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CONTENTS

Time and Frequency Domain Analysis of the Linear Fractional-order Systems

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***Abstract*— Recent years have seen a tremendous upsurge in the area related to the use of Fractional-order (FO) differential equations in modeling and control. FO differential equations are found to provide a more realistic, faithful, and compact representations of many real world, natural and man-made systems. FO controllers, on the other hand, have been able to achieve a better closed-loop performance and robustness, than their integer-order counterparts. In this paper, we provide a systematic and rigorous time and frequency domain analysis of linear FO systems. Various concepts like stability, step response, frequency response are discussed in detail for a variety of linear FO systems. We also give the state space representations for these systems and comment on the controllability and observability. The exercise presented here conveys the fact that the time and frequency domain analysis of FO linear systems are very similar to that of the integer-order linear systems.**

Keywords- Fractional-order systems, fractional calculus, stability analysis.

I. INTRODUCTION

The mathematical modeling of FO systems and processes, based on the description of their properties in terms of Frac- tional Derivatives (FDs), leads to differential equations of in- volving FDs that must be analyzed. These are generally termed as Fractional Differential Equations (FDEs). The advantages of fractional calculus have been described and pointed out in the last few decades by many authors in [1], [2], [3], [8], [9], [24]. The latest and very exhaustive literature survey about the FC and FO systems is given in [17]. It has been shown that the FO models of real systems (especially distributed parameter type and memory type) are more adequate than the usually used Integer-order (IO) models.

Fractional Derivatives (FDs) provide an excellent instrument for the description of memory and hereditary properties of various materials and processes. This is the main advantage over the IO models, which possess limited memory. The advantages of FDs become apparent in applications including modeling of damping behaviour of visco-elastic materials, cell diffusion processes [8], transmission of signals through strong magnetic fields, modeling mechanical and electrical properties of real materials, as well as in the description of rheological properties of rocks, and in many other fields [25].

In feedback control, by introducing proportional, integral and derivative control actions of the form s^{α}, $1/s^{\alpha}$, $\alpha \in R^{+}$, we can achieve more robust and flexible design methods to satisfy the controlled system specifications. Studies have shown that an FO controller can provide better performance than integer order (IO) controller.

The paper is organised as follows : Section II and III give special functions and definitions of fractional calculus theory respectively. Section IV defines linear FO system in general. Section V describes the stability analysis of fractional-order systems, Section VI explains the representations of fractional-order systems and in Section VII analytical results of FO systems are given with the conclusion in Section VIII.

II. SPECIAL FUNCTIONS OF FRACTIONAL CALCULUS (FC)

Some special functions need to be used in Fractional Calculus (FC). These functions play important role in the theory of FC and in the theory of fractional differential equations (FDEs).

A. Gamma Function

One of the most basic functions of FC is Euler's gamma function $\Gamma(z)$, which generalizes the factorial function z! and allows z to take also non-integer and even complex values [10]. The gamma function ($\Gamma(z)$) is given by the following expression,

$$\Gamma(z) = \int_{0}^{\infty} e^{-u} u^{z-1} du . \qquad (1)$$

Note that when $z \in Z^+$ we have $\Gamma(z+1) = z!$

B. Mittag-Leffler Function

The exponential function e^z plays a very important role in the theory of integer order differential equations. Its 1 parameter generalization function for a complex number z is given by [10],

$$E_\alpha(z) = \sum_{k=0}^{\infty} \frac{z^k}{\Gamma(\alpha k + 1)}, \qquad (2)$$

The 2 parameter function of the ML function, which is also important in FC is defined as,

$$E_{\alpha,\beta}(z) = \sum_{k=0}^{\infty} \frac{z^k}{\Gamma(\alpha k + \beta)}, (\alpha > 0, \beta > 0). \qquad (3)$$

This basic definition is very useful in deriving the response of an FO system to any forcing function, for example, step response, ramp response.

III. DEFINITIONS FOR FRACTIONAL-DIFFERINTEGRALS

The three equivalent definitions [6],[10] most frequently used for the general fractional derivatives (FD) are the Grunwald-Letnikov (GL) definition, the Riemann-Liouville and the Caputo definition [10]. In all the definitions below, the function **f** (t) is assumed to be sufficiently smooth and locally integrable.

1) The Grunwald-Letnikov definition of fractional-order $\alpha \in \Re^+$ using Podlubny's limited memory principle [4] is given by

$$_aD_t^\alpha f(t) = \lim_{h \to 0} h^{-\alpha} \sum_{j-0}^{[(t-a)/h]} (-1)^j \, {}^\alpha C_j f(t - jh), \qquad (4)$$

where [.] means the integer part and ${}^\alpha C_j$ is the binomial coefficient.

2) The Riemann-Liouville definition obtained using the Riemann-Liouville integral is given as,

$$_aD_t^\alpha f(t) = \frac{1}{\Gamma(n-\alpha)} \frac{d^n}{dt^n} \int_a^t \frac{f^n(\tau)}{(t-\tau)^{\alpha-n+1}} d\tau, \qquad (5)$$

for $(n-1 < \alpha < n)$ and $\Gamma(.)$ is the Gamma function.

