles $\emptyset(\eta)$, respectively. These figures show that $\theta(\eta)$ and $\emptyset(\eta)$ increase for the increasing values of Nt in both branches. These increments in the thickness of boundary layers are due to the fact that the higher effect of Nt supports molecules of nanoparticles and fluid to transfer heat to the next layer and therefore temperature and concentration increase.

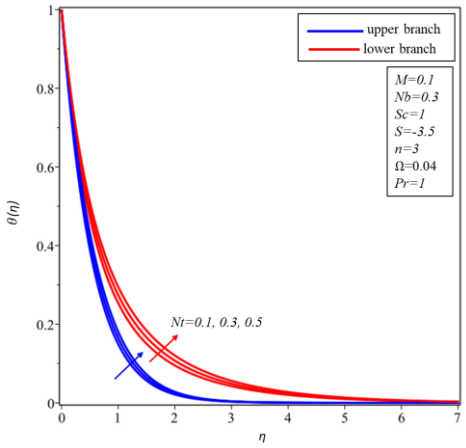

Figure 10. $\theta(\eta)$ for different values of Nt.

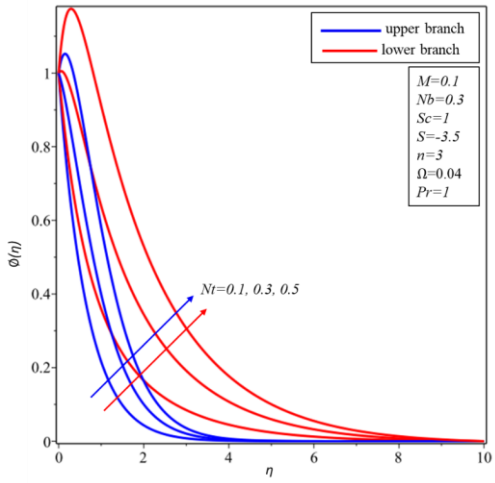

Figure 11. $\emptyset(\eta)$ for different values of Nt.

Figures 12-13 are prepared to see the variations in temperature profiles $\theta(\eta)$ and concentration profiles $\emptyset(\eta)$ for various magnitudes of Nb, respectively. Figure 12 indicates that $\theta(\eta)$ rises for the increasing values of Nb in both branches. This situation is true because, in the fluid flow process, it is possible to surge in the rate of heat transfer in the presence of the thermophoresis effect. The concentration of boundary layers, on the other hand, decreases in thickness in both branches. The consequence of Brownian motion can be described as the nanoparticles extending in the entire fluid and thus decrease in the concentration profiles.

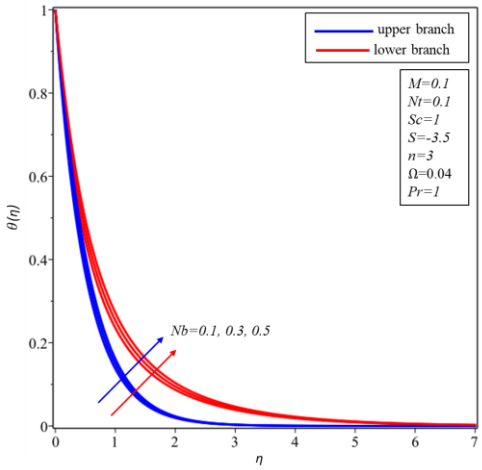

Figure 12. $\theta(\eta)$ for different values of Nb.

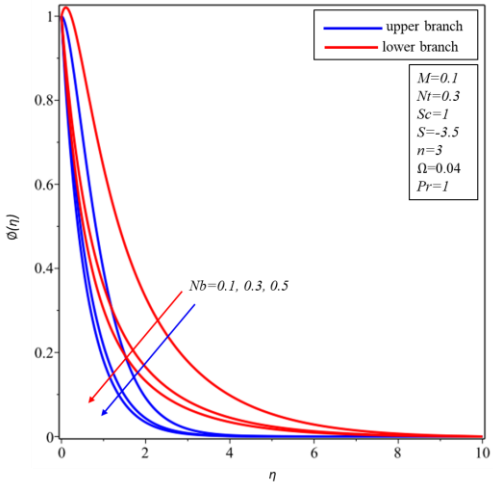

Figure 13. $\emptyset(\eta)$ for different values of Nb.

Figure 14 illustrates that $\theta(\eta)$ decreases for increasing values of Pr in both branches. The development of nanofluid, a blend of center fluid and nanoparticles, depends on values of Pr. The rising Pr values enhance the base fluid viscosity, resulting in a decline in the thickness of the thermal boundary layer and thus a decrease in heat transfer for the higher Pr values. This is because the extremely viscous nanofluid results in poor conductivities of thermal that influence the phenomenon of

conduction to reduce the thickness of thermal boundary layer. In the extremely viscous nanofluid, the motions of dispersed nanoparticles are often more impacted because of lower nanoparticle forces between one another.

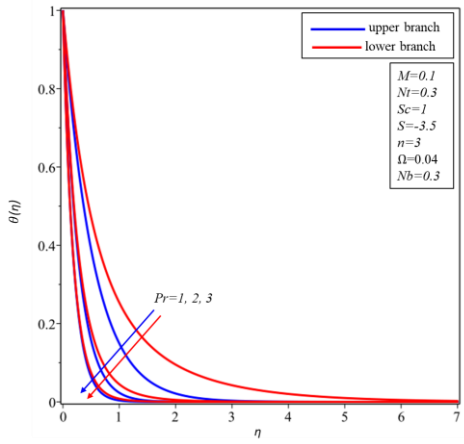

Figure 14. $\theta(\eta)$ for different values of Pr.

Figure 15 is plotted for $\emptyset(\eta)$ to analyze the effects of Sc. It is observed that $\emptyset(\eta)$ decreases for the increasing values of Sc in both branches. This decrease in $\emptyset(\eta)$ for large values of Sc is justified due to the fact that Sc is directly proportional to the kinematic viscosity of the nanofluid. The increasing values of Sc increase the viscosity of the nanofluid which results in a decrease in $\emptyset(\eta)$. Finally, it is noted that the stable branch has symmetrical behavior with regard to the parameter of rotation (See Figure 16). It can be easily concluded from Figure 16 that the symmetrical branches belong to this fluid model.

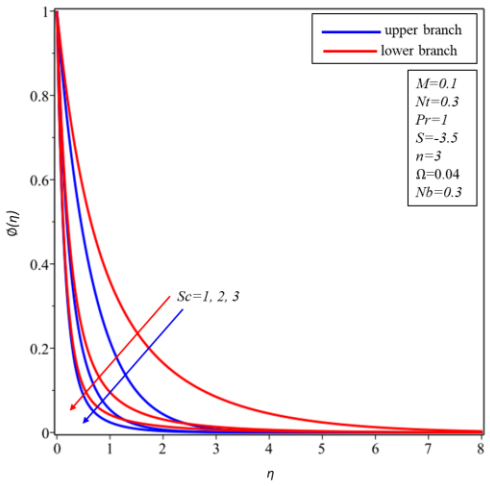

Figure 15. $\emptyset(\eta)$ for different values of Sc.

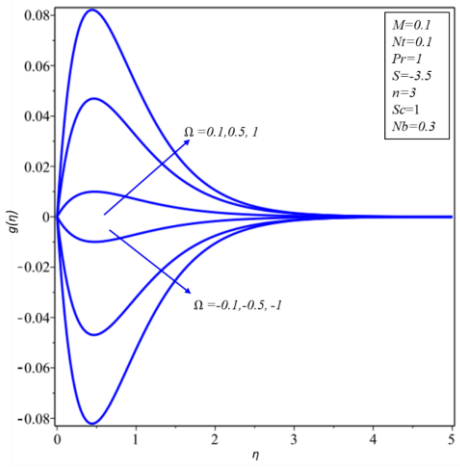

Figure 16. $g(\eta)$ for different values of Ω.

Governing Equations (26-29) have been resolved by employing the bvp4c function. The results of the smallest eigenvalues are given in Table 2. The governing system provides an infinite range of eigenvalues. The smallest negative eigenvalues; $\varepsilon < 0$ implies that the flow has an initial disruption development that may disrupt the flow and, ultimately, induce unstable flow. Besides that, the smallest positive eigenvalues; $\varepsilon > 0$ specifies that an initial decay of disturbance occurs in the flow, are showing the stable flow.

Table 2. Values of ε for S and n where $M = 0.1 = Nt, Nb = 0.3, Sc = Pr = 1, \Omega = 0.04$.

n	S		ε
		Upper branch	Lower branch
2	-2.403	0.0001	-0.0001
	-2.6	0.1271	-0.0478
	-3	0.5973	-0.8696
2.5	-2.625	0.0005	-0.0007
	-2.8	0.3857	-0.5945
	-3	0.9643	-1.0642
3	-2.83	0.0002	-0.0009
	-3	0.4585	-0.3946
	-3.2	1.0962	-0.9738

5. Conclusion

In this study, we investigate MHD nanofluid 3D flow through a non-linear shrinking sheet for the heat transfer performance with multiple branches and stability analysis characteristics. The numerical analysis is conducted by applying the three-stage Labatto IIIA method in bvp4c solver to study the multiple branches of the problem with the stability analysis of the branches. Fluid suction/injection is found to have a major effect on the distribution of velocity, temperature, and concentration, which transitively influences the presence of multiple branches within the boundary layer. The main findings of the current study are

1. For $S \geq S_c$, there are two branches of the nanofluid problem solution, namely a lower and an upper branch. It is noticed that the lower one is not a physically suitable branch.

2. Upper branch is a stable branch from both branches.

3. An increase in the thermophoresis parameter advances nanofluid temperature along with concentration profiles.

4. Brownian motion parameter reduces the nanofluid concentration.

5. Increasing Hartmann number causes the reduction of nanofluid velocity uniformly due to the presence of Lorentz force.

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Testing Salience Model on Work Family Interface: A Regression Analysis

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Abstract:

The simultaneous arrangement of home and work life is important for all. Many who work at home, however, face difficulties in maintaining their work and domestic relations balance, since both fields are mixed together on a single roof. As telecom technology progresses, the possibilities of working from home have been improved. Discussed the effects of working at-home solutions on the quality of work life of the individual. The current research examined in a sample of service workers from Pakistan an extended version of the differential salience model and a related salience model. The results of this study provide some support for the model in a variety of cultural and domestic settings; however, they reveal that domain resources and requirements vary across cultures and households as well. Strong job demands and the present situation of COVID-19 represent primarily technically the work-to-home interference (WtHI). Traveling tools have been identical in terms of reducing the WtHI and work-to-home enhancement (WtHE). WtHE was expected to be more likely because of the activation of personnel services. However, testing one's work had no big influence on WtHE. Moreover, unlike the theoretical model, restriction requirements at the interfaces between work and family have been found to be differential, not comparatively significant.

Keywords: *work demands, work-to-home interference, work-to-home enrichment, work family interface*

1. Introduction

Increasing participation of women in the workforce, globalization, and flexible working patterns has led to a growing sense of strain in the workplace, the pressure and the ever-increasing conflict between work and personal life [1]. Thus, the work–family interface studies (WFI), which have mainly examined the causes and implications of family-work conflict, are always overwhelmed by a conflicting viewpoint. The WFI discussed the causes and effects of conflicts between work and private life. Aspects of the work and family domains might interact in a variety of ways. Research has recently focused on a more constructive WFI approach by examining the relevant aspects of multi-role participation such as WFI or facilitation [2].

As a result, the work–family interface is better understood when both viewpoints are considered. Negative and optimistic WtHI centered on the effect in this line of research on the family domain in cognitive assessments of the working field. The view of conflict and enhancement between work and family (WFC/E) is gathered from the measurement of its effect, its resources and its work and family roles results. The patterns of association between resources and demands on the one hand are nuanced and not instantly obvious,

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but enrichment and conflict on the other. For example, it can increase work resources and offset job demands in order to avoid WFI conflicts [3]? Voydanoff is known as integrated model, involves a differentiating family conflict and facilitation, work-related approach to work, while the border-related services are needed to depict similar connections with facilitation and conflict. To analyze an integrated model of demands and resources and the WFI, "differential output vs. comparable output" model has been used [3].

The latest literature is extended in a variety of ways. Firstly, only a sample of workers in the United States was checked on Voydanoff's model [3]. In order to draw firm conclusions, the theoretical models can be evaluated in various national/cultural settings. Although Voydanoff [3] found support for its model in theory, empirical findings created some inconsistencies with its theoretical model. More empirical tests are therefore necessary to evaluate the utility of the model further. Secondly, the original model of "different salience versus comparable salience" [3] is expanded to include domain requirements and resources and border resources by also incorporating domain-wide demands. In a later article, boundary demands were proposed [4]. Like border services, border demands are supposed to be compared by prominent to negative and positive WtHI. However, in an applied study model, this has not been empirically checked yet. Thirdly, we have provided initial empirical evidence of effective labor-to-home intervention in the context of Pakistan. Whereas in the Pakistani samples there has been substantial empirical evidence of the conflict perspective and its negative effect on employee well-being, WFI's positive view in work-family research in Pakistan has so far been ignored [5]. Some recent applications of similar work-family interface model are reported in [6-10]

After a significant spike in the 3rd wave, touching the record levels of +/-200 deaths/day in end of April, the COVID-19 situation in Pakistan is currently going through a mild decrease. Following the recent slowdown in COVID incidence and death figures due to the 3rd wave, the government has announced partial lifting of some social restrictions: complete lockdown on all commercial activities in all the larger cities from 2 days a week to 1 day; lifting of ban on local tourism subject to vaccination; non-contact sports activities allowed; restaurants to open for outside dining (incl. home delivery, take-away); 50% work from home policy relaxed [11].

Initially, a brief overview is given of the theoretical context of the participating buildings. A series of hypotheses are established and tested, is grounded on the differential salience versus the comparable salience mode. Finally, the findings are addressed as well as the consequences, drawbacks and recommendations for future studies.

2. Theoretical framework

2.1. The work-family interface

In empirical research in the WFI two competing theoretical viewpoints were used to describe the effects of the multiple life functions. Both are the case of scarcity and the argument for improved function theory. An individual has a small number of resources and energy, according to the scarcity claim. By encouraging various roles in life, as professional and personal life, it means fighting for these resources, leading to work-family conflict experiences. Few studies have evaluated work/home interference as a multi-dimensional system, however [12]. Those research that analyzes the three dimensions of WtHI separately finds no difference in working history [13].

Sociological theories of 1970s which are based upon the work and the case for enhanced life indicate that having busy in diverse pursuits will give social and economic capital and thus be of benefit to persons. In a thirty-year study [14] the long-term positive influence of multiple positions on women's health and social inclusion has been demonstrated. While there is convincing proof that numerous roles can be advantageous, work-family research is controlled by a

conflicting viewpoint that is based on the shortage of claims of the theory of roles. Just recently, family students have developed a set of constructions that control the positive side of the work-family interface, as positive spillover, enhancer and facilitation [2].

This study focuses on WtHE, which is described as "the excess of the quality of life in the other role that experiences in one role improve" [2]. Work/home enrichment is a bidirectional and multidimensional system similar to work/family conflict: work exposure can develop the excellence of family and private life WtHE and family and private experience can improve the quality of work. Two ways of enhancing the other function are: resources as material resources, expertise and society capital increases quality and performance in another area. WtHE is comprised of three dimensions: affective developmental, capital and enhancement, while HtWE depends on a small difference between developmental, affective, and efficiency-based enhancement.

2.2. Differential salience vs. comparable salience model

By building the work-house intervention model of dual-process [3] an integrative demand and resource structure were proposed, incorporating all the theoretical arguments. The "differential salience versus the comparable salience" model indicates that the demands and resources of the internal domain work vary from the negative and the positive interference from work and family, while the boundary resources remain comparatively essential to positive and negative interference of the family and work.

Domain job requirements denote social or organizational and physical facets of a position which involve sustained psychological and physical efforts and thus associated with unique physical and mental costs. In keeping with the scarcity claim, internal work demands restrict employees' ability to handle non-work domain obligations effectively, consequently leading to undesirable and negative interferences with their work-to-family. Time-based pressures, as extended working hours and spare time, can limit the available time for people to live in their families and also develops hardships for them to accomplish responsibilities of family. strain-based work involves a person's willingness or readiness to fulfill family roles responsibilities which can contribute to tension and stress experiences [15].

Domain workplace tools relate to elements of your job that work to achieve job goals, minimize costs linked to job requirements, or encourage personal growth and development. Jobs tools may be either inherent to the task or within the workplace. The improvement argument of multiple life roles encouraging workers to act better in the family domain, allows involvement in work to produce certain domain resources including talents, abilities, certain attitudes and social support. Psychological benefits and awards, such as inspiration, success and self-esteem, can also reach out from work to family and improve constructive interference with family work.

However, domain demand and resources are features of the workplace environment that reduce or improve employee capacity to fulfill family-related responsibilities, border requirements and resources deal specifically with the relation between the workplace and the family/home. The Instances of boundary demands are unsupportive family-work culture or a home-work culture. Examples of border-spreading tools are assistance from managers and colleagues and agreeable working measures. Border-crossing resources, according to the theoretical model, are able to both minimize negative family-to-work intrusion or interference and increase positive family-to-work interference through mechanisms that improve employees' ability to handle work-to-family boundaries.

We have developed a series of hype-sets on the basis of [3] integrative structure for a various domain requests and resources, border requirements and resources and work-for-the-home intervention and home enrichment. The research variables and hypothesized relations are summoned in Figure 1.

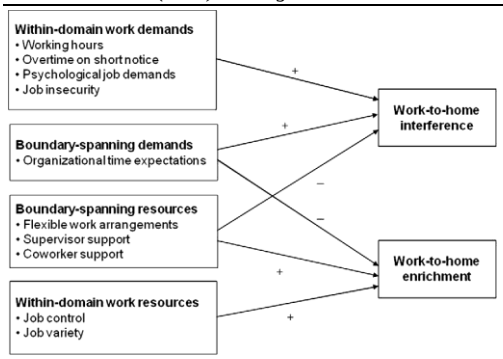

Fig. 1. Research model adapted from [3]

3. Hypotheses

3.1. Work demands

A prominent topic in the field of family research was the negative effect of extensive working hours and extra time of duty on workers' ability to efficiently handle their work-family interface. The amount of negative work-to-home intervention supposed by the person increases in proportion to the number of hours spent at work according to the logical model of work-family conflict. A variety of observational studies that indicate a positive connection between work and working hours are behind this claim. This argument is backed by Furthermore, short-term overtime conditions explicitly restrict the freedom of workers to fulfill workplaces and increase negative intrusion from work to private life [3].

Hypothesis # 1: Working hours will be positively related to WtHI.

Hypothesis # 2: Overtime on short notice will be positively related to WtHI.

The requests for therapeutic work relate to stressors specifically linked to the task and workload. For example, a heavy workload and competing demand for employment can generate a pressure that penetrates private lives and increases WtHI's experience.

Hypothesis # 3: Psychological job demands will be positively related to WtHI.

Global rivalry and restructuring have intensified the employee's feelings of vulnerability and are well known in the literature as its harmful influence on workers' jobs and well-being. This research stresses on the assumed job insecurity and in assurance that refers to the fear or concern of a person about the future of work.

Hypothesis # 4: Perceived job insecurity will be positively related to WtHI.

3.2. Work resources

Work resources may be connected to the job or to the wider work environment. In this paper, we concentrate on two kinds of intrinsic work tools, namely job management and the variety of skills/work. Employment management is about how an employee knows him/her will control when, where and how his/her work is done. The diversity of employment and abilities mentions the skills and imagination, a worker requires versatility of workers to choose their skills at work.

Hypothesis # 5: Job control will be positively related to WtHE.

Hypothesis # 6: Job variety will be positively related to WtHE.

3.3. Boundary-spanning demands and resources

Supporting domestic work and domestic work rules or policies are essential components of a work environment that is familiar [16]. Family work culture refers to the ideals and principles behind the preference of work over family and vice versa in organizing the work culture it refers to the universal values. Voydanoff [3] claims that a culture of a family-backed company legitimizes the unworked needs of workers at work and efforts to respond to private obligations. This will reduce the burden on workers and their distress in connection with disputes between professional and private and upsurge the positive spillover of jobs and the non-labor domain.

As the culture of Work and family is characterized in family literature as a multidimensional construct with expectations of time, negative job outcomes, supervisor and co-worker support that encompasses the main areas of work-family culture. With regard to

the different aspects of family work culture [4] the categorization of border demands and resources, organizational time requirements can better be interpreted as border-related demands, whereas manager and coworkers' aid is border-related resources.

Hypothesis # 7: Organizational time expectations will be (a) positively related to WtHI and (b) negatively related to WtHE.

Hypothesis # 8: Supervisor support will be (a) negatively related to WtHI and (b) positively related to WtHE.

Hypothesis # 9: Co-worker support will be (a) negatively related to WtHI and (b) positively related to WtHE.

The reaction and response to growing job and household requirements of workers flexible working policies (FWAs) have been adopted by many businessmen as telework, shortened work weeks flextime, Flexible working agreements permit workers to handle both their jobs and their non-work duties more efficiently, allowing employees temporary or room flexibility on their work site.

Hypothesis # 10. Use of flexible work arrangements will be (a) negatively related to WtHI and (b) positively related to WtHE.

4. Methodology

4.1. Procedure and participants

The data were obtained from employees in services in three Lahore University of Lahore, Lahore Garrison University and Management University institutions. In an online questionnaire, we collected information. The questionnaire could be completed during working hours by all participants. A total of 500 questionnaires have been circulated to different levels of hierarchy. Returned 231 questionnaires (for an overall response rate of 46 percent).

39% of the participants were male and 61% were female. The mean age of the participants was 34.3. 44% had married or lived in partnership, and the remainders were individual.

The participants were asked how many hours they work each week, including paid or unpaid hours, but they don't take into account travel time.

4.2. Psychological job demands

In order to assess the psychological demands at work [17], 5 items have been taken from the Swedish Demand–Control–Support Questionnaire (DCSQ). The ratings for each object were 4-point (1 = never to 4 = always)

Job insecurity: Four Likert-scale items were used to assess work insecurity perceived (1 = strongly disagree to 5 = strongly agree) [18].

Job control: Two items from the decision-making authority level of Swedish DCSQ [17], were evaluated for job management, each item being scored on a 4-point scale (1=never to 4 = always).

Job variety: The Swedish Demand–Control–Support Questionnaire (DCSQ) [17] used the three elements on the discretionary range to evaluate the variety of employment. Answers were given on a 4-point scale (1 = never; 4 = always).

Work-family culture: Three elements each were used for measuring the dimensions of perceptions of organizational time and support from employees. The supervisor help calculates two things. Several things were extracted from the measurement of family culture and multi-dimensional work [19]. A five-point Likert scale reply was received. (1 = strongly disagree to 5 = strongly agree).

FWA use: Participants were asked whether they had worked for flextime, telework or a shortened workweek for the last 12 months. It was calculated that a dummy variable with 0 showed that no flexible work structures were implemented, while one proposed that one policy at least had been adopted in the last 12 months.

Table 1. Coefficients of Pearson's correlation for independent and dependent variables

	Variable	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Sex	---	---	---														
2	Age	34.3	8.37	−0.04	---													
3	Education	5.48	3.24	−0.30**	−0.07	---												
4	Marital status	---	---	−0.11**	0.17**	0.08**	---											
5	No. of children	0.74	0.93	−0.18**	−0.02	0.07*	0.23**	---										
6	Actual working hours	40.18	3.89	−0.36**	−0.02	0.28**	−0.02	−0.07**	---									
7	Overtime on short notice	1.61	0.67	0.06*	0.01	−0.08*	0.01	−0.05	0.18**	---								
8	Psych. job demands	2.34	0.52	0.11**	0.14**	−0.11**	0.03	−0.03	0.12**	0.37**	---							
9	Job insecurity	1.9	0.89	0.04	0.01	−0.11**	−0.03	−0.05	−0.09*	0.04	0.13**	---						
10	Org. time expectations	3.01	0.99	−0.04	0.08*	0.13**	0.01	−0.03	0.16**	0.33**	0.32**	0.17**	---					
11	FWA use	---	---	−0.31**	0.06*	0.35**	0.11**	0.06	0.21**	−0.17**	−0.16**	0.01	0.14**	---				
12	Job control	1.99	0.54	−0.16**	0.02	0.24**	0.07*	0.12**	0.17**	−0.12**	−0.15**	−0.19**	−0.11**	0.31**	---			
13	Job variety	2.36	0.55	−0.12**	0.03	0.14**	0.03	0.03	0.23**	0.04	0.15**	−0.06*	−0.05	0.18**	0.46**	---		
14	WHI	1.98	0.56	0.10**	0.09**	−0.04	−0.04	−0.04	0.21**	0.29**	0.52**	0.20**	0.37**	−0.10**	−0.07*	0.07*	---	
15	WHE	2.57	0.95	0.10**	0.02	−0.01	0.02	0.01	−0.03	−0.05	−0.07*	−0.04	−0.03	0.07*	0.14**	0.15**	−.09**	---

Note: N=231 * p <0.05 ** p<0.01

Table 2. Regression analysis of work-to-home interference

Variables and statistics	**Standardized betas**				
Controls	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Female sex	0.04	0.12 **	0.12 **	0.11 **	0.11 **
Age	0.07 *	0.05	0.05	0.05	0.05
Education	0.02	0.01	0.01	−0.01	−0.01
Married	−0.04	−0.03	−0.03	−0.02	−0.01
Work demands					
Working hours		0.18 **	0.19 **	0.18 **	0.17 **
Overtime on short notice		0.11 **	0.09 **	0.04	0.02
Psych. job demands		0.41 **	0.41 **	0.38 **	0.37 **
Job insecurity		0.19 **	0.17 **	0.15 **	0.15 **
Work resources					
Job control			0.00	0.01	0.04
Job variety			−0.03	−0.02	−0.01
Boundary − spanning demands					
Org. time expectations				0.18 **	0.17 **
Boundary − spanning resources					
Supervisor support					−0.08 **
Co − Supervisor support					−0.06 *
FWA use					−0.08 *
F	7.24 **	38.00 **	32.65 **	32.95 **	29.53 **
R^2	0.06	0.34	0.34	0.36	0.37
Adjusted R^2	0.05	0.33	0.33	0.34	0.36
Change in R^2		0.28	0.00	0.01	0.02

Note: N = 231 *p <0.05 **p <0.01

Table 3. Regression analysis of work-to-home enrichment

Variables and statistics	**Standardized betas**				
Controls	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Female sex	0.17 **	0.15 **	0.16 **	0.15 **	0.15 **
Age	0.047	0.04	0.04	0.04	0.05
Education	−0.03	−0.03	−0.04	−0.04	−0.04
Married	0.03	0.03	0.03	0.03	0.02
Work demands					
Working hours		−0.03	−0.04	−0.04	−0.03
Overtime on short notice		−0.05	−0.05	−0.05	−0.03
Psych. job demands		−0.05	−0.07	−0.07	−0.06
Job insecurity		−0.03	−0.02	−0.02	−0.02
Work resources					
Job control			0.06	0.06	0.02
Job variety			0.14 **	0.14 **	0.12 **
Boundary − spanning demands					
Org. time expectations				0.03	0.02
Boundary − spanning resources					
Supervisor support					0.14 **
Co − supervisor support					0.13 **
FWA use					0.14 *
F	4.08 **	3.47 **	4.66 **	4.39 **	5.81 **

R^2	0.04	0.05	0.07	0.07	0.11
Adjusted R^2	0.03	0.03	0.05	0.05	0.09
Change in R^2		0.00	0.02	0.00	0.04

Note: N = 231 *p <0.05 **p <0.01

Work-to-home interference: The WtHI evaluation was conducted using three elements from the SWING Work–Home Interaction Survey Nijmegen [20]. Each object has been classified on a scale of 4 points (1 = never to 4 = always).

Work-to-home enrichment: The developmental factor of WtHE has been measured through three elements taken from the enrichment scale of the work-family [21]. A five-point Likert scale was followed (1 = strongly disagree to 5 = strongly agree).

Control variables: The statistical analysis used the control variables of sex, age, educational level, educational status, marital status and number of children. Sex is 0 = male, 1 = female, marital status is 0 = not married, 1 = married. Sex is married 0 = not married. The level of education was measured by requiring the participants to show in a 7-point scale the highest level they had attained.

5. Results and Discussions

The coefficients, means and normal variants for Pearson's correlations for all variables have been shown in Table 1. The trial hypotheses had been tested with ordinary least square regression analyzes. The equation contained demands for work, sequential control variables, work capitals and boundary demand and resources. Dummy variables were used to analyze further socio-demographic variables. Table 2 and Table 3 display the results for WtHI and WtHE.

Table 2 showed that many requests from inside the domain were linked positively to negative interference with working hours (ß =.18), Overtime on short notice (ß =.11), psych. job demand (ß =.41) and to job insecurity (s =0.19) (Model 2). There was no influence on coefficients by incorporating job tools. However, when border-related demands were made, extra time was a significant predictor of WtHI in the short term. Hypothesis 2 was not thus supported, although our evidence supported Hypotheses 1, 3 and 4. In line with the forecasts, expectations of organizational time in the case of WtHI (ß = 0.18), supporting hypothesis 7a, are important and optimistic. The WtHI (assistant supervisor's help (ß=–.08); co-superstor assistance (ß=-.08); FWA use (ß=–.08)) is strongly and adversely linked to multiple boundary resources. So, the 8a, 9a and 10a hypotheses were endorsed. with our Figure 1 theoretical model, there were no significant interactions between within the domain working resources and WtHI.

Table 3 shows that demands for work were not substantially associated with our theoretical model WtHE (Model 5). The use of flexible work arrangements was substantially connected to WtHE in many border-spanning tools, supervisor support (ß=.14), and co-supervisor support (ß=.13) in addition to the application of flexible work arrangements (ß=.14), thus supporting Hypothesis 8b, 9b and 10b. In comparison to the forecasts, WtHE did not substantially apply to border-related requirements. Hypothesis 7a has therefore not been endorsed. In the work tools, WtHE (model 5), supporting hypothesis 6, was linked significantly and positively only by the variety of work (ß=.14). Contrary to Hypothesis 5, a substantial association with WtHE has not been seen in the job regulation.

The latter paper researched the extended sampling in Pakistan as servicing workers for the "differential salience versus similar salience model" [3]. The model implies that demands for work and resources are different from the others, while restricting demands and resources are equally important in relation to both definitions. It partly supports the extended model of salience that results in some findings which vary from [3] theoretical and past

empirical findings. This term has shown significant and positive correlations with WtHI between requirements such as hours of work, demands for mental work, and job insecurity. Overtime for short notices was not substantially connected to WtHI contrary to forecasts and [3] findings. The relationship was negligible until demands of organizational time were taken in consideration, which suggested that overtime could serve as a mediator in the short term. A request to stay at work for longer periods in a short period seems to give the impression that a time-consuming organization has no difference for non-work and private life, apart from work. These insights form a significant share of a working/family culture in the organization and have been got to negatively impair the emotional state of employees in their personal lives. According to [3] The partnership was negligible before the organizational time demands were addressed, which indicated the possible short-term mediation of overtime. A proposal for longer periods of stay at work in a short period seems to suggest that the time-consuming organization, aside from work, does not value work and private life. Such experiences are an important part of a work/family culture of an enterprise and have revealed their own emotions. Van Echtelt, Glebbeek, and Lindenberg [22], for example, staff working in high-level organizations worked far longer than they wanted location control and time ("autonomy paradox"). The focus was not on clock time but on the task and project completion in these working environments. Employees were so involved that they spent time on work completing their work tasks and projects. Although they were formally entitled to adjust the working time, there was no reduction in the working environment. Contrary to the view of the WTHI reduced resources for scheduling power and work autonomy, Schieman and Glavin [23] Take responsibility for "blurring the lines between work and home. You may demonstrate that the blurring of the role of the homework is related to an increased degree of conflicts between work and home. In a similar vein, [24] employees with high level of authority and freedom of choice were more likely to be adversely affected from home to work.