3) The Caputo definition can be written as,

$$_aD_t^\alpha f(t) = \frac{1}{\Gamma(\alpha-n)} \int_a^t \frac{f^n(\tau)}{(t-\tau)^{\alpha-n+1}} d\tau, \qquad (6)$$

for $(n-1 < r < n)$, where $f^n(t)$ is the n^{th} order derivative of the function **f** (t). Since we deal with causal systems in the control theory, the lower limit is fixed at $a = 0$ and for the brevity it will not be shown in this paper. We see that the Caputo definition is more restrictive than the RL. Nevertheless, it is preferred by engineers and physicists because the FDEs with Caputo derivatives have the same initial conditions as that for the integer-order differential equations. Note that the FDs calculated using these three definitions coincide for an initially relaxed function (($f(t=0)=0$).

IV. LINEAR FRACTIONAL-ORDER SYSTEMS

A general linear FO system is given by the FO transfer function as :

$$G(s) = \frac{Y(s)}{U(s)} = \frac{\sum_{k=0}^{m} b_k (s^\alpha)^k}{\sum_{k=0}^{n} a_k (s^\alpha)^k}, \qquad (7)$$

where $a_n = 1$, $m > n$, $Y(s)$ and $U(s)$ are the Laplace transforms of the output $y(t)$ and input $u(t)$ respectively. It can be represented by the block diagram as shown in Fig.(1).

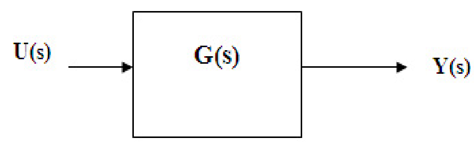

Figure 1. Block diagram representation of linear FO system.

Fig.(2) represents the general block diagram of a closed-loop FO system with $Y(s)$ and $U(s)$ are the Laplace transforms of the output $y(t)$ and input $u(t)$ respectively, k is the gain, $G(s)$ is the system transfer function, and $H(s)$ is the feedback component. $Y(s)$ and $U(s)$ are not usual polynomials but are pseudo-polynomials with fractional-orders. In this work we have taken unity feedback for all examples.

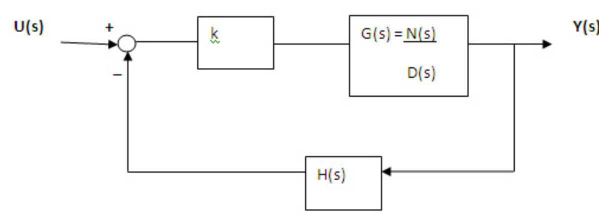

Figure 2. Block diagram representation of closed-loop linear FO system.

V. STABILITY OF FRACTIONAL-ORDER SYSTEMS

The stability analysis is important in control theory. Recently, there has been some advances in control theory of fractional differential systems for stability. In the FO systems the delay differential equation order is non-integer which makes it difficult to evaluate the stability by finding its roots or by using other algebraic methods. The stability of FO systems using polynomial criteria (e.g Routh's or Jury's type) is not possible due to the fractional powers. A generalization of the Routh-Hurwitz criterion used for stability analysis for fractional-order systems is presented in [12]. However, this method is very complicated. The geometric methods such as Nyquist type can be used for the stability check in the BIBO sense (bounded-input bounded-output). Root locus is another geometric method that can be used for analysis for FO systems [11], [14]. Also, for linear fractional differential systems of finite dimensions in state-space form, stability can be investigated. The stability of a linear fractional differential equation either by transforming the s -plane to the F -plane $(F = s^{\alpha})$ or to the w -plane $(w = s^{1/v})$, is explained in [13]. The robust stability analysis of a Fractional-order Interval Polynomial (FOIP) family is presented in [15] and [16].

A. *Stability using Riemann surfaces*

The study of the stability of FO systems can be carried out by obtaining the solutions of the differential equations that characterize them. To carry out this study it is necessary to remember that a function of the type

$$a_n s^{\alpha_n} + a_{n-1} s^{\alpha_{n-1}} + \ldots + a_0 s^{\alpha_0}, \qquad (8)$$

with $\alpha_i \in R^+$, $i = 1,\ldots,n$ is a multi-valued function of the complex variable s whose domain can be seen as a Riemann surface of a number of sheets. The principal sheet is defined by $-\pi < \arg(s) < \pi$. In the case of $\alpha_i \in Q^+$, that is, $\alpha = 1/v$, v being a positive integer, the v sheets of the Riemann surface are determined by,

$$s = |s| e^{j\phi}, \quad (2k+1)\pi < \phi < (2k+3)\pi, \qquad (9)$$

$k = -1, 0, \ldots, v-2$.

where $k = -1$ is the principal Riemann sheet. These sheets are transformed to another plane called w -plane with the relation $w = s^{\alpha}$. The regions of these sheets on the w -plane can be defined by :

$$w = |w| e^{j\theta}, \ \alpha(2k+1)\pi < \theta < \alpha(2k+3)\pi, \qquad (10)$$