6. Conclusion and implication

The theoretical implications of the current research are numerous. The research first tested the differential salience against the corresponding salience model in a separate national sense [3] Our findings from a Pakistan-wide sample of service employees nevertheless suggest the variations between the WtHI and WtHE border-wide requirements. Our review confirms that limited resources need to be defined as technically distinct from WtHI and WtHE-related domain-specific resources. In general, it gives some initial empirical proof of Pakistan's history of job-to-home enrichment.

From an applied perspective, the study shows that organizations designed to reduce the friction among workers crossed the simple drop-in labor requirements and created a satisfactory working atmosphere in which the family enjoys its wellbeing. Organizations have a specific benefit from investments in staff-based facilities, as two advantages are found by managers and partners and flexible job arrangements, less negative participation from work in the home and greater enhancement from homework.

'Family-friendly' work and work-life balance is important for peace and performance. Numerous limitations of the research design must be considered during the analysis of the findings of this report. This study concerns workers in the service sector in order to prevent a wider population from reaching the conclusions. The analysis of a wider range of industries will help with future studies. The second disadvantage of this study is that the transversality of non-experiments is not definitive in causes. Although the study results conform greatly to the supposed causal model in Figure 1, rival interpretations of the relationships found cannot be ruled out. In future experimental study designs and longitudinal studies must specifically identify the directions of such connections.

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Analyzing Usability of Mobile Banking Applications in Pakistan

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Abstract:

Usability is a key factor in the quality of the product, which includes ease of use, user satisfaction and the ability of the user to quickly understand the product without practice. As smartphone usage increases, most organizations have shifted their services to mobile applications, such as m-banking. Most of the people uses banking services but hesitate to use m-banking due to complex interfaces. Usability researchers concentrate on the value of design simplicity so that users can perform a particular task with satisfaction, efficiency, and effectiveness. If a mobile app lacks one of these usability features, users may get confused while using the app. This research examines the key usability issues in existing m-banking after checking the usability satisfaction level through System Usability Scale. To compare and highlight a number of usability issues, the researcher used two types of usability evaluation method 'User Testing' and 'Heuristic Evaluation'. In heuristic evaluation expert users used two M-banking apps i.e., Bank of Punjab (BOP) and Muslim Commercial Bank/ Islamic Bank (MIB) to evaluate them against Neilson 10 heuristics and extract the usability issues in apps. The user testing is then performed by novic[1]e users which includes tasks (translated from extracted problems by heuristic evaluation). After completion on whole testing users filled the post-test SUS's questionnaire. The result shows that the overall success rate of the tasks was 83%, SUS score was 77 and overall relative time-based efficiency very 54.2%. The expert evaluators found 83% minor errors and 17% major errors. The finding of this paper shows usability problems and recommendations are provided to increase the usability of mobile banking applications at the end of this paper.

Keywords: *Usability testing; Think Aloud; System usability scale; User testing; Mobile Banking*

1. Introduction

In the major banking industry, the integration of information technology has created significant changes. Banks compete closely and try to attract more customers by facilitating them with more and more facilities. Mobile business is booming and its consumers are growing steadily. The main reason for this is that inexpensive telecommunications services are available.

The definition of m-banking is like a payment via mobile. M-banking provides banking clients the opportunity to send SMS notifications such as deposits and withdrawals, check account status, credit card details and provide account operational information. It also provides the user with the facility to pay their utility bills, transfer funds, etc [1].

The challenge today is to develop m-banking that can easily meet all users ' needs.

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User design involves specific challenges: the lives, needs and expectations of these users in developing countries such as Pakistan are likely to vary considerably from the perceptions of the designer. In order to avoid any inconsistencies, the design of m-banking must be developed in partnership with primary users and must require a thorough study of their experiences and problems. The end-user can also help to continually test and finish projects throughout the design process by identifying design flaws.

In addition to the design of these systems effectiveness, efficiency and satisfaction are considered important factors in the application design. The problem that is emerging in the computer science community is that the usability of applications is overlooked by many developers which causes problems [2]. The need for enhancing usability is therefore very important, and numerous researchers in this field have shown that the usability of software is affected by different factors. Usability is an important factor in the production of high-quality and usability products, such as websites and mobile applications.

The main purpose of interface design is the usability of a good system. The various usability models have shown that by examining them, applications that have a high-quality interface can be created with great help.

1.1. Usability

ISO 9241-11 states that the extent of usability is to be used by a specific user to attain the specific objectives in a specific context of application in terms of effectiveness, efficiency and satisfaction [3]. Learning and ease of use is a created entity for people. The subject you use may be a program, a web-based system, a tool, a procedure or anything else with which you can interact. A series of recent studies solely focused on mobile usability with the occurrence and the swift acquisition of Smartphone tech. The physical restrictions on cell phones and wireless networks mean that the right research method must be carefully chosen and the possible contextual factors to be known should be reduced if they are not central to design and mobile usability studies. The assessment of product development and user experience is critical to the way in which the process model, product development and final outcome have been established. The usability and experience of the user are distinct, as they also consider the usefulness. By analyzing usability, we can better visualize aspects of software architecture usability before implementation. Then, it can help you identify the user interface's 3 major components. “The required components”, “The user-friendly components” and “The components to run them”. Mobile usability involves several mobility-related challenges such as: mobile frames, networks, various resolutions, small screen sizes, and capacity and limited processing capabilities and processing inputs. Features of usability make the product or system usable. In all other, the user must possess both subjective and objective experience if a system is to be used.

1.2. Literature Review

In the banking sector, m-banking is a vibrant topic because rapid technological changes increase competence. In this section, the related research literature helps to identify the variables related to the problem referred to earlier in the study.

Kaikkonen tested mobile applications' usability in his study. He performed two different tests, the first test was conducted in the laboratory and the second test conducted in natural environment of users. He found 22 different usability issues in mobile applications under observation [4].

There are four different application categories compared by Ryan and Gonsalves. They consist of the different types of applications based on web-based PC, device-based PC, mobile web and mobile devices. The worst performance has shown by mobile web-based applications. The low page display speed is the reason. The fact is data provided from the web is low. The speed of low-page viewing adversely affects usability. Ryan and Gonsalves ' analysis could lead to a significant gap in the functionality of both a mobile application and a PC application with the same features and capabilities [5].

The literature reviewed reveals that the usability of a user interface is not one "single dimension" property. Many usability attributes need to be considered and measured. Shackel proposed four-dimensional characteristics that impact product acceptance: efficacy, ability to learn, adaptability and attitude [6]. Siti Elliyana and Puspita Kencana Sari carried out a study on internet banking website of Mandiri bank of Indonesia with Nielsens's usability heuristics. The method of research used was a descriptive analysis, with hundred participants participating through questionnaires. According to this study, Mandiri internet banking does not fully implemented all heuristics. Heuristics which were judged not well, those were; error prevention, flexibility and efficiency of use, and aesthetic and minimalist design [2].

Adane kebkab used qualitative method (heuristic evaluation) to measure usability of banking website. He found different usability issues mentioned by experts. He also suggested ways to improve the usability of banking website by using user centered approach [7]. A method that examines the usability of mobile apps and recognizes the possibility of usability problems has been developed by Biel Grill and Gruhn. The SATURN method consists of five activities. These activities include the context of analysis, determination of scenarios, evaluation of scenarios, interpretation, review and tools. Biel Grill and Gruhn have used the mobile SATURN model and observed major usability problems [8].

Zereh Lalji and Judith Good studied the design of a mobile device for illiterate users. While the study adopted an incremental and UCD approach. They have tried to explain how the results from their study can be beneficial to non-traditional users in the fields of design [9]. Victor Ndako Adama and Ibrahim Shehi Shehu develop a prototype on m-banking for novice users on the basis of recommendations and guidelines found in literature. They involved novice users and tested their prototypes. The results showed that the satisfaction level of users increased with new prototype [10].

Bernhaupt provided a set of the 'classical' approaches and adds several theoretical innovations in the field of mobile devices and applications to test usability. He recommends incorporating both forms of field assessment and standard laboratory testing to accommodate many stages of the UCD and development procedure [11]. Amin Babazadeh Sangar presented the smart banking model to enhance the usability of mobile software. In this respect, four new "visibility," "design," "navigation" and "compatibility" factors were achieved. The proposed model was presented in accordance with the factors in the earlier studies and obtained factors from his research. They had created an application for a bank based on this model, following the proposed usability pattern by increasing the level of satisfaction [12].

Azham Hussain has shown a range of usability measures to assess m-banking's usability. Measurement and dimension have been produced through systematic literature review in the relevant previous studies [13]. Fatih proposed a model that helps solve complex problems in the evaluation process of M-banking services and improves the performance of M-banking operations [14].

2. Methods and Materials

To achieve the goals of this paper, in this study the researcher selected different mobile banking apps running in Pakistan to analyze the usability of these app and to check the issue faced by the diversity of mobile banking users so that the researcher can give recommendations to increase usability of mobile banking applications.

2.1. Evaluation Methods and Approaches

Following two usability evaluation methods in this research work.

2.1.1. Heuristic Evaluation

Heuristic evaluation is the evaluation method. It was formulated by Nielsen [15], based on a number of guiding principles of usability or ' heuristics'. It can be described as an exercise that involves a number of experts to make use of heuristics to identify usability issues of an interface with less effort and in short period of time. "Heuristic assessment is a widely recognized diagnostic approach for

critical usability challenges and is common in various disciplines" stated by Magoulas [16].

2.1.2. Approach

In this research 5 experts were chosen to evaluate the usability of the mobile banking app of BOP and MIB. Evaluators were given a set of 30 questions, 3 against each Nielsen 10 heuristics. Evaluators scored each sub-criterion with a 5-point Likert scale starting from strongly agree (0) to strongly disagree (4). Each heuristic violation identified needed to be explained by the evaluators.

After completion of heuristic evaluation, the duplicate usability violations were consolidated and combined. Finally, a severity rating was carried out to assess the extent of usability problems. The usability issue was assessed by each evaluator using the five-point severity rating scale of Jakob Nielsen [17]. Table 1 shows the scale of the severity rating.

TABLE 1. Nielsen Severity Rating for Usability Problems

0	This is not a usability problem at all
1	Cosmetic problem only – does not need to be fixed unless extra time is available on the project
2	Minor usability problem - fixing this should be given low priority
3	Major usability problem - important to fix, should be given high priority
4	Usability catastrophe - imperative to fix

2.1.3. User Testing

In this method of testing, different novice users were given typical tasks (translated from extracted problems by heuristic evaluation) on mobile banking app. These tasks were consisting on main functionality of m-banking app and the researcher used the results to see how the UI of m-banking app assists users in their tasks. Each task given to the user, had precise goal to test the usability goals/ principles on which the researcher evaluate the system. User testing includes many methods like Coaching Method, Co-Discovery Learning Method, Performance Measurement, Questions asking Protocols, Thinking Aloud Protocol etc. We used “Think Aloud” Protocol.

- **Think Aloud**

“Think Aloud” protocols, in this a user worked on an interface and we encouraged them to "think aloud" say what they think and wonder, at every moment. “Think Aloud” conventions are of specific esteem since they center on a user’s issues. This allows researcher to obtain a detailed picture of the behavior of users that can be analyzed to highlight usability issues. This protocol helped to record the user's time to perform tasks and to calculate the efficiency. It also helped researchers to monitor user satisfaction level and application effectiveness under observation.

List of Tasks

The following tasks were performed by the users in user testing.

- Balance checking
- Funds Transfer within bank
- Funds Transfer outside the bank
- Mobile Top-ups
- Bill Payments
- Deactivate Card
- Update Settings
- Approach

Users were requested to fill Pre-Test survey to know essential data about candidate with the goal that researcher can assess about the candidates i.e. novice, moderate or master in this area. Then method of test and what is expected from them was presented, together with the idea of "Think Aloud" convention and the assignments they should performed on the Mobile Banking Application. This ease-of-use testing directed so that just a single candidate at any given moment could play out the examination, so as to empower the cautious observing of their activities and conduct. At the end user have to fill Post-Test survey in which

questions regarding task which facilitates the research objective given. Each question has a rating 0 to 5 calculating the satisfaction level of candidate from "Strongly Disagree" to "Strongly Agree". At the end, we calculated the satisfaction level, effectiveness and efficiency of task performed.

2.1.4. Questionnaire

This study contains two questionnaires: pre-test and post-test. The pre-tests were utilized to collect demographic information from users, both for "Heuristic Evaluation" and "User Testing". The post-test survey was used for two purposes in the user test: 1) the user's viewpoints were obtained, and 2) the user's disappointment and/or satisfaction level calculated, when they using the "Mobile Banking App". As a post-test questionnaire, the researcher used SUS questionnaire. A simple and extensively-used 10 questions survey is the "System Usability Scale" (SUS) which provides qualitative calculations of system usability. In this study users were asked to rate the 10 declarations half of their agreement or disagreement positively, and half of them negative about the Mobile Banking App. For presenting outcomes, this study uses the scoring model that transforms a single score based on Brooke's standard measuring method into a single score.

- **Sample of Candidates**

In this research work, different types of users were chosen i.e. Novice and expert users. The aim was to measure the difference in performance among the two groups, which was achieved by observing attentively and closely the behavior of users throughout the user testing. 18 users were chosen for user testing out of which 9 were novice and 3 were experienced and 6 were moderate level users who don't use mobile banking app frequently. Users were also chosen from different age groups to achieve the research goals.

Below are the samples of users we chose for my testing.

•Businessman (Who frequently use App) → Expert level User

•Businessman (Who use only few times App) → Moderate level User

•Businessman (Who never user App) → Novice User

•Housewives

•Students

•Professionals

TABLE 2. Gender and Experience User's Group Distribution

User Type	No of Users	Gender		Total
		Male	Female	
Novice	9	7	2	18
Moderate	6	4	2	
Experienced	3	2	1	

TABLE 3. Gender and Age Wise User's Group Distribution

Gender	Age Class			
	20-25	26-30	31-35	Above 35
Male	3	2	4	4
Female	1	2	1	1

3. Results and Analysis

The results from the two methods ("Heuristic Evaluation" and "User Testing") that have been used in this experiment are shown in this section. It begins by summarizing each user's problems during the "user testing" and calculating usability metrics including satisfaction, efficiency and success rate of each task. Then researcher calculates the usability of the mobile banking app with the help of the system usability scale (SUS).

3.1. User testing Results

3.1.1. Tasks Analysis

It is not essential to evaluate all of the tasks carried out by the participants in great detail during the evaluation process. A comprehensive examination will be enough for some of the tasks most successfully performed. A more comprehensive explanation would be more suitable for the usability problems as well as other challenging tasks. The concise work needs to be scanned carefully in order to ensure they are a true example of mobile banking. Each of the tasks in this section is examined and analyzed to find out the possible causes of the results of the work performed by the participants.

Fig. 1a. Home page

• Balance checking

This task was the easiest task among all, almost every user was successful except one novice female user. Data collected via "Think Aloud" protocol found that it was the easiest task for almost all users and completed within few seconds after login. Most of the Mobile Banking Apps show their balance in home page or it is easy to navigate account balance. To demonstrate that we took screenshots form Bank of Punjab's mobile banking application for reference at figure 1(a,b).

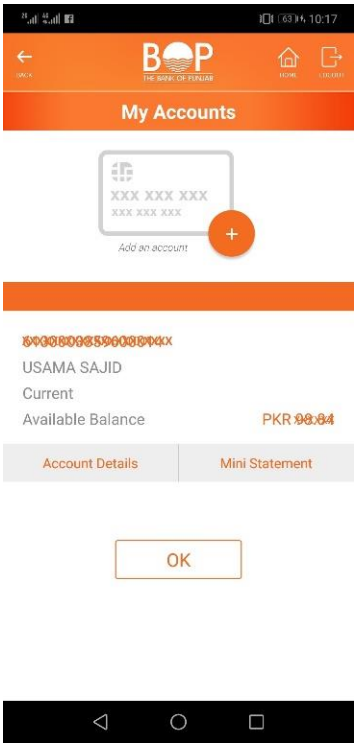

Fig. 1b. Balance Check

3.1.2 Bill Payments

This task was easy for those users who already were paying bills from their apps so they took not much time to complete this task. For those users who have never paid their bills through app, first needed to add their Bill before paying it. Adding bill details took some time for some users but almost all of them were successful only 5 persons were unsuccessful because they did not find from were to add bill details. This is because few apps have different screens to add bills so some users find difficulty to navigate (MIB app have this

problem). While most of the apps give facility to add bill details on same page if bill details not added. Below print screen Figure 2 shows add bill option have on same screen of bill payments while Figure 3 shows no options found in bill payment screen to add bill details.

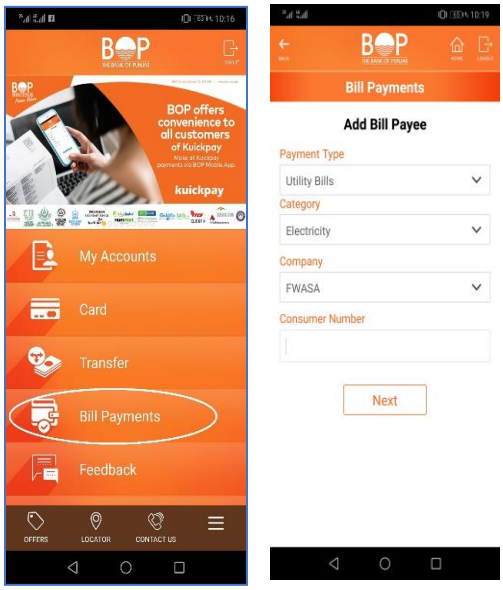

Fig.2. Bill payment and add bill

This task was also easy for those users who already were recharge their mobile balance from their apps so they took not much time to complete this task. For those users who have never recharge their mobile balance though app, first needed to add their network provider details to recharge their balance. Adding details took some time for some users but almost all of them successful only few were (6 persons) unsuccessful because they did not find from were to add bill details. This is because few apps have different screens to add bills so some users find difficulty to navigate (e.g. MIB app have this problem). While most of the apps give facility to add bill details on same page if bill details not added. Above print screen Figure 2 shows add bill option have on same screen of bill payments while Figure 3 shows no options found in bill payment screen to add bill details.

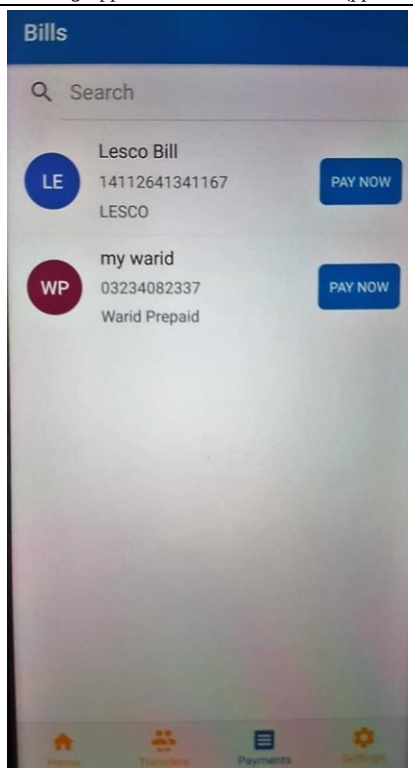

Fig.3. Absent of add bill option

3.1.4 Funds Transfer within bank

During Funds transfer tasks expert users were in their comfort zone, because they had done this so many times before while moderate or novice users find it a bit difficult to complete this task and took 6 to 10 minutes to complete this task. Through "Think Aloud" protocol we observed that most of the users find difficulty to check if their funds transferred successfully or not because of poor feedback from mobile apps. Few of the users also find difficult to navigate through the app to add beneficiary's details. Some novice users also complain about the name conventions used in some apps was not easy to understand for them. From Figure 4 we can see the process of funds transfer and add beneficiaries.

3.1.3 Mobile Top-ups

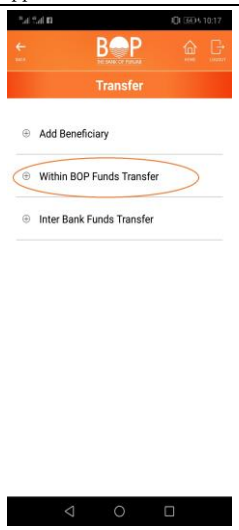

Fig.4. Fund transfer

3.1.5 Update Settings (e.g. change password)

This task was also easy for both users (expert or novice) because update setting is common operation/ term used in mobile app or web apps. Those users who are using any app or maintaining any account in any app or website were familiar to this task. We asked them to change their passwords most of the users were done it within 2 to 3 minutes only 2 were unsuccessful in doing this task.

3.1.6 Overall Success Rate

The following Table 4 shows the no of participants who have successfully performed each task on the mobile banking apps. Although majority tasks have been successfully completed within the expected completion period or approximately, some have been found hard [18]. Nielsen [10] defines the "percentage of tasks that the user completes correctly." This is the rate (i.e. success rate). For calculating the success rate Nielsen employs the following formula:

$$\text{Success Rate} = \frac{successful\ task + (partially\ successful\ task) * 0.5}{Total\ no\ of\ tasks}$$

TABLE 4. Success rate of tasks performed

Tasks	Gender	Age Class	Novice/ Experience	Successful	Partially Successful	Failed	Success Rate
Balance Checking	13 Males and 5 Females	20 to above 35	Both	18	0	0	100 %
Bill Payments				13	1	4	75 %
Mobile Top-ups				12	3	3	75 %
Funds Transfer				12	2	4	72%
Update Password				16	2	0	94%

Overall Success Rate		83.2%

3.1.7 Overall Relative Time based Efficiency

The overall relative time-based Efficiency of a product defined as the ratio of effective users' work time to all users' work time. Many experienced users had the least time to perform most of the tasks effectively while novice users took more time complete/ partially complete the task. Table 5 shows the user testing results for calculating overall relative table-based efficiency.

TABLE 5. Overall relative time-based efficiency

Tasks	Successful	Failed
Balance Checking	18	0
Bill Payments	13	5
Mobile Top-ups	12	6
Funds Transfer	12	6
Update Password	16	2
Overall Relative Time based Efficiency	**54.2%**	

TABLE 6. System usability score

Participant	Q1	Q 2	Q 3	Q 4	Q 5	Q6	Q 7	Q 8	SU Score
P1	4	5	2	2	3	4	4	2	**40.0**
P2	2	4	4	1	2	5	2	3	**32.5**
P3	3	2	3	3	2	3	2	3	**37.5**
P4	2	4	4	3	4	4	4	4	**37.5**
P5	3	3	2	2	2	2	2	3	**37.5**
P6	5	4	4	4	3	2	3	5	**40.0**
P7	1	3	3	3	1	2	3	5	**27.5**
P8	5	3	2	2	3	4	5	5	**42.5**
P9	5	2	2	3	3	2	5	5	**47.5**
P10	4	3	5	3	3	3	3	5	**42.5**
Average									**38.5**

3.1.8 User Satisfaction by SUS

After user testing candidates filled SUS questionnaire which had 10 questions with Likert scale. From the results researchers have found that the overall average usability score is 38.5 which is below the satisfaction level [19] [20]. Table 6 shows the System usability score in detail of each participant.

3.1.9 Heuristic Evaluation Results

For the m-banking apps, the researcher has established a usability checklist for heuristic evaluation. Table 7 shows that the ratio of major error highlighted by expert evaluators is 7%, minor error's ratio is 40% and cosmetic error were 54%.

TABLE 7. Heuristic evaluation results

Problem Type	Cosmetic	Minor	Major	Catastrophic	Total
Visibility of system status	4	5	2	0	11
Match between system and the real world	5	7	1	0	13
User control and freedom	4	4	0	0	8
Consistency and standards	7	4	1	0	12
Error prevention	6	5	1	0	12
Recognition rather than recall	4	3	0	0	7
Flexibility and efficiency of use	5	2	0	0	7
Aesthetic and minimalist design	3	2	0	0	5
Helps users recognize, diagnose, and recover from errors	6	3	0	0	9
Help and documentation	5	2	0	0	7
No of problems discovered	49	37	5	0	91
Percentage of problems discovered	54%	40%	6%	0%	

4. Discussions and recommendations

This segment shows users and expert's feedback on the challenges experienced during the two experiments, and provides a set of recommendations. The results of the test show that the novices had significantly more difficulty than the experienced users in executing certain tasks, but they were able to cope with that with time.

User satisfaction is among the main components of usability in order to enhance the usability of interactive mobile banking applications. When designing such a program, one should bear in mind not only for first-time users but also the retention of existing app users. As observed during User Testing, most of the users faced navigations problems, Feedback issues and naming convention's related issues. Few faced efficiency issues like response time.

Some suggestions for improving mobile banking applications are provided below.

- Use easy terminologies which are understandable for users.
- Enhance visibility of the status of transactions especially in case of transferring funds or paying bill.
- Provide help to novice users in case they mistake by proper feedback.
- Provide functionality of adding beneficiary details on same funds transfer page in case of the beneficiary not added.
- Improve navigation so that user is able to understand where he is and what to do next.
- Don't make interfaces a mess, keep it simple and provide only necessary information.
- FAQ and help button should be visible to the user.
- Title of each page should be displayed at the top.

5. Conclusion and Future work

The main objective of this study was to recognize and inspect the usability issues of the m-banking applications to enhance its

interaction with users. SUS survey was used to check the satisfaction level of a user which was below the average. Later, usability testing and heuristic evaluation showed that Mobile Banking apps are significantly harder for beginners than for experienced users. Based on the experiment conducted and expert opinions, recommendations are provided for UX/UI developers and designers. Banking sectors should follow the design principles of usability while designing apps in order to achieve best possible user satisfaction, effectiveness and efficiency of the system. Future work can be undertaken to evaluate the user interface of the m-banking application using combining multiple techniques, based on these integrated usability guidelines and their impact on the usability of m-banking applications. Low fidelity and high-fidelity prototypes can be developed to get better results. Multi-Criteria Decision analysis like AHP, Fuzzy AHP and TOPSIS techniques can also be used to prioritize m-banking usability issues in future work. Research on the design of m-banking applications for disabled or blind users may also be carried out in future work.

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Ontology-Based Transformation and Verification of UML/OCL Constraints

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Abstract:
In Software Engineering (SE), the graphical models specify the system's architecture, connection, and characteristics. New SE methods such as Model Driven Architecture (MDA) utilize graphical models as a nucleus of all development activities. In the MDA, the UML class models are very important and play very significant role in software development. But UML class model did not have support of any formal System. Therefore, it is very difficult to verify the correctness of UML class model. This paper presents the transformation and verification of class diagram and Object Constraint Language (OCL) and transformation algorithm from Class model to ontology in the continuity of our research on UML and ontology integration. The class diagram is transformed into ontology, and constraints specified through OCL are transformed into SPARQL. The benefit of the method presented in the study is that the availability of many efficient reasoners which can perform reasoning on huge ontology models in a very adequate time. This electronic document is a "live" template and already defines the components of your paper

Keywords: *UML, OCL, Ontology, SPARQL*

1. Introduction

In the present time software are part of our daily life; they control the stock exchange, manage patient records, taking decisions, etc. However, software failure causes either losses of human life and economical. Therefore, the correctness of software must be testified before implementation. Testing has two main issues 1. Testing never gives 100% grantee of error-free software. It only checks specifics bugs that drive from the test cases 2. testing activity is executed after completion of code. The bug identification and rectification cost are much higher in the later phases than in earlier phases [1]. Furthermore, more complex and large software is required in the industry, requiring extensive human efforts, and software houses want to agility in release software due to completion with their rivals [2]. Hence, new software development techniques have been developed to tackle the issues, and Model Driven Architecture (MDA) is one of them.

In MDA approach, graphical models play key roles in the development. MDA uses Unified Modeling Language (UML) as the main modeling language. UML is an industry-standard, and currently, it is used in all development activities such as analysis, design and documentation, code generation, and testing [3][4]. It provides many diagrams that deal with various facets of software [5][6][7]. The UML Class diagram is very important part of UML [5][8][9][10]. It represented the real-world model via classes, collaboration, and constraints [11]. Object Constraint Language (OCL) is a constraint speciation language, and its small scripts are attached with UML for defining constraints, conditions, and business

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rules [12]. However, the MDE approach has some limitations, and it also has some limitations, such as it is not free from error risk. For example, the model may be created with bugs that can be indirectly transported into the code. Verification of the model can be a possible solution to the problem.

Current UML Class/OCL model transformation and verification techniques offer good support to verify the model's correctness. However, formal and semi-formal methods are used in them for the formalization of the model and their notation based on mathematics. It is numerously diversified from the UML and very hard to understand by the software engineer. On the other side, the UML class model and ontology have so many common components and are developed to represent real-world concepts [13].

The OCL is an important element of UML. It is used to specify constraints that add additional restrictions in the UML model. It can access objects attributes, operation, and navigate object to object through associations and query operation calls. It is specially used to apply integrity constraints on the class model and also be used in other UML models such as the state chart model.

SPARQL Protocol and RDF Query Language (SPARQL) is a semantic query language for manipulating ontology [14]. It is not only used for the query. It is also used for various other functionality, e.g. ASK and CONSTRUCT, which are used for checking constraint consistency. The ASK command is used to verify constraints consistency, and the CONSTRUCT command is used to inferring new information. The OCL constraints are transformed into SPARQL ASK Negation as failure (NAF) Query in the proposed method.

2. Methodlogy and Proposed Solution

In [14], we have proposed ontology-based approaches for transformation and verification UML class model and presented how the SPARQL can efficiently represent OCL. This work presents an extension of our ongoing research ontology-based verification of the UML Class and OCL [14] [15] [16][17][18]. It presents the detailed mapping of different OCL elements into SPARQL. Ontology and UML class/OCL model have various similar elements e.g. classes, collaborations, constraints, instances, and generalization. However, ontology has additional benefits, such as reasoning, and on the other hand, UML does not have an appropriate formal foundation and reasoning ability. The UML model and ontology have a difference, such as Open World Assumption (OWA), which is supported by ontology UML supports Close Work Assumption (CWA). In OWA, the currently unknown assumption is treated as true, and in CWA, an unknown assumption is treated false. We proposed the representation of UML and OCL constraints into the SPARQL negation as failure (NAF) queries for supporting CWA in the ontology.