Thus, an equation of the type (8) which in general is not a polynomial, will have an infinite number of roots, among which only a finite number of roots will be on the principal sheet of the Riemann surface. The roots which are in the secondary sheets of the Riemann surface are iso-damping and only the roots that are in the principal sheet of the Riemann surface are responsible for a different dynamics: damped oscillation, oscillation of constant amplitude, oscillation of increasing amplitude. For the case of systems, whose characteristic equation is a polynomial of the complex variable $w = s^{\alpha}$ the stability condition is expressed as [6],

$$|\arg(w_i)| > \frac{\alpha\pi}{2}, \qquad (11)$$

where w_i are the roots of the characteristic polynomial in w. For the particular case of $\alpha = 1$ the well known stability condition for linear time-invariant systems of integer-order is recovered:

$$|\arg(w_i)| > \frac{\pi}{2}. \qquad (12)$$

B. *Frequency Response - Bode Plot*

In general, the frequency response has to be obtained by the evaluation of the irrational-order transfer function of the FO system along the imaginary axis for $s = j\omega$, $\omega \in (0, \infty)$ [6]. The frequency response can be obtained by the addition of the individual contributions of the terms of order α resulting,

$$G(s) = \frac{P(s)}{Q(s)} = \frac{\prod_{k=0}^{m} (s^{\alpha} + z_k)}{\prod_{k=0}^{n} (s^{\alpha} + \lambda_k)}, \qquad (13)$$

where z_k and λ_k are the zeros and poles respectively. For each of these term the magnitude plot will have a slope which starts at zero and tends to $\pm\alpha 20$ dB/decade, and the phase plot will go from 0 to $\alpha\pi/2$.

VI. REPRESENTATION OF FRACTIONAL-ORDER SYSTEMS

A. *Laplace Transform*

In system theory, the analysis of dynamical behaviors is of- ten made by means of transfer functions. Hence introduction of the Laplace transform (LT) of fractional-order derivatives is necessary for the study. Fortunately, LT for integer-order systems can be very easily applied as an effective tool even for fractional systems [10]. Inverse Laplace transformation (ILT) is also useful for time domain representation of systems for which only the frequency response is known. The most general formula assuming zero initial conditions is the following:

$$L\left\{\frac{d^m f(t)}{dt^m}\right\} = s^m L\{f(t)\}. \qquad (14)$$

This is very useful in order to calculate the inverse Laplace transform of elementary transfer functions, such as non integer order integrators $1/s^m$.

B. State-space Representation

For linear fractional differential systems of finite dimensions in state-space form, stability is investigated [6]. Consider the commensurate-order TF defined by (7), associated with this TF, canonical state-space representations can be proposed, which are similar to the classical ones developed for IO differential equation systems.

Controllable Canonical Form : Defining the first state in terms of its Laplace transform as,

$$X_1(s) = \frac{1}{\sum_{k=0}^{n} a_k (s^{\alpha})^k} U(s), \tag{15}$$

and the remaining elements of the state vector in a recursive way from this one as

$$x_{i+1} = D_t^{\alpha} x_i, \quad i = 1,2,..,n-1 \quad , \tag{16}$$

the state representation, expressed in the controllable canonical form, is given by [6],

$$D_t^{\alpha} x = Ax + Bu, \tag{17}$$

where $D_t^{\alpha} x = \begin{bmatrix} D_t^{\alpha} x_1 \\ D_t^{\alpha} x_2 \\ \vdots \\ D_t^{\alpha} x_{n-1} \\ D_t^{\alpha} x_n \end{bmatrix}$,

$$A = \begin{bmatrix} 0 & 1 & \cdots & 0 & 0 \\ 0 & 0 & \cdots & 0 & 0 \\ 0 & 0 & \cdots & 0 & 0 \\ \vdots & \vdots & \cdots & \vdots & \vdots \\ 0 & 0 & \cdots & 1 & 0 \\ 0 & 0 & \cdots & 0 & 1 \\ -a_0 & -a_1 & \cdots & -a_{n-2} & -a_{n-1} \end{bmatrix},$$

$$B = \begin{bmatrix} 0 \\ 0 \\ \vdots \\ 0 \\ 1 \end{bmatrix},$$

$$y = \left[b_0 - b_n a_0 \cdots b_{n-1} - b_n a_{n-1} \right] \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix},$$

where $b_i = 0$, for $m < i \le n$

$$C_0 = \begin{bmatrix} B & AB & A^2B & \cdots & A^{n-1}B \end{bmatrix} \tag{18}$$

Controllability criterion is that the system is controllable if and only if matrix C defined by (18), which is called as controllable matrix is full-rank. Rearranging the above FO state equations, the observable canonical form can be obtained with the matrices A, B and C matrices. The observability condition is also same as for integer-order LTI systems.

VII. ANALYTICAL RESULTS

Some FO systems are analyzed in this section. Their stability, step response, frequency response, and the SS representation is discussed. The analysis is done using MATLAB [20]. The standard commercially available simulation softwares cannot be used for evaluating the step, ramp, frequency response of the FO systems. Recently, in MATLAB two toolboxes dedicated to FO systems are available. They are CRONE [19] and NINTEGER toolbox [18].

A. Example 1

Consider the FO integrator system with TF of the form,

$$G(s) = \frac{1}{s^{\alpha}} \ . \tag{19}$$

For the FO integrator if $\alpha = 0.5$, then consider $w = s^{0.5}$, hence $\tilde{G}(w) = \frac{1}{w}$

The system with the above function has one open-loop pole at origin. The Riemann surface of the function $w = s^{1/v}$ has two Riemann sheets.