2.1. Class Model Transformation

In this work, the UML classes are converted into ontology classes, and Class properties are converted into the Ontology datatype property. Associations are converted into the object properties of Ontology, and their multiplicities are transformed into the Qualified cardinalities. The complete detail of class model transformation can be found in [13]. In this work, we presented the transformation algorithm of the UML class model to Ontology. According to the algorithm, the proposed method will take the UML class model in XMI format, read the entire file, and convert the model element according to the proposed method

2.2. OCL to SPARQL Transformation

SPARQL has similar data types as OCL for example integer, real etc., and both support common operations and functions. OCL has 4 Basic type such as Integer, Real, String, and Boolean and SPARQL support all OCL basic datatype such as for Real SPARQL has a decimal, float, and double as shown in table 1. OCL integer transformed into xsd:integer,

string into xsd:string, and Boolean into xsd:boolen.

Algorithm : Transformation (*f as XMI File*)

Pre: Required Class diagram in XMI format
Post: OWL File
While *f <> Eof*

1) e←getElemet(*f)*
2) **if e=UMLclass**
   addOWLClass(UMLclass.name)
   while e.Attributes<>null
   a← e.Attributes
   addOWLDataProperty (a.ame,e.name as domain ,a.datatye as range)
3) **if e=UMLassociation**
   if (e.type = unidirectional)
   addOWLObjectProperty (e,e.sourse as domain, e.target as range)
   else
   addOWLObjectProperty (e,e.sourse as domain, e.target as range)
   addOWLInverseObjectProperty (e,e.traget as domain , e.sourse as range)
4) **if e=UMLgeneralization**
   a. s ←Call SuperClass
   b. AddOWLSubCLass(e,s)
   return (OWLModel)

End

TABLE I. Primitive Types.

OCL	SPARQL
Real	xsd:float,xsd:double,xsddecimal
Integer	xsd:integer
String	xsd:string
Boolean	xsd:Boolean

The primary computational operator of OCL, such as arithmetic, relational, and logical also supported by SPARQL, as shown in Table2. OCL has many types of functions such as number, string, conversion, and group. The number functions perform different manipulation on a number such as ceiling and floor of a number. The transformation of the numeric function into the SPARQL is shown in table 3.

TABLE II. Operation on primitive type

Arithmetic		Relational		Logical	
OCL	SPARQL	OCL	SPARQL	OCL	SPARQL
+	+	<	<	Or	Or
-	-	>	>	And	And
*	*	<=	<=	Not	Not
/	/	>=	>=		
		<>	!=		

TABLE III. OCL Function Transformation

Integer	
OCL	**SPARQL**
Abs()	Abs()
Floor()	Floor()
Round()	Round()
Ceil()	Ceil()
Mod()	NA
String	
OCL	**SPARQL**
Concat()	Concat()
Substring()	SUBSTR()
ToUpperCase()	UCASE()
ToLowerCase()	LCASE()
Size()	STRLEN()
Conversion	
OCL	**SPARQL**
toInteger()	Xsd:integer()
toReal()	Xsd:float() xsd:double() xsd:decimal()
toBoolean()	Xsd:Boolean
Group	
OCL	**SPARQL**
Max()	Max()
Min()	Min()
Sum()	Sum()
Count()	Count()

2.3. Transformation of Collection Operations

OCL provides various operations on the collection types. They are specially designed for projecting new collections from existing ones. this section discusses the transformation of the collection operation

2.3.1. Select and Reject operation

Select and Reject operations specify a selection from a specific collection. The select specifies a subset of a collection. It returns a

collection that contains the elements where the Boolean-expression evaluates to true. In SPARQL, the select operation is mapped into a select query, as shown in table 4.

The reject operation is just the inverse of the select. It rejects all the elements where the Boolean-expression evaluates true. In SPARQL, it is mapped into the inverse of select

2.3.2. Include and Exclude

Include operation returns true if the specified object exists in the collection and exclude returns true when the object does not exist. In SPARQL, the includes and excludes are mapped into Exits and Not Exit, as shown in the example presented in Table 4.

2.3.3. ForAll, Exit and Collect

The ForAll operation declares multiple iterators, which iterate over the complete collection. It returns true if the expression is true for each element. In SPARQL, it mapped into the simple query filter without Exits and Not Exits, as shown in Table 4. The Exits operation returns true if at least expression is true for one element. In SPARQL, it can be map into the filter with No Exists statement, as shown in Table 4.

3. Conclusion

UML Class/OCL model constraints are essential elements of UML. It is used for graphically representing real-world entities. This paper presents a new method for the transformation and verification of OCL constraints into SPARQL. OCL and SPARQL have many common elements, such as data types, operators, and functions. However, different types of collection operations such as select, reject, includes, includes all etc. can be easily mapped into the SPARQL through NAF ASK query with Filter construct

TABLE IV. Equivalences of OCL operations

Includes	
context Employee inv: self.worksFor->includes(self.manages.Department)	Ask where { ?E :Manage ?D. Filter (NOT EXISTS {?E :Workin ?D}) }
Excludes	
context Employee inv: self.subordinates->excludes(self)	ASK where { ?E1 rdf:type Com1:Employee. ?E1 :Workin ?E2 Filter (EXISTS {?E1 :Workin ?E2}) Filter ((?E1 = ?E2))}
IncludesAll	
context Faculty inv: self.works.controls->includesAll(self.worksOn.Researchproject)	ASK where { ?F rdf:type Com1:Faculty. ?F :Work ?D. ?D :Manage ?RP. Filter (NOT EXISTS {?F :Workon ?RP})}
ExcludeAll	
Inverse of Include	
Exit	
context University inv: self.Faculty->exists(firstName = `Abdul')	ASK where { Filter (!(NOT EXISTS {?F :FName "Abdul"^^xsd:string})) }
Forall	
context University inv: self.Faculty->forAll(age <= 65)	ASK Where { ?F :age ?age. Filter (!(?age >65)) }
Select	
context University inv: self.Faculty->select(Sal > 10000)->notEmpty()	ASKwhere { Filter (NOT EXISTS {?D :iworkin ?F. ?F :Fsal 10000}) {select ?D where { ?D rdf:type :Department}}}
Reject	
context University inv: self.Faculty->reject(isMarried)->isEmpty()	Inverse of reject

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The Mathematical Model for searching the Shortest Route for Tuberculosis Patients with the help of Dijkstra's Algorithm

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Abstract:

In this research paper, we have studied TB (Tuberculosis) patients who come from different traffic routes in order to seek medical help and treatment in Karachi, Sindh, Pakistan. Through this scholarly article, we have focused on the transportation problems of the TB patients. These TB patients can travel on the paths having minimum distance as found out in this paper using Dijkstra's Algorithm.

People hope that they have better treatment opportunities and financial medical relief in the government and private hospitals in Karachi. People belonging to the poor or lower and middle classes approach government hospitals adequately as private hospitals are expensive. Among them, Nazimabad Chest Hospital for TB patients (under the supervision of Dow University of Health Sciences) provides good medical treatments for the similar medical issues and it is renowned for its high quality treatment of TB patients. The hospital is located inside Government Hospital Nazimabad (under the control of Dow University), Karachi. TB Patients have to visit the hospital on weekly basis from their homes and residences. They use several combinations of traffic routes to reach the hospital as these patients live in different areas like, Malir Cantt, Safari Park, Hassan Square, North-Nazimabad, North Karachi, Gulshan-e-Iqbal, etc. In this scholarly article, research has been made to locate the shortest route for the convenience for these TB patients by making a mathematical model using the method of Dijkstra's algorithm. Our result shows that a TB patient residing in Malir Cantt should follow the route comprising of Malir Cantt, Safari Park, Laiquatabad and Nazimabad Chest Hospital for TB patients, without changing the sequence, in order to make the traveling more effective in terms of the transportation cost or fare, distance, reduced suffering, time, etc.

Keywords: *Dijkstra's Algorithm; Node 1 - Malir Cantt; Node 5 - Nazimabad Chest Hospital; Dow University; Karachi; Permanent Label; TB; Tuberculosis*

1. Introduction

Karachi city is a mega city of Pakistan. Nazimabad Institute of Chest Diseases is giving medical services to TB (Tuberculosis) patients in Karachi. The said institute is working under the supervision of Dow University of Health Sciences, Karachi. It is located inside Government Hospital, Nazimabad. The said hospital is the only hospital equipped with latest facilities, competent and qualified staff. WHO (World Health Organization) also honored it as a centre of excellence for TB treatment. These paramedical staff and qualified doctors are

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available for people who are living at various locations in Karachi like, Gulshan-e-Iqbal, Safari Park, Malir Cantt, North Karachi, North Nazimabad, etc. Patients living in different areas are encountering problems in getting medical treatment from the Nazimabad Chest Hospital for TB patients (under the supervision of Dow University). In order to get the proper medical treatment from the hospital, they spend a lot of time, money as well as energy in travelling back and forth between the hospital and their residential areas.

Tuberculosis is a disease which usually destroys the lungs. The problem with this disease is that it is has the ability to spread in the body and affect other organs. Another problem with TB is that it can spread slowly through air. It is known that bacteria named Mycobacterium is responsible for this disease. This disease gradually and painfully kills the sick patient if it is not taken seriously. This is evident from the fact that approximately about a million deaths are caused by TB in the world. Fortunately, in this modern era of health sciences, a TB patient gets cured after getting proper medical attention and treatment [1].

In this paper, research has been done to find out the shortest traffic route in order to provide accessibility and convenience to the needy and poor TB patients. With the help of the application of a mathematical model using Dijkstra's Algorithm, efforts have been made to track down the shortest route from Malir Cantt to Nazimabad Chest Hospital for TB patients (running under the management of Dow University) [2][3][4][5].

To accomplish the objective, the City Government, Highway Authority and inter-related departments were approached to get the data necessary for the determination of alternate routes. Different important locations inside Karachi have been chosen and labeled as nodes. The information created from the data consisting of the nodes and the distances between them is represented by Table 1. The names of the physical location represented by each node have been shortened so that the process becomes more intuitive while keeping the accuracy of the results unaffected [6][7][8].

These locations are chosen as nodes due to the fact that TB patients frequently travel from and through these locations to reach the hospital. These nodes are taken by us for our research study also because of the fact that while traveling, these TB patients constantly face problems in terms of money, time and energy as there exists several combinations of possible traffic routes among these chosen nodes and TB patients do not have

Table 1: Nodes, corresponding numbers, locations and distances among them

Starting Location name	Corresponding Node No.	Ending Location name	Corresponding Node No.	Distance (km)
Malir Cantt	1	Safari Park	2	8
Safari Park	2	Liaquatabad	4	9
Gulshan Chowrangi	3	Safari Park	2	3
Malir Cantt	1	Gulshan Chowrangi	3	12
Gulshan Chowrangi	3	Liaquatabad	4	7
Gulshan Chowrangi	3	Nazimabad Chest Hospital for TB patients	5	13

information about the shortest possible route that they should follow in order to reduce their sufferings as well as increase their efficiency of medical treatment.

To find the shortest route from Malir Cantt to Nazimabad Chest Hospital for TB patients (under the supervision of Dow University), Dijkstra's algorithm showed itself to be useful in this mathematical model. Dijkstra's algorithm has been used to calculate the shortest route / path between the source node and every other node in the network [9][10][13]. Dijkstra's Algorithm has been applied in a general manner so that it allows determining the shortest route / path between any two nodes in the network [14][15].

Our scientific study is important and effective with respect TB patients traveling to seek medical help. Even 1 km can increase the chances of saving lives of TB patients. Furthermore, our finding of the shortest route will reduce financial burden on the TB patients with respect to the transportation cost in this mega city of Pakistan. Furthermore, our research work will also help to reduce the suffering time of seriously infected TB patients by reducing the traveling distance, even if it is only 1km.

2. Methodology And Modeling

In this method, we applied this Dijkstra's algorithm to judge the shortest path. Different assumptions and notations have been used in the paper for applying Dijkstra's algorithm on the problem. Dijkstra's algorithm is limited to work on positively valued metrics only. Here, every metric represents a spatial distance (1 dimensional quantity) among the nodes. All distances are measured in kilometers. Further notations are discussed below.

2.1. Notations

Let u_i be the shortest distance from source Node 1 to Node *i*. Let $d_{ij} \geq 0$ where d_{ij} defines the arc length (*i*, *j*). The label of the immediate successor of node *i* i.e. node *j*, can be defined by the algorithm by (1):

$$[u_j, i] = [u_i + d_{ij}, i], d_{ij} \geq 0 \quad (1)$$

In the path finding process, the label [0, ––] given to the starting node indicates that the node has no predecessor.

2.2. Permanent and Temporary Labels

Node labels in Dijkstra's algorithm are of two types i.e. Temporary and Permanent. A temporary label is modified if a shorter route to a node can be found. If no better route can be found, the status of the temporary label is changed to permanent. The status of the labels are changed according to Dijkstra's algorithm and also verified by open source program code later on in this paper.

2.3. Sequence of Operation

The computation by the algorithm is carried out using two major steps.

2.4. Step No. 1

In the first step, consider the starting point node 1. We apply permanent label [0,—] on node 1. We also let $i = 1$.

2.5. Step No. 2 (a)

In the second step, evaluate the temporary labels $[u_i + d_{ij}, i]$ for every node *j* that can be reached from node *i*, provided *j* is not permanently labeled. If node *j* is previously labeled with $[u_j, k]$ via another node *k* and if $u_i + d_{ij} < u_j$ then replace $[u_j, k]$ with $[u_i + d_{ij}, i]$.

2.6. Step No. 2 (b)

If all the nodes have permanent labels then stop the computation. Otherwise, select that label $[u_r, s]$ among all the temporary labels that has the shortest distance i.e. for any temporary Node *r*, its reaching distance u_r is the smallest one. Set $i = r$ and repeat Step no. 1.

2.7. Network Diagram and Table

Keeping in view the present scenario, the chosen nodes from 1 through 5 are outlined in Table 2 and the created network diagram is shown in Fig. 1.

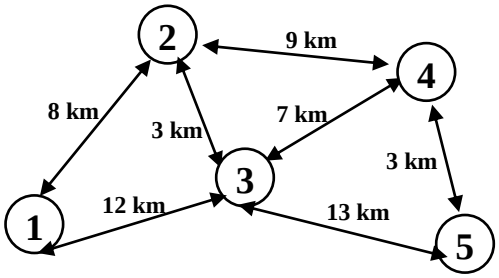

Fig. 1. Network diagram of the scenario.

Table 2: Summary Table of Node No. alloted against each location

Node No.	Map Location name shortened for Node Name
1	Malir Cantonment (or simply, Cantt)
2	Karachi Safari (or simply, Safari) Park
3	Gulshan-e-Iqbal (or simply, Gulshan) Chowrangi
4	Liaquatabad (formerly, Lalukhet or Laloo Khait)
5	Nazimabad Chest Hospital for TB patients under the supervision of Dow University of Health Sciences, Karachi (or simply, Nazimabad)

2.8. Iteration no. 0

In this iteration no. 0, we allocate the permanent label [0, —] to node 1 due to the fact that there is no preceding node.

2.9. Iteration no. 1

In this iteration no. 1, Nodes 2 and 3 can be reached from the node 1 (labeled as permanent, previously). Thus, the labeling (temporary and permanent) for these nodes are shown in the Table 3.

Table 3: Node Labels at Iteration no. 1

Node No.	Label	Status
1	[0, –]	Permanent
2	[0 + 8, 1]= [8, 1]	Temporary
3	[0 + 12, 1] = [12, 1]	Temporary

From two temporary labels [8, 1] and [12, 1], the yield of Node 2 is smaller for $u_2 = 8$. Thus, the status of Node 2 is changed to permanent.

2.10. Iteration no. 2

In this iteration no. 2, we can reach Nodes 3 and 4 from Node 2 (labeled as permanent, previously). Thus, the labeling (temporary and permanent) for these nodes are shown in the Table 4.

Table 4: Node Labels at Iteration no. 2

Node No.	Label	Status
1	[0, –]	Permanent
2	[8, 1]	Permanent
3	[12, 1], [8 + 3, 2] = [11, 2]	Temporary
4	[8 + 9, 2] = [17, 2]	Temporary

From the temporary labels [12, 1] and [11, 2], the yield of Node 3 is smaller for $u_3 = 11$. Thus, the status of Node 3 changes to permanent.

2.11. Iteration no. 3

Nodes 4 and 5 can be reached from Node 3 (labeled as permanent, previously). Thus, the list of labeled nodes (temporary and permanent) becomes as shown in the Table 5.

Table 5: Node Labels at Iteration no. 3

Node No.	Label	Status
1	[0, –]	Permanent
2	[8, 1]	Permanent
3	[12, 1], [11, 2]	Permanent
4	[17, 2], [12 + 7, 3] = [19, 3]	Temporary
5	[12 + 13, 3] = [25, 3]	Temporary

From the temporary labels [17, 2] and [19, 3], the shorter distance exists for Node 4 when u_4 = 17. Thus, the status of Node 4 is changed to permanent.

2.12. Iteration no. 4

Node 5 can be accessed from Node 3 as seen previously. The label list gets updated as shown in the Table 6. The rejected and accepted labels along the iteration cycles are shown in Fig. 2.

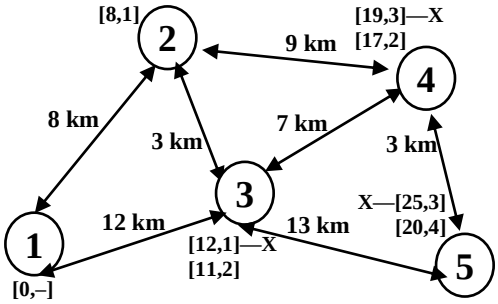

Fig. 2. Updated Network diagram of the scenario

Table 6: Node Labels at Iteration no. 4

Node No.	Label	Status
1	[0, –]	Permanent
2	[8, 1]	Permanent
3	[12, 1], [11, 2]	Permanent
4	[17, 2], [19, 3]	Permanent
5	[25, 3], [17 + 3, 4] = [20, 4]	Temporary

Node 5 can also be accessed from Node 4 with temporary label [20, 4] as shown in Table 6. Node 5 is already labeled as [25, 3]. Since the label [20, 4] gives a shorter distance, the label at the Node 5 changes its state to permanent with distance u_5 = 20.

2.13. Completion of the computation

Now, all the nodes are permanently labeled and the algorithm's computation has completed successfully. For any Node w, the shortest distance from Node 1 to Node w computed by the algorithm in our scenario at its different iterations can be summarized in the Table 7.

Table 7: Shortest Distance per Iteration no.

Iteration No.	Destination node, *w*	Shortest distance, u_w (km)
0	1	0
1	2	8
2	3	11
3	4	17
4	5	20

The shortest route between Malir Cantt and Nazimabad Chest Hospital for TB patients (under the supervision of Dow University of Health Sciences, Karachi) can be easily seen if we consider destination Node 5 and then follow the nodes in reverse direction using the information given by the permanent labels.

The following sequence establishes the shortest path from Node 1 to Node 5:

Sequence 1. Shortest possible traffic route sequence

$$(5) \rightarrow [20, 4] \rightarrow (4) \rightarrow [17, 2] \rightarrow (2) \rightarrow [8, 1] \rightarrow (1)$$

In Sequence 1, the right headed arrow "→" represents the tracking direction of the nodes from tail to head of the arrow. In the sequence, "(*w*)" represents Node *w* and "[*u w*, *k*]" represents the shortest distance u_w

between Node *w* and Node 1 if TB patients come on the physical location represented by Node *w* from the physical location represented by the immediate Node *k*. Thus, the desired route to follow is shown in Sequence 2:

Sequence 2. Shortest possible route's nodes sequence

Node 1 → Node 2 → Node 4 → Node 5

Hence, the shortest route between Nazimabad Chest Hospital for TB patients and Malir Cantt is found out to be equal to 20 kilometers only.

2.14. Results and Discussion

The shortest distance from Node 1 (Malir Cantt) to Node 5 (Nazimabad Chest Hospital for TB patients, working under the supervision of Dow University of Medical Sciences, Karachi) has been evaluated using the method of Dijkstra's algorithm and is equal to 20 km. The exact result is also achieved from iteration no. 4 as shown in the Table 8.

Table 8: Node Label acceptance

Iteration No.	Accepted Label	Rejected Label
1	[0, –]	-
2	[8, 1]	-
3	[11, 2]	[13, 1]
4	[17, 2]	[19, 3]
5	[20, 4]	[25, 3]

The shortest route possible between nodes 1 and 5 has been determined with the help of the Sequence 1 i.e.

(5) → [20, 4] → (4) → [17, 2] → (2) → [8, 1] → (1)

Thus, the desired route nodes and sequence fond out to be Sequence 2 i.e.

Node 1 → Node 2 → Node 4 → Node 5

The said route's length is found out to be of 20 km only.

The result was also verified by writing a computer program code of Dijkstra Algorithm in Python computer programming language using different free online resources like, [16] and [17]. The output of the Python code in Fig. 3 is same as listed in Table 7 or the accepted labels listed in Table 8. The code was made on Python version 3.4.4 with online documentation found at [19]. It was executed using IDLE (Integrated DeveLopment Environment) version 3.4.4 with online documentation found at [18].

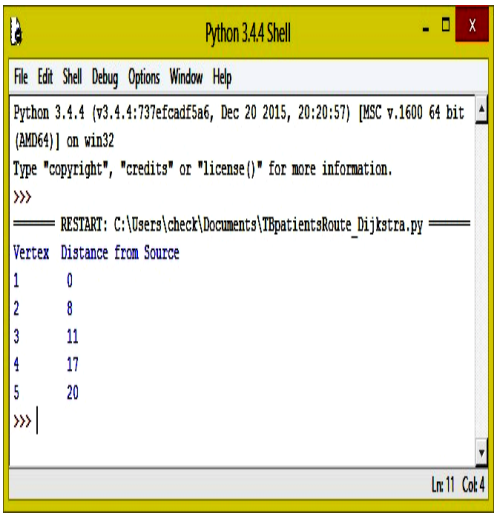

Fig. 3. Calculations of distances verified via Python

The dataset used in this research work consists of real values taken from Karachi city so this study is applicable to Karachi city only. Furthermore, the data is taken for patients residing in Malir Cantt area of Karachi and the corresponding location is referred to as the source node in this paper. The patients are traveling and trying to reach the Nazimabad TB centre of Karachi and the corresponding location is referred to as the destination node in our study. The source node will change if a patient resides in any other area of Karachi and the shortest path will vary accordingly. For example, for a patient residing at Saddar area of Karachi, the shortest path will be calculated between the patient's residential area (Saddar) and

Nazimabad TB centre of Karachi. There will be no change in the methodology and the source code of Python programming language used in our research work other than the corresponding dataset. The methodology presented in this scholarly article can also be adopted to find the shortest path from a location to any other specific hospital within any city of Pakistan using the corresponding dataset. Similarly, our methodology can also be used to find the shortest distance from a location to any other important destination in a city such as, rescue camps, amusement parks, academic institutions, etc. For example, the shortest path for an employee of IBA Sukkar travelling from his/her residential area to IBA Sukkar can also be found out using our methodology, the programming code and corresponding dataset.

3. Conclusion

Nazimabad Chest Hospital for TB patients (running under the supervision of Dow Medical University of Health Sciences, Karachi) from different areas outside the city of Karachi, the shortest route has been found between Malir Cantt and Nazimabad Chest Hospital within Karachi, a mega city of Pakistan. The said route is found out to be 20 km in length and this finding has been done with the help of Dijkstra's algorithm. The said route consists of Nodes 1, 2, 4 and 5. TB patients coming from Malir Cantt have to follow the nodes in the order given below to get advantage of the said route:

Malir Cantt → Safari Park → Laiquatabad → Nazimabad Chest Hospital for TB patients (under the supervision of Dow University of Health Sciences, Karachi).

In order to reach the TB hospital, the said route is found out to be the shortest traffic route that exists among all other traffic routes formed by different combinations of these nodes. The distance traveled by the person on the said route will be only 20 km. The result was also verified by using Python programming language.

The advantage of following the suggested route sequence includes reduced transportation cost that is significant for the TB patients with financial problems, increased chances of saving seriously infected TB patients, decreased amount of suffering time by TB patients due to lessened traveling time, etc.

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Impact of Playing Video Games on Cognitive Functioning and Learning Styles of Adolecents

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Abstract:

Video games are especially popular with teens as a form of entertainment and the time they spend playing video games has grown exponentially. The focus of previous studies remained on the negative effects of video games on teen's behavior. Whereas, the present study intended to explore the possible positive effects of video games. The main objective of this study was to evaluate the effect of video games on cognitive functions and learning style in school going teens. A cross-sectional research design was used to compare cognitive functions and learning style of teen game players and non-players. The cognitive functions, including memory, attention and executive functions of 80 teens were measured who were divided into two groups: those who played video games regularly (n = 40) and those who did not play video games regularly (n = 40). Other data, such as demographic data, medical information, types of video games, and time spent playing video games, were also collected through the questionnaire. Out of 80 respondents, 77.5% of teens were from private schools and 22.5% from public schools between the ages of 15 and 17 (M=15.6, SD=0.575). Results indicated that visual memory and visual learning type scores were significantly better in the play group. Participants who were playing video games regularly indicated significant differences in visual type of learning (p=0.000). Whereas, no significant differences were found in aural learning (p=1.000) and verbal learning (p=1.000). Based on the results, it can be concluded that playing video games has a positive effect on the type of visual learning. Future studies could investigate more ranges of higher-order cognition, such as reasoning, and critical thinking to differentiate between different types of video games.

Keywords: *Video Games, Cognitive Functions, Learning Style.*

1. Introduction

There is still much research to be done on the effects of video games (VG) on cognitive functions (CF) of teens and this is certainly an important group of study to consider. It is usually argued that the impact of VGs on teens' behavior and CF requires a changed perspective to better understand the potential negative effects as well as the benefits of these games [1]. It is important to consider these potential benefits, considering that the perspectives of these games have changed something of a late, different, sensible and social nature [2]. Even a core group of studies has started to emerge, usually in the last five years that records many benefits. These

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findings suggest that playing VGs provides teens with clear and engaging social, intellectual, and exciting experiences. Furthermore, these experiments have been shown to improve learning in teens as reported by authors [3].

Playing VGs helps four crucial territories: mental, enticing, eager, and social advantages. By joining encounters from developmental, positive, and social examination, it very well may be inferred that playing VGs energize authentic benefits. Numerous analysts have given adequate confirmation and a speculative thinking to persuade new activities of investigation on the by and large ignored benefits of playing VGs. Though modestly little assessment has focused in on the upsides of playing VGs expressly, the limits and benefits of having VGs for the most influence have been perused for a significant long time.

Groundbreaking cerebrum research has since a long time back underscored the flexible components of playing VGs and in developmental mind science, the positive limit of playing has been a running subject for indisputably the most respected specialists in the field. Analysts propose that playing VGs licenses youths to investigate various roads with respect to their scholarly capacities and reenact elective eager outcomes, which would then have the option to accomplish their objectives outside the play setting [5] expressed that "playing VGs offers opportunities to young people to reproduce real conflicts, to work out ideal objectives for their own pleasure and to improve contrary feelings". Ongoing neuroscientific research with rodents proposes express frontal cortex instruments that help explain how playing VGs explicitly prompts the improvement of scholarly capacities as revealed by [6]. Test research office inspects show that playing VGs achieves the appearance of substance improvement factors in the bits of the frontal cortex that are made for significantly amicable activities, thus propelling the turn of events and progression of these areas. Despite a couple exceptional variables, comparative energetic subjects recognized in adolescents' play experiences (e.g., transcendence, nurturance, apprehension, and improvement) are similarly examined in PC games, considering huge scholarly, excited, and social capacities to be secured.

There are a lot of examinations demonstrating the impact of VGs with various subjects and objections. These games can be played with other truly existing players, or with countless other online players, alone, appropriately, or in a real sense, and are played on an assortment of gadgets, from consoles to PCs. Thinking about the individual extent of assessments, contingent upon how VGs can move, contingent upon their order, it is truly hard to make an expansive coherent characterization of contemporary games. In any case, to do a short examination concerning this examination. This consistent game plan is a key change. Like different games, other significant appraisals are changed, and powerfully, VG can be played socially and nonsensically, assistant, and all things considered, and the intricacy of the games relying upon the game kind. Where the player takes an interest in these particular gaming arrangements. Given this colossal positioning in VG, acclaim alone can't be significant. Many top examiners in the field have revealed that "nobody can say more regarding the impacts of food than the impacts of PC games' or VGs [7]. From that point forward, rather than capturing VGs, rather than showing a steady contortion. "Gamer" alludes to individuals who play VGs dependably, longer than an hour daily. Unintentionally, playing VGs builds up a wide scope of mental capacities, as opposed to the standard inclination that playing VG isn't useful for young people direct [8. 9].

The most persuading affirmation comes from starter considers that select clueless gamers and self-emphatically apportion them to play either a shooter game or such a VGs for an equivalent time span. Showed up contrastingly according to control people, those in the shooter game condition show speedier and more careful idea scattering, higher spatial goal in visual preparing, and improved mental turn limits [10]. A really scattered meta-assessment pondered that the

spatial limits overhauls got from playing fiscally accessible shooter PC games are indistinguishable with the impacts of formal courses featured improving these tantamount limits. Further, this new meta-appraisal showed that spatial limits can be set up with VGs in a passably concise period, that these preparation benefits last all through an extensive time interval, and frantically, that these limits move to other spatial undertakings outside the VGs setting [11].

These planning peruses have essential consequences for tutoring and calling progression. A longitudinal assessment with a test set up the power of spatial capacities in predicting achievement in science, development, planning, and math. These topics have been more than once associated with long stretch job accomplishment and are expected to be especially fundamental in the next century [12]. Preliminary investigation has moreover displayed that these scholarly advantages show in quantifiable changes in neural planning and capability. For example, another utilitarian appealing resonation imaging study found that the frameworks that control thought assignment were less powerful during a troublesome model acknowledgment task in conventional gamers than in nongame's, driving the researchers to recommend that shooter game players relegate their attentional resources even more capably and channel out pointless information even more suitably [13].

As of late, there has been expanding interest in the potential impacts of VGs on different cognitive capacities. Cognitive load is a significant thought, especially for teens. The principle objective of this study was to survey the impact of VGs on CF and learning style in VGs players and non-players in the range of 15 and 17 years of age.

2. Literature Review

The following section is divided into two parts, which will discuss different studies conducted on the effects of playing VGs on teens' behavior and effects of playing VGs on CF of teens.

2.1 Effects of Playing Video Games on Teens

The authors in [14] represent that the legitimacy of the connection between VGs and aggressive conduct depends on feeble proof or uncertain outcomes. Numerous investigations have been directed on the connection between the VGs and aggressive conduct of players [15]. Authenticity from the point of view of VGs is isolated into two principle parts, graphical authenticity and social authenticity. Graphical authenticity is the capacity to shape and change individuals from this present reality to the virtual world with exceptionally top notch. Social authenticity is the capacity of an individual in the virtual world to act like a similar manner in genuine reality. The outcomes show that there is no huge impact of the authenticity of the VGs into the progressions that may occur for the players [16]. The authors in [17] lead test to explore the relationship between social authenticity in the games and the aggressive conduct in the players. The authors make analyzed the effect of two different types of VGs on aggressive conduct. The findings of this examination show that there was no increment in aggressive conduct of the players.