Now if $\alpha = 1.5$, and consider $w = s^{0.5}$, then $\tilde{G}(w) = \frac{1}{w^3}$

The system with the above TF has three open-loop poles at origin.

Step Response: The system transfer function is,

$$\frac{Y(s)}{U(s)} = \frac{1}{s^{\alpha}}, \tag{20}$$

Consider step input, $U(s) = 1/s$,

$$Y(s) = \frac{1}{ss^{\alpha}} = \frac{1}{s^{\alpha+1}}. \tag{21}$$

Taking inverse Laplace transform of the equation we get

$$y(t) = \frac{t^{\alpha}}{\Gamma(\alpha+1)}. \tag{22}$$

The Fig.(3) shows the step response of the system for $\alpha = 0.1, 0.5, 0.8, 1$ and 1.5.

Frequency Response: Put $s = j\omega$ in the system function given by (19) we can plot the magnitude and phase plots. The magnitude and phase plot of the system for $\alpha = 0.1$, 0.5, 0.8, and 1 is plotted as shown in the Fig.(4). From the above response we can conclude that:

1) The magnitude has a constant slope of -20α dB/decade.
2) The phase plot is a horizontal line at $-\alpha\pi/2$.

B. Example 2

Consider the incommensurate system given by the following transfer function [6] [7]

$$G(s) = \frac{1}{0.8s^{2.2} + 0.5s^{0.9} + 1}. \quad (23)$$

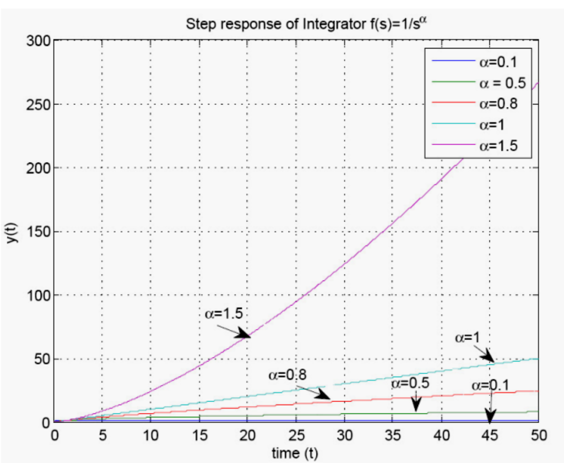

Figure 3. Step response of Example (1)

The system given in the equation can be written as

$$G(s) = \frac{1}{0.8s^{\left(\frac{1}{10}\right)22} + 0.5s^{\left(\frac{1}{10}\right)9} + 1}. \quad (24)$$

Consider $w = s^{\frac{1}{10}}$ the system has 10 Riemann sheets.

$$\tilde{G}(w) = \frac{1}{0.8w^{22} + 0.5w^{9} + 1}. \quad (25)$$

The open-loop poles and their appropriate arguments of the system are shown in table I. Fig.(5) gives the pole-zero plot of the open-loop system.

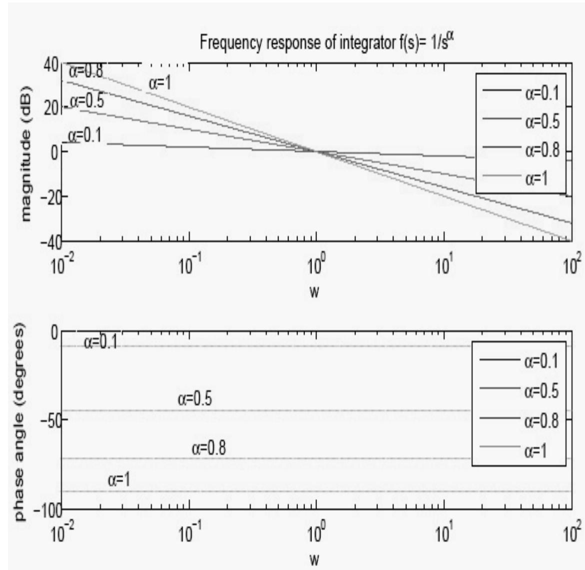

Figure 4. Frequency response of Example (1) for different values of α

Physical significant roots are in the first Riemann sheet, which is expressed by relation $-\pi/v < \phi < \pi/v$, where $\phi = \arg(w)$.

In this example complex conjugate roots in first Riemann sheet are $w_{21,22} = 1.0045 \pm 0.1684j$,

$|\arg(w_{21,22})| = 0.1661$, which satisfy conditions $|\arg(w_{21,22})| > \pi/2v = \pi/20$ is as shown in Pole-zero plot shown in Fig.(5).

TABLE I. OPEN LOOP POLES AND CORRESPONDING ARGUMENTS OF EXAMPLE (2)

Poles	Arguments in radians
$w_{1,2} = -0.9970 \pm j0.1182$	$\lvert\arg(w_{1,2})\rvert = 3.023$
$w_{3,4} = -0.9297 \pm j0.4414$	$\lvert\arg(w_{3,4})\rvert = 2.698$
$w_{5,6} = -0.7465 \pm j0.6420$	$\lvert\arg(w_{5,6})\rvert = 2.431$
$w_{7,8} = -0.5661 \pm j0.8633$	$\lvert\arg(w_{7,8})\rvert = 2.151$
$w_{9,10} = -0.259 \pm j0.9625$	$\lvert\arg(w_{9,10})\rvert = 1.834$
$w_{11,12} = -0.0254 \pm j1.0111$	$\lvert\arg(w_{11,12})\rvert = 1.595$
$w_{13,14} = 0.3080 \pm j0.9772$	$\lvert\arg(w_{11,12})\rvert = 1.265$
$w_{15,16} = 0.5243 \pm j0.8359$	$\lvert\arg(w_{15,16})\rvert = 1.010$
$w_{17,18} = 0.7793 \pm j0.6795$	$\lvert\arg(w_{17,18})\rvert = 0.717$
$w_{19,20} = 0.9084 \pm j0.3960$	$\lvert\arg(w_{19,20})\rvert = 0.411$
$w_{21,22} = 1.0045 \pm j0.1684$	$\lvert\arg(w_{21,22})\rvert = 0.1661$

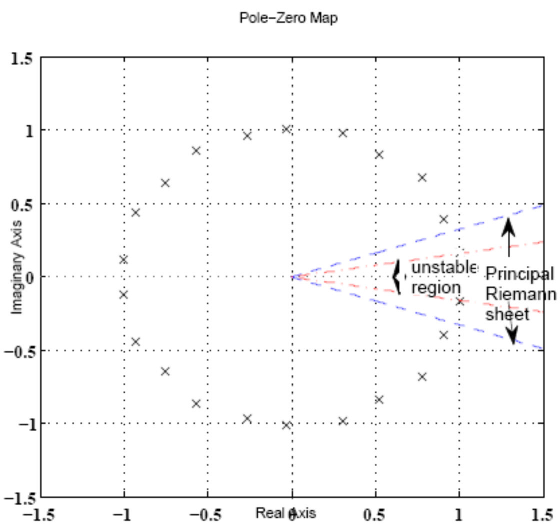

Figure 5. Open loop pole-zero plot of Example (2)

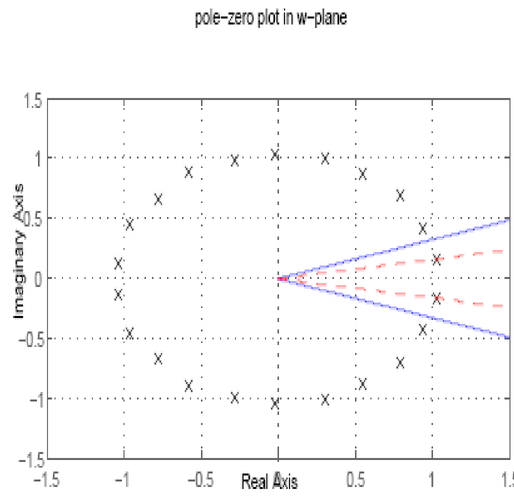

Figure 6. Closed loop pole-zero plot of Example (2)

The roots in first Riemann sheet satisfy the stability criteria, hence the system is stable. Other roots of the system lie in secondary Riemann sheets. The first Riemann sheet is transformed from s plane to w-plane as follows:

$$-\pi/10 < \arg(w) < \pi/10 \text{ , and}$$

$$-\pi < 10\arg(w) < \pi . \tag{26}$$

Therefore from this consideration angle obtained is

$$|\arg(s)| = 10|\arg(w)| . \tag{27}$$

The closed loop poles are given in table II and are plotted in Fig.(6).

TABLE II. CLOSED LOOP POLES AND CORRESPONDING ARGUMENTS OF EXAMPLE (2)

Poles	Arguments in radians
$w_{1,2} = -1.0298 \pm j\,0.1311$	$\|\arg(w_{1,2})\| = 3.015$
$w_{3,4} = -0.9557 \pm j0.4483$	$\|\arg(w_{3,4})\| = 2.703$
$w_{5,6} = -0.7764 \pm j0.6694$	$\|\arg(w_{5,6})\| = 2.430$
$w_{7,8} = -0.5776 \pm j0.8863$	$\|\arg(w_{7,8})\| = 2.148$
$w_{9,10} = -0.2768 \pm j0.9956$	$\|\arg(w_{9,10})\| = 1.842$
$w_{11,12} = -0.0173 \pm j1.0430$	$\|\arg(w_{11,12})\| = 1.587$
$w_{13,14} = 0.3099 \pm j1.0055$	$\|\arg(w_{11,12})\| = 1.271$
$w_{15,16} = 0.5488 \pm j0.8676$	$\|\arg(w_{15,16})\| = 1.006$
$w_{17,18} = 1.0348 \pm j0.1653$	$\|\arg(w_{17,18})\| = 0.1584$
$w_{19,20} = 0.9412 \pm j0.4170$	$\|\arg(w_{19,20})\| = 0.417$
$w_{21,22} = 0.7989 \pm j0.6953$	$\|\arg(w_{21,22})\| = 0.7162$

Step Response: The system TF is,

$$\frac{Y(s)}{U(s)} = \frac{1}{0.8s^{2.2} + 0.5s^{0.9} + 1} . \tag{28}$$

For step response of the system, $U(s) = 1/s$.