Late youth and early youthfulness address the most tedious between different ages in playing computer games. It's anything but a significant job in changing their character for great or more terrible. There are numerous valuable and useful or abused media and games that are coordinated toward this life stage [18]. To explain this connection, an examination on a gathering of kids matured from 6 to 11 from the European Union was directed. The investigation shows that there is no connection between the measure of time that the child spent on playing the computer games and the children's psychological wellness, passionate, Attention-Deficit or Hyperactivity Disorder, acts or companion relationship [19]. Another investigation was led for enormous scope Norwegian teenagers. In this investigation, it was shown that there is no connection between the measures of time went through playing with inward issues that

may happen to the children with playing these games [20].

The authors [21] examined teen participants to identify with what VGs mean for the practices and feelings of players, regardless of whether this impact is good or negative. It has been shown that games may cause an assortment of changes on the players like aggressive conduct, negative or agreeable and consideration from the positive side. The gathered information from the player was viewed as the primary part in dissecting the character of the major part to discover the effect of the VGs on the player. This information was gathered by using two different methods. The first was called self-detailing information, which depends on gathering the information by the player utilizing polls, studies, interviews or ethnographic perceptions either, previously, during or in the wake of playing the game. The subsequent way was brought in-game information collection, where the information was gathered straightforwardly from the player through the VGs (i.e. while playing). Most of studies infer that there was a connection between the VGs and the player's conduct. In these investigations, the specialists presume that the VGs affect the player character, similar to feelings, reflexes, practices, inspirations, needs, thinking way and approach interior and outside circumstances. Then again, there is another exploration indicating that the VGs had no effect on the players. The authors [22] supported their case in two angles. The first depending on the game type and the subsequent one depending on the time that the player spent playing a game.

A large number of studies of the past shed light on the fact that playing VGs really involves a basic scenario through which the value of power and aggression, hostility, stress, violence is validated, as reported by authors, [23]. For example, a study on the effects of VGs showed how teens used to play enthusiastically and they improved their communication with their family members. The association between teen's joy and their improvement in cheerful skills, social skills, and affirmation of friendship has also been determined by observational studies [24].

2.2 Effects of Playing Video Games on Cognitions

In many experiments, [25] effect of playing VGs was assessed in regular players with several tasks such as attention, comprehension, memory and concentration. Regular players always performed better at these tests than non-players. The increase of performance seems induced by the activity of playing VGs, since in another experiment, a control group didn't get involved in playing and the experimental group played were engaged in playing VGs for an hour a day. Afterwards, the experimental group performed better at several of the same tasks than the control group. Nevertheless, in other studies, VGs was used as the experimental setting, and changes were observed. In two experiments, Researchers [26] asked students to play "VGs for half an hour a day for one month. Their improvement at different tasks was measured, four of these tests were taken from the standardized test battery. The results indicated improvement in attention, memory, focus and comprehension.

More recently, [27] demonstrated the specificity of improved memory by playing VGs. In their setting, experienced VG players outperformed non-players at tasks related to memory, but not at a series of other cognitive capacity tests. In a second experiment, female students played one hour sessions of VGs and showed the same gain than control group on the same tests. They concluded that if a cognitive ability can be increased by playing VGs, it is likely very domain specific and could concern only specific representations. Authors [28] reported some improvements in the dynamic memory and concentration of school children. The gender was an issue as boys benefited more from the VGs than girls. But initial visual learning turned out to determine the influence of the playing sessions: participants' highly skilled children showed no gain with the playing of VGs. However, low skilled participants who played VGs for three sessions of an hour significantly improved at the post test.

The list of studies assessing different cognitive aspects of participants is still long. The methodologies are rather comparable, they either compare regular VGs players to non-players on several tests, or they establish a pre and posttest method and ask participants to play in between. Depending on studies, control groups do not play or sometimes play a game considered to have no influence. However, in a study [29] the participants of the control group were assigned to play VGs and obtained no effect with them, while [30] found effects of playing "VGs both on attention and perceptual abilities.

Researchers [31] recently explored the effect of playing VG on learning and understanding using an active research methodology. The authors [32] have recently begun to focus on more interactive devices, although attempts to investigate the effects of VGs by asking adolescents to play an interactive game designed to improve attention and focus. Different learning conditions were proposed and the study underscored the importance of orientation for the retention and transfer of learned knowledge. Positive aspects of interactive game were found but under specific conditions. The game used was a multimedia simulation similar to a questionnaire and could be compared more to an educational entertainment product than to a real conventional type of VGs.

In order to study the learning potential of games, [33] used an interactive game to teach "Newton laws to school children". The modality of feedback to the participants was either in an animated graphics way or numeric displays. Results were in favor of graphical feedbacks improve comprehension and retention of the material. In another study, [34] the researchers presented several simulations as activities to learn. They discussed the importance of "serious play" as a goal for active and meaningful engagement by the participants. The findings showed that without multimedia explanations, the content from the VGs was not remembered.

In summary, three trends were identified in the cognitive research related to the playing of VGs according to the dimensions beyond the scope: cognitive abilities and skills, affective and motivational aspects, knowledge and content learning. In most of these studies, VGs were considered as promising new materials or tasks that can foster knowledge of the dimension under investigation.

3. Methodology

A cross-sectional comparative study was conducted to investigate cognitive functions and learning style in video game players and non-players. Cognitive functions, including memory, attention, and comprehension, were assessed in 80 adolescents who were playing VGs regularly and those who were not playing VGs regularly. The selection criteria was based on the number of hours a day being spent in playing VGS. Those who were spending an hour a day were inducted in the players group and those who were playing less frequently or not playing at all were inducted in the non-players group. Assessment of cognitive functioning was done using "The Cognitive Functioning Inventory" developed by Lorna and learning styles were measured using "Learning-Style inventory" developed by Ronne. Based upon the aforementioned purpose of study, the research null hypotheses were formulated as "there will be no significant differences in cognitive functioning of video game players and non-players" and "there will be no significant differences in learning styles of video game players and non-players"

4. Results

Results included descriptive analysis followed by the results of one-way Between-groups ANOVA which determined if significant differences existed between the video game players and non-players.

Participants who were playing video games regularly indicated significant differences in cognitive functions including attention ($p=0.000$), planning ($p=0.000$), comprehension ($p=0.000$), memory ($p=0.000$), and cognitive control ($p=0.000$) as shown in Table-1 and mean differences are shown in Figure-1 below.

Table 1. Cognitive Functions

Cognitive Functioning	Sum of Squares	df	Mean Square	F	Sig.
Attention	37.813	1	37.813	65.288	.000
Planning	22.050	1	22.050	22.780	.000
Comprehension	32.513	1	32.513	50.543	.000
Memory	37.813	1	37.813	65.288	.000
Cognitive Control	37.813	1	37.813	65.288	.000

Participants who were playing video games regularly indicated significant differences in visual type of learning (p=0.000). Whereas, no significant differences were found in other learning styles aural (p=1.000) and verbal (p=1.000).

Table 2. Learning Styles

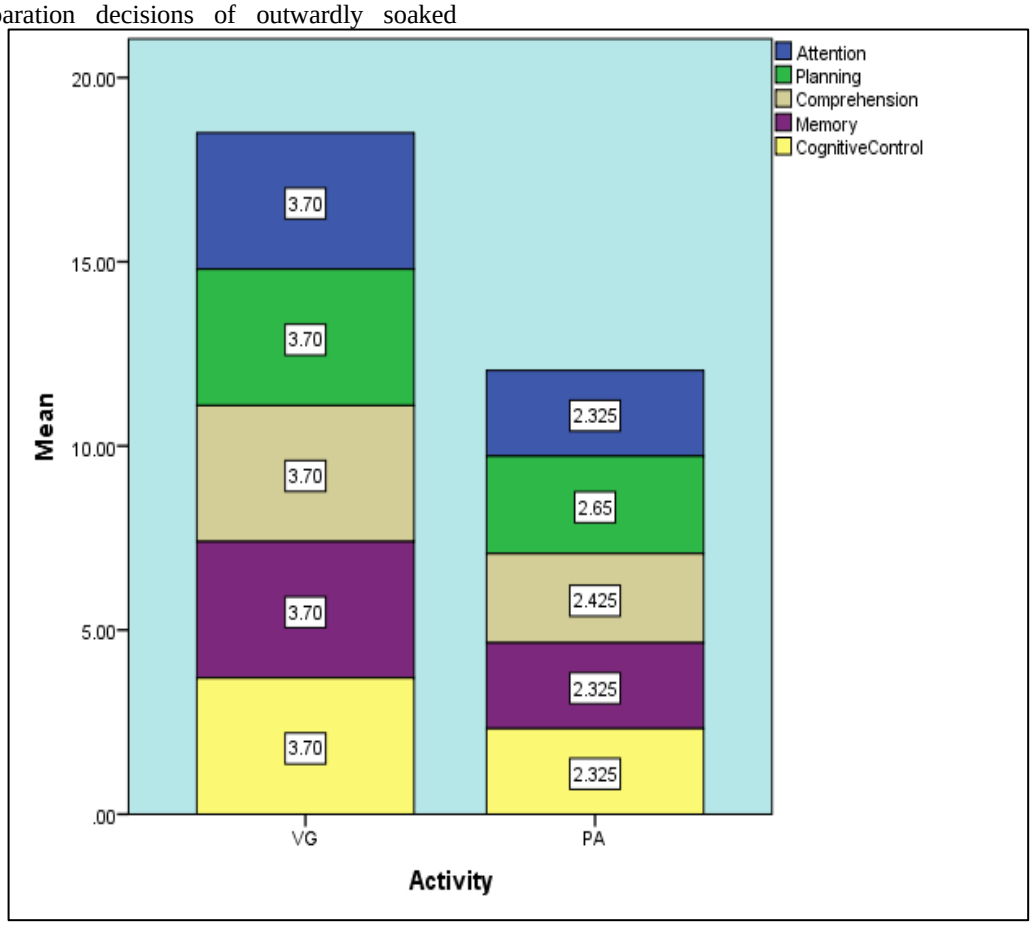
Learning Styles	Sum of Squares	df	Mean Square	F	Sig.
Visual	37.813	1	37.813	65.288	.000
Aural	.000	1	.000	.000	1.000
Verbal	.000	1	.000	.000	1.000

5. Discussion

Previous examination proposes that playing VGs, in any event, for a generally brief timeframe, improves execution on various assignments that action visual and consideration abilities. A few investigations have discovered that having members play VGs can improve execution on research center assignments that, by all accounts, are not quite the same as the games they were approached to play [9]. Accordingly, the VGs experience seems to upgrade fundamental abilities that can be applied to novel assignments. The discoveries of the current investigation demonstrated that teens who played VGs showed better scores in intellectual capacities. The new ascent in interest in VGs as a methods for improving essential intellectual and perceptual abilities expands on past discoveries. For instance, playing VGs was found to altogether improve intellectual abilities in teenagers contrasted with non-playing controls [12]. Abilities gained while playing VGs appeared to continue to different undertakings also. For instance, teens who played VGs performed better compared to controls on memory and comprehension [17]. Numerous VGs expected players to concentrate on different covering and requesting part assignments, so improved memory results from better consideration control.

Authors [18, 19, and 20] gave proof that VGs can improve execution in a progression of

consideration and comprehension. Both players and non-players who were allowed a couple of long stretches of playing VGs exhibited predominant execution on the consideration squint errand, a proportion of consideration adaptability over the long haul. Studies showed that players additionally exhibited a more prominent flank impact, demonstrating more noteworthy visual resources and members who played VGs. Significantly, members who played VGs with comparative engine segments contrasted with different games yet with less requests for consideration didn't enhance these assignments. Most shockingly, the players who rehearsed on VGs exhibited a change in visual learning or the capacity to make fine separation decisions of outwardly soaked upgrades. Extra proof of the unrivaled presentation of VGs comes from crafted by, [13] showing that in a progression of errands, gamers exhibit quicker reaction times than non-gamers. At the point when taken together, these investigations recommend that playing VGs guarantees better execution in a wide assortment of circumstances; the exchange of the VGs experience gives off an impression of being broad. The exchange undertakings portrayed above were not quite the same as what the game members played on both the screens and the necessary reactions, however the exchange actually happened.



The motivation behind this examination was to investigate whether the advantages of VGs are restricted to visual and consideration assignments, or whether the upgrades could be broader. Notwithstanding proportions of visual consideration, the impact of contacting VGs on various memory, thinking, and learning control assignments. It is realized that teens measure data diversely and the present circumstance influences the presentation of different intellectual capacities. It is currently all around acknowledged that VGs influence intellectual capacities and learning emphatically. In any case, it is completely difficult to carry out this beneficial outcome in clinical practice.

6. Conclusion

1. Based on the results, it can be concluded that playing video games has a positive effect on the type of visual learning. Future studies could investigate more ranges of higher-order cognition, such as reasoning, planning, and critical thinking to differentiate between different types of video games. This study has several limitations. First, due to the cross-sectional nature, it is impossible to determine the direction of the associations between the data. Longitudinal studies will be needed to rule out possible cohort effects. Second, self-reported responses are open to many well-known biases, such as social desire and memory recall biases, which can affect the veracity of the findings.

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Orthogonal Zones for Interference Migration in 2.4 GHz Mesh Backhaul

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Abstract:

Managing interference in the multi-radio networks is critical challenge; problem becomes even more serious in 2.4 GHz band due to minimal availability of orthogonal channels. This work attempts to propose a channel assignment scheme for interference zones of 2.4 GHz backhaul of Wireless Mesh Networks (WMN). The static nodes of Infrastructure based Backhaul employing directional antennas to connect static nodes, orthogonal channel zones introducing Interference are formatted with the selection of single tire direct hop and two-tier directional hopes. The effort maintains the orthogonality of channels on system thus reduce the co-channel interference between inter flow and intra flow links. Group of non-overlapping channels of selected band are obtained by a mathematical procedure, interference is modeled by directed graph and Channel assignment is carried out with the help of greedy algorithms. Experimental analysis of the technical proposal is done by simulation through OPNET 14. Our framework can act as an imperative way to enhance the network performance resulting a leading improvement in system throughput and reduction in system delay

Keywords: *Wireless Mesh Networks (WMN), Backhaul, Orthogonal,Non-orthogonal*

1. Introduction

The wireless networks are going to restructure for the ultimate communication service comparable in the performance of wired Ethernet [1], [2]. Advance wireless networks support some resource allocation procedures for the effective utilization of spectrum [3], which makes efficient use the simultaneous communication channels of spectrum; interference has been a central issue in this type of networking, There is a possibility that same channel allocate to several nodes which create co-channel interference between simultaneous communications, or there may be adjacent channel interference when adjoining channels allocate to neighboring nodes [4]. In such conditions WMN backhaul is a potential network to offer preferred performance [5], the fact is only to observer

and manages the backhaul links to reduce interference [6]. In the condition of WMN infrastructure, backhaul links are concurrently working on dissimilar channels; the arrangement of channels for backhaul links may enhance or reduce interference of system [7]. However, if the channels are not properly assigned to nodes then the performance of system drops proportionally with the amount of nodes and interfaces. Interference in any form can be reduced by using a suitable arrangement for the allocation of channels.

In general, two methods are used for the allocation of channels: Static channel (SC) assignment and dynamic channel (DC) assignment. Dynamic scheme support the mechanism where channels assign to

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interfaces animatedly [8], nodes have ability to sweep channels to meet the required criteria of system, in this respect dynamic channel assignment is effective in use for mobile communication, on the other hand static allocation of channels is suitable for fixed nodes [9], under static allocation, channels allotted to interfaces, remains permanent and fixed for required time. In our previous work, the employed strategy was used by backhaul links of Wireless local area network [10], here the proposed strategy is employed on infrastructure based WMN backhaul. The backhaul is working on 2.4 GHz band and linked by directional antennas. The key consideration of this work is formatting the interference zones and selection of orthogonal channels for such zones to reduce co channel interference, whereas improper (non-orthogonal) arrangement of channels under directional antennas creates serious level of interference as the signals would have more power in particular direction and covers maximum areas. To cover such parameter the zones of interference in proposed to covers both inter-flow links (single tier of direct hop), and intra-flow links (two tiers of directional hop) of directional antenna.