Calculating the residues and poles by partial fractions are shown in table III.

TABLE III. RESIDUES AND CORRESPONDING POLES

Residues	Poles
$-0.0264 \pm j0.0209$	$0.7793 \pm j\,0.6796$
$0.0147 \pm j0.0313$	$-0.5662 \pm j0.8633$
$0.0355 \pm j0.0079$	$-0.9298 \pm j0.4415$
$-0.0006 \pm j0.0391$	$0.3080 \pm j0.9772$
$-0.0422 \pm j0.0068$	$1.0045 \pm j0.1684$
$-0.0142 \pm j0.0447$	$-0.0254 \pm j1.0112$
$0.0467 \pm j0.0210$	$-0.9970 \pm j0.1182$
$0.0271 \pm j0.0477$	$-0.2597 \pm j0.9625$
$-0.0476 \pm j0.0323$	$0.9085 \pm j0.3960$
$-0.0369 \pm j0.0464$	$0.5243 \pm j0.8360$
$0.0441 \pm j0.0409$	$-0.7466 \pm j0.6420$

Using inverse Laplace transform [6],

$$L^{-1}\left\{\sum_{i=1}^{n} \frac{r_i}{s(s^{\alpha} + p_i)}\right\} = \sum_{i=1}^{n} r_i t^{\alpha} E_{\alpha,\alpha+1}(-p_i t^{\alpha}) , \tag{29}$$

where $E_{\alpha,\beta}(.)$ is the Mittag Leffler (ML) function as defined in Section II, r_i are the residues and p_i are the corresponding poles for $i = 1$ to 22.

To plot step response we have used the MATLAB subroutine 'mlf()' developed by Podlubny [21]. The step response plot is plotted as shown in Fig.(7). The step response shows it is a underdamped system. This is obvious as the two stable poles in the principal Riemann sheet are very close to the imaginary axis in the s-plane. See Fig.(6) for the corresponding w-plane situation.

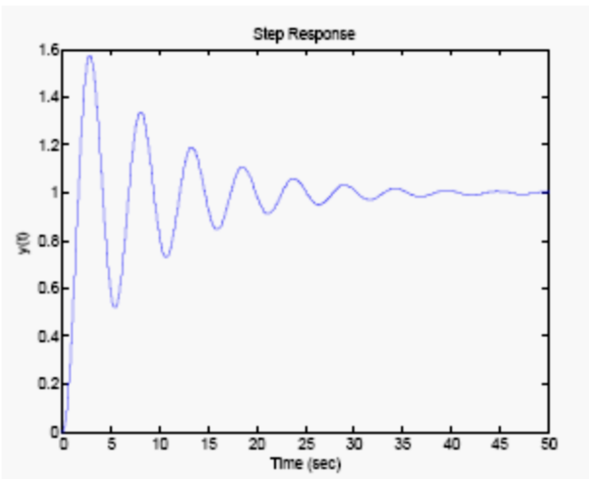

Figure 7. Step response of Example (2)

Frequency Response: Put $s = j\omega$ in the given system function. The magnitude plot and phase plot of the system using MATLAB is plotted as shown in the Fig.(8). The gain margin is ∞ and the phase margin is about 177°.

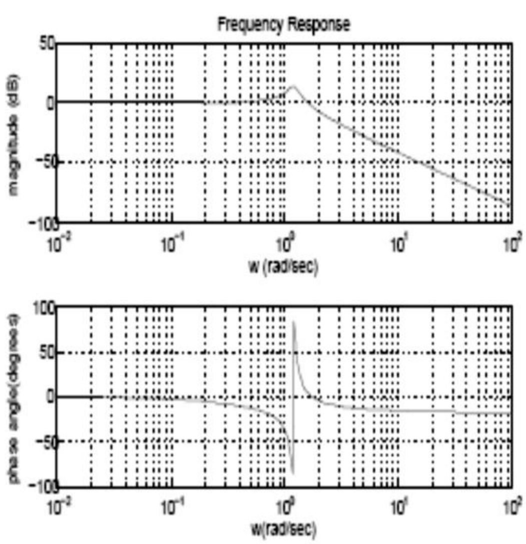

Figure 8. Frequency response of Example (2)

State-space Representation: The canonical form of the system is obtained as,

$$\frac{Y(s)}{X(s)} = \frac{1}{0.8s^{(0.1)22} + 0.5s^{(0.1)9} + 1}. \quad (30)$$

$$((s^{0.1})^{22} + 0.625(s^{0.1})^{9} + 1.25)Y(s) = 1.25X(s). \quad (31)$$

Consider input u(t) and taking inverse Laplace transform we get,

$$D_t^{2.2}y(t) + 0.625D_t^{0.9}y(t) + 1.25y(t) = 1.25u(t), \quad (32)$$

Case 1: Let $y(t) = x_1(t)$ and

$$D_t^{0.1}x_1(t) = x_2(t) \quad (33)$$

In general we have $x_{i+1} = D_t^{0.1}x_i$, $i = 1,2,..,21$.

$$D_t^{0.1}x_{22}(t) = -1.25x_1(t) - 0.625x_{10}(t) + 1.25u(t), \quad (34)$$

The controllable canonical form is therefore given by,

$$\begin{bmatrix} D_t^{0.1}x_1(t) \\ D_t^{0.1}x_2(t) \\ \vdots \\ D_t^{0.1}x_{22}(t) \end{bmatrix} = \begin{bmatrix} 0 & 1 & \cdots & 0 & \cdots & 0 \\ 0 & 0 & \cdots & 0 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \cdots & \vdots \\ -1.25 & 0 & \cdots & -0.625 & \cdots & 0 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \\ \vdots \\ x_{22}(t) \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ \vdots \\ 1.25 \end{bmatrix} u(t)$$

$$y(t) = [1 \quad 0 \quad \cdots \quad 0]\, u(t). \quad (35)$$

Case 2: Let $y(t) = x_1(t)$ and $D_t^{0.9}x_1(t) = x_2(t)$. (36)

The controllable canonical form is therefore given by,

$$\begin{bmatrix} D_t^{0.9}x_1(t) \\ D_t^{1.3}x_2(t) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -0.125 & -0.625 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 0 \\ 0.125 \end{bmatrix} u(t). \quad (37)$$

The controllable matrix of this system is full rank and hence the system is controllable. It is also shown that there can be no unique state space representation for a fractional-order system. In the analysis of this incommensurate FO system we conclude that the system is stable, controllable and observable.

C. Example 3

Consider the commensurate system given by the following transfer function [6] :

$$G(s)=\frac{1}{s-2s^{0.5}+1.25}. \qquad (38)$$

The system given in the equation can be written as

$$G(s)=\frac{1}{s^{\left(\frac{1}{2}\right)^{2}}-2s^{\left(\frac{1}{2}\right)^{1}}+1}. \qquad (39)$$

Consider $w=s^{\frac{1}{2}}$, the system has two Riemann sheets. Transforming the system onto w-plane we get,

$$\tilde{G}(w)=\frac{1}{w^{2}-2w+1.25}. \qquad (40)$$

The open-loop poles and their appropriate arguments of the system are shown in table IV.

TABLE IV. OPEN LOOP POLES AND CORRESPONDING ARGUMENTS OF EXAMPLE 3

Poles	Arguments in radians
$w_{1,2} = 1.0000 \pm j0.5000$	$\arg(w_{1,2})\vert = 0.4636$

The open-loop pole-zero plot is shown in the Fig.(9). The poles lie in the unstable region $-\pi/4<\arg(w)<\pi/4$, and the first Riemann sheet is $-\pi/2<\arg(w)<\pi/2$.

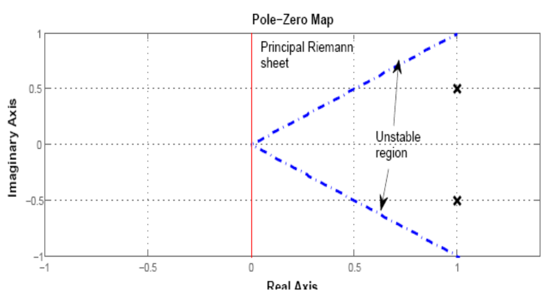

Figure 9. Open-loop pole-zero plot of Example (3)

The closed-loop poles and their appropriate arguments of the system are shown in table V.

TABLE V. CLOSED LOOP POLES AND CORRESPONDING ARGUMENTS OF EXAMPLE 3

Poles	Arguments in radians
$w_{1,2} = 1.0000 \pm j1.1180$	$\arg(w_{1,2})\vert = 0.8411$

The closed-loop pole-zero plot is shown in the Fig.(10). The poles are in the stable region, which implies that the closed-loop system is stable.

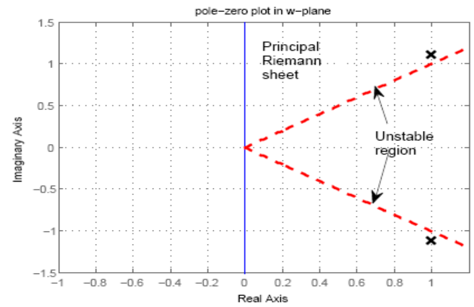

Figure 10. Closed-loop pole-zero plot of Example (3)

Step Response: The step response is obtained using invlap subroutine [23] for the closed-loop system with unity gain as shown in Fig.(11). It is observed that the ML function calculation is time consuming and may not give proper results in all the cases. In such cases they can also be plotted using invlap.m subroutine (numerical ILT) [22], [23].