In doing so this paper presents 7 sections. Section 2 presents review of the literature; section 3 provides mathematical procedure to find orthogonal sets. Section 4 discusses about the modelling of the proposed system. Section 5 presents greedy algorithm for channel assignment. Results and discussion on orthogonal channel zones of 2.4 GHz system is presented in section 6. Finally, section 7 provide conclusion.

2. Literature Review

The litratutre review reflects lot of research work to deal the problem of interfernce introduced by partially overlapped channels. The concept of utilizing Partially overlapped channels with the alteration of energy masks was presented by the authors of [11], [12], [13]. This technique introduces, loss of information relative to the overlapped frequency range of partially overlapped channels. In other work, orthogonal channels are modeled as Least Congested Channel Search (LCCS), where periodically channel's traffic is observed, in the case of overflow of traffic from threshold level, channel sweeps to LLC [14]. Their work was limited and does not support sudden change of traffic. The work of [15], tried to solve the problem of interfernce in multi channel (POC) environment by multicasting. They employed rational nodes to form multicast trees from soure to destination. Every node of tree, eqqiped with gateway which reduce the interference by limitting the broadcasting of POS channels. Their work aspects the bottelneck problem in heavy traffic. The bottel neck problem is some how overcomed the recent work of [16] where links were ranked on mobility data. The mobility data derived by traffic load and topology of network. Ranking links through multiple data types interduce system latency. The work of [17 and 18] focused on Interference of directional antennas in multi hop networks, Interference among the signals of directional antennas are measured in [17], both antennas are at 90 degree phase change in alignment the work did not contains data regarding spatial separation. The Performance of 802.11g system is observed with the support of multi radio [18], they try to prove with quantity study that the overall network efficiency is depended on the employment position of directional antennas, the position consider antennas alignment and distance. Algorithm "directionality as needed (DAN)", is presented in [19], this work meets two aims: network with minimum interference with limited budget. The work of [20] presents the behavior of channel assignment in the environment of directional antennas. They present Outdoor testbed-based measurement of 802.11a, the system connected by directional antenna, in that system they estimate adjacent channel interference with the help of the antenna's physical position, transmitted power of the interfaces and WMN throughput. Research work of [21], [22], [23] assignment of partially overlapped channels discuss about interfering signal and noise ratio (SINR) based novel model for channel allocation, the authors considered that the use of the channel partiality at some affordable

interference focused collective interference. Therefore, they are able to model only physical interference. A MICA algorithm-based allocation of partially Overlapped Channels (POS) is presented in [22], their focus was to enhance performance while decreasing interference of system. They sustain channel separation and node orthogonality with the consideration of Physical distance of nodes. Another technique to reduce interference is adopted in [23], where alternate channels in the form of odd number are selected for allocation, their results are equivalent with channel assignment where only limited orthogonal channel are used. A greedy channel assignment algorithm for Multi radio Multi Channel WMN is presented in [24] the total interference of static nodes is approximated and assigned channels with the nodes having minimum interference. The suggested work in this paper solved the bottel neck problem by directional antennas at physical layer with minimum latency. Static channels assign to perticular antenna this maintain the orthogonality and channel spacing between channels. Thus there was no loss of energy produced by masking of energy.

3. Mathematical Procedure to Find Groups of Orthogonal Channels

Traditionaly the orthogonal channels are drived by using energy masks [11,12,13], discussed in litrature review. This process consumes times and introduce losses of energy w.r.t overlapped portion of two channels. Here a set theory is used to find out the groups of non-overlapped and overlapped channels for the (channel 1 to channel 11) on frequency band 2.4 GHz. Universal set "S", of 2.4GHz band is combination of two sets: Orthogonal and Non-orthogonal.

S = {Orthogonal channels, Non-orthogonal channels}

S = {On,NOn}

Orthogonal channels "O", contain all non-overlapped channels related to the channel number "n" can be find out as,

On = ∪N

m=1 = {|(m− n)| > 4}

Non-orthogonal channels "NO", contain all overlapped channels related to channel number "n", and can be find out as,

TABLE I. GROUPS OF ORTHOGNAL CHANNELS RELATED TO INDIVIDUAL CHANNEL

Channel Number	Orthognal Channels	Non-orthogonal Channels
1	{6, 7, 8, 9, 10, 11}	{1, 2, 3, 4, 5}
2	{7, 8, 9, 10, 11}	{1, 2, 3, 4, 5, 6}
3	{8, 9, 10, 11}	{1, 2, 3, 4, 5, 6, 7}
4	{9, 10, 11}	{1, 2, 3, 4, 5, 6, 7, 8}
5	{10, 11}	{1, 2, 3, 4, 5, 6, 7, 8, 9}
6	{1, 11}	{2, 3, 4, 5, 6, 7, 8, 9, 10}
7	{1, 2}	{3, 4, 5, 6, 7, 8, 9, 10, 11}
8	{1, 2, 3}	{4, 5, 6, 7, 8, 9, 10, 11}
9	{1, 2, 3, 4}	{5, 6, 7, 8, 9, 10, 11}
10	{1, 2, 3, 4, 5}	{6, 7, 8, 9, 10, 11}
11	{1, 2, 3, 4, 5, 6}	{7, 8, 9, 10, 11}

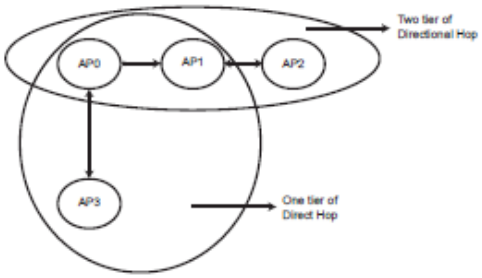

Fig. 1. Interference zone of different AP's NOn = {S\On}

4. Modelling of Proposed System

The network graph G for proposed work is identified as G = (U, V,L). The network consists of n mesh routers, distributed uniformly and independently over unit area. All nodes are connected by directional antennas for backhaul connectivity. The Area is divided into non overlapping directional

Interference zones "Iz". The system must satisfy the following considerations.

• Number of interference zones = number of interfaces for backhaul connectivity

• Beamwidth of directional zone = 360 deg / number of zones

• Linear area of zones = 2 directional nodes (2 Tier of directional hop)

• Vertical area of zone = 1 direct node (single tire of direct hop)

• Minimum number of zones = 1

Area of system is divided in zones, equal to the number of interfaces of node, each zone has a mesh router that is responsible for serving clients within the zone and linked with other zones by directional antenna. To deal with interferences, it is important to identify the interference nodes in Interference zones "Iz" in the network. Work considered two sources of interference, directional and direct links, here the nodes of directional links are identified "u" and nodes with direct links are identified as "v", these nodes are connected by links "L".

The network graph G for proposed work is identified as G = (U, V,L). As stated in proposed work, every node have interference area up to second hop of directional antennas "u" and "u+1" and up to single hop for direct connected node "v" (as the directed node is in different direction of directional antenna). Using neighbouring directed coloring graph the identified interference zone is expressed as Iz = (u, u+1, v). For our work, we modeled 2.4 GHz backhaul via OPNET 14. The system is designed with two scenarios.

• Allocation of non-orthogonal channels to interference zones of WMN backhaul

• Allocation of orthogonal channels to interference zones of WMN backhaul.

Both scenarios comprise Multiple Access points, every access point have 3 interfaces, 2 interfaces are reserved for backhaul link, there for it comprises 2 interference zones. The third interface is used for user access. Running application for system is FTP, which serves users in uniform pattern. In 1st scenario the channels are randomly assign to all nodes of zones without any care of orthogonal channels. While in 2nd scenario the group of orthogonal channels formatted by proposed mathematical process assigned to different interference zones. This maintains the orthogonality of channels within zones resulting minimum interference.

5. A. Greedy Algorithm for 2.4 GHz backhaul link

Following section illustrates the pseudocode of greedy algorithm for channel assignment of 2.4 GHz backhaul links.

The core idea is to select, identified interference links and set of orthogonal channels, then assign channels to every link of in interference. That procedure will repeat until channels assigned to complete network. Every time selected interference links and channel set must be different. With this the network sustains orthogonality to reduce channel interference.

B. Algorithm Greedy channel Assign for 2.4 GHz backhaul

Input: Graph G = (U, V,E);
Available channels 1, 2, 3, ・ ・ ・ , 11
1) Find conflict links Ec for each node v belongs to G = (U, V,E)
2) For each interference zone Iz = (u, u + 1, v), select set of orthogonal channels of channel "n" by, On = ∪N m=1 = {|(m − n)| > 4}
3) Assign channel, member of On = uj ,
4) Assign channel, member of On = uj+1,
5) Assign channel, member of On = Vi,
6) Iz 6= Iz of (1) and Orthogonal channels for n 6= n of (1)
7) Repeat from 1 to 5 for every node belongs to G
8) end

6. Results and Discussion

Proposed work analyzed the throughput and delay of orthogonal and non-orthogonal channel schemes for interference zones. Figure 2 presents the comparative results of two scenarios in terms of average throughput, throughput of both scenarios of system is in quiet mode up to 50 sec, which is time taken by server to respond to users.

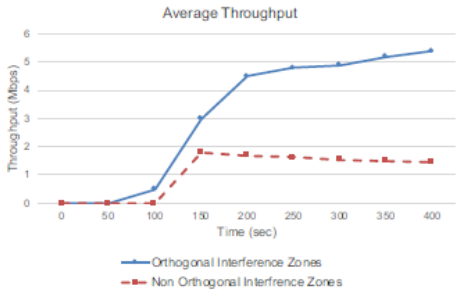

Fig. 2. Average throughput of both schemes

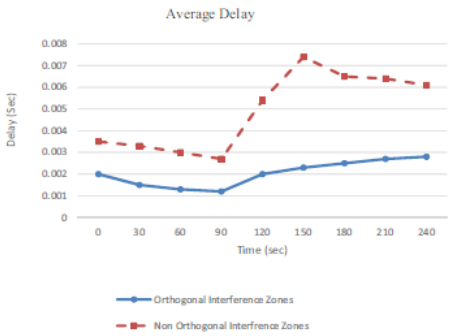

Fig. 3. Average delay of both schemes

Fig. 2 illustrate the association of both scenarios by average throughput, this comparison shows that non-orthogonal allocation throughput drops after certain events while throughput of orthogonal allocation is constantly increasing, further it is observed that performance of proposed scheme sweeps 70% more than non-orthogonal.

Fig: 3 expressed the performance of both scenarios in terms of average delay, it shows that the maximum delay for

orthogonal interference zones is less than 0.003 sec, while for some events of non-orthogonal interference zones, the delay reaches to 0.008 sec. Approximately we can reduce the delay in system by half with orthogonal interference zones.

This can be further justified from Fig. 4 and 5, where the average throughput and average delay is plotted with number of users. The number of users varies with the difference of 10 and provides 10 different points to observe the results. Both results show the considerable enhancement in system performance when we use the proposed channel assignment scheme for backhaul links. With respect to simulation analysis, the simulation model is
repeated for multiple times with different number of users and find out the different confidence intervals. The Table II shows the statistical data for two scenarios of 2.4 GHz backhaul. For the given statistical values, Fig. 6 and 7 presents the plots for normal distribution of both scenarios

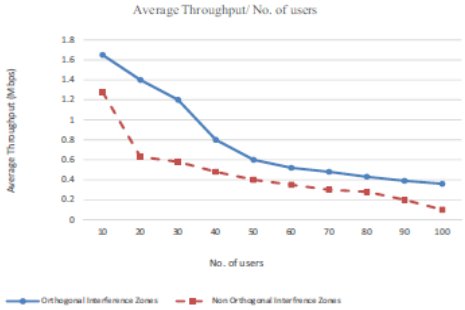

Fig. 4. Average throughput/No. of users of both schemes

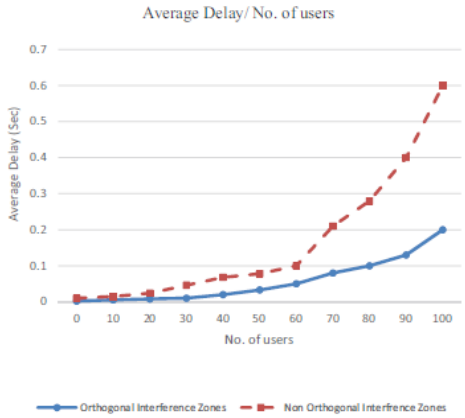

Fig. 5. Average delay / No. of users of both schemes

TABLE II. STATISTICAL DATA OF BOTH SCHEMES

Name	Orthognal Interference Zone	Non-orthogonal Interference Zone
Mean	767,414.690782754	1,868,221.18507254
Standard Deviation	825,250.842094302	1,873,929.15033696
Expected Value	767,414.690782754	1,868,221.18507254
Variance	681,038,952,377.355	3,511,610,460,482.59
80% conf. interval	(660,576.767636136, 874,252.613929373)	(1,625,620.16204562, 2,110,822.20809947)
90% conf. interval	(630,282.681125929, 904,546.70043958)	(1,556,830.20280094, 2,179,612.16734415)
95% conf. interval	(604,023.360127813, 930,806.021437696)	1(,497,202.14236595, 2,239,240.22777914)
98% conf. interval	(573,454.175969055, 961,375.205596454)	(1,427,787.50820243, 2,308,654.86194266)
99% conf. interval	(552,755.161988635, 982,074.219576874)	(1,380,785.45294526, 2,355,656.91719983)

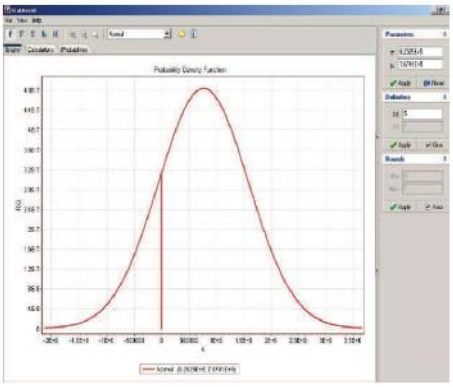

Fig. 6. Normal distribution of orthogonal interference zone

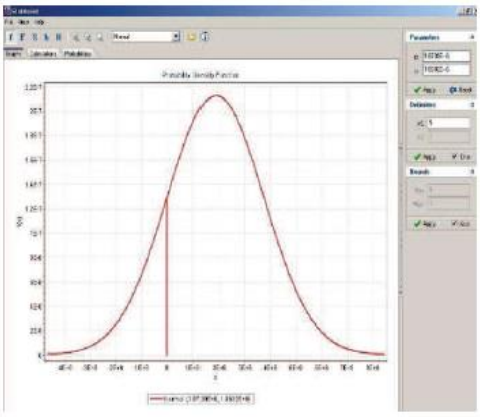

Fig. 7. Normal distribution of non-orthogonal interference zone

7. Conclusion

An effective channel assignment scheme is presented where channels of 2.4 GHz are statically arranged as orthogonal channels to the Inter flow and Intra flow links of WLAN backhaul. Co-channel interference from 360 degrees is initially controlled by directional antennas, further the proposed channel arrangement sustaining orthogonality between direct (inter-flow) and directional (Intra-flow) links, this reduces the co-channel interference among these nodes.

In suggested work the interference is controlled at two phases: 1st by reducing interference directions (degrees), 2nd by allocating orthogonal channels to selected links. This study found significant improvement in system performance with the increase in system throughput and reduction in delay. Simulated results clearly illustrate that orthogonal scheme reaches approximately twice the performance in comparison with the non-orthogonal scheme.

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