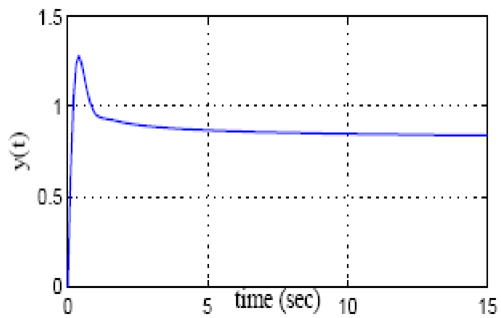

Figure 11. Step response of Example (3)

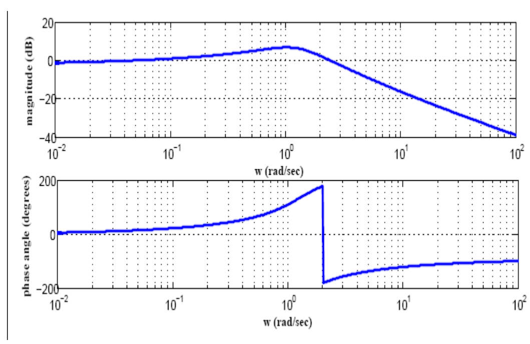

Figure 12. Frequency response of Example (3)

Frequency Response: Put $s=j\omega$ in the given system function. The magnitude plot and phase plot of the system using MATLAB is plotted as shown in the Fig.(12). The gain margin is ∞ and the phase margin is about 193°. This shows that the system is stable with a wide range of gain and phase margins.

State-space Representation: The canonical form of the system is obtained as,

$$\frac{Y(s)}{X(s)} = \frac{1}{s - 2s^{0.5} + 1.25}, \tag{41}$$

Using the procedure as given in Section VI, we get,

$$D_t^{0.5}\begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -1.25 & 2 \end{bmatrix}\begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t) \tag{42}$$

$$y(t) = \begin{bmatrix} 1 & 0 \end{bmatrix} u(t). \tag{43}$$

Where $A = \begin{bmatrix} 0 & 1 \\ -1.25 & 2 \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$, $C = \begin{bmatrix} 1 & 0 \end{bmatrix}$

The system is found to be controllable and observable. From the open-loop and closed-loop pole-zero plots, and the gain margin and phase margin it can be concluded that the system is stable in the closed-loop configuration.

D. Example 4

Consider the commensurate system given by the following open loop transfer function [11].

$$G(s) = \frac{s^{0.5} - 1}{s^2 - 3s^{1.5} - 2s + 2s^{0.5} + 12}. \tag{44}$$

The system given in the equation can be written as

$$G(s) = \frac{s^{0.5} - 1}{s^{\left(\frac{1}{2}\right)4} - 3s^{\left(\frac{1}{2}\right)3} - 2s^{\left(\frac{1}{2}\right)2} + 2s^{\left(\frac{1}{2}\right)} + 12}. \tag{45}$$

Consider $w = s^{\frac{1}{2}}$, the system has two Riemann sheets. Transforming the system onto w-plane we get,

$$\tilde{G}(w) = \frac{w - 1}{w^4 - 3w^3 - 2w^2 + 2w + 12}. \tag{46}$$

The open-loop poles, zeros and their appropriate arguments of the system are shown in table VI.

TABLE VI. OPEN LOOP POLES AND CORRESPONDING ARGUMENTS OF EXAMPLE 4

Poles	Arguments in radians
$w_1 = 3.0000$	$\lvert\arg(w_1)\rvert = 0.0000$
$w_2 = 2.0000$	$\lvert\arg(w_2)\rvert = 0.0000$
$w_{3,4} = -1.0000 \pm j1.0000$	$\lvert\arg(w_{3,4})\rvert = 2.3562$
Zeros	**Arguments in radians**
$w_5 = 1.0000$	$\lvert\arg(w_5)\rvert = 0.0000$

The open-loop pole-zero plot of the system in the w-plane is as shown in the Fig.(13). It shows the unstable region $-\pi/4 < \arg(w) < \pi/4$, and the first Riemann sheet is $-\pi/2 < \arg(w) < \pi/2$. Also there are 2 poles and 1 zero in the unstable region and 2 poles in the stable region on the second Riemann sheet.

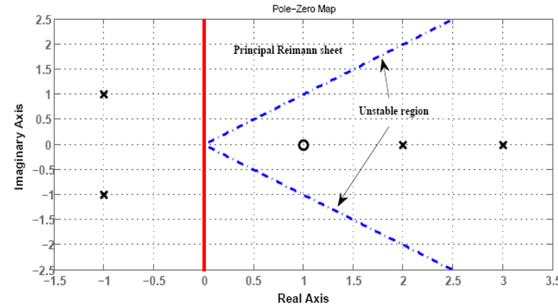

Figure 13. Open-loop pole-zero plot of Example (4)

The closed-loop poles, zeros and their appropriate arguments of the system are shown in table VII.

TABLE VII. CLOSED LOOP POLES AND CORRESPONDING ARGUMENTS OF EXAMPLE 4

Poles	Arguments in radians
$w_1 = 2.867$	$\lvert\arg(w_1)\rvert = 0.0000$
$w_2 = 2.1183$	$\lvert\arg(w_2)\rvert = 0.0000$
$w_{3,4} = -0.9915 \pm j0.9109$	$\lvert\arg(w_{3,4})\rvert = 2.3985$
Zeros	**Arguments in radians**
$w_5 = 1.0000$	$\lvert\arg(w_5)\rvert = 0.0000$

The pole-zero plot of the closed-loop system in the w-plane is as shown in the Fig.(14). There are 2 poles and 1 zero in the unstable region and 2 poles in the stable region on the second Riemann sheet which is similar to the case of open-loop system.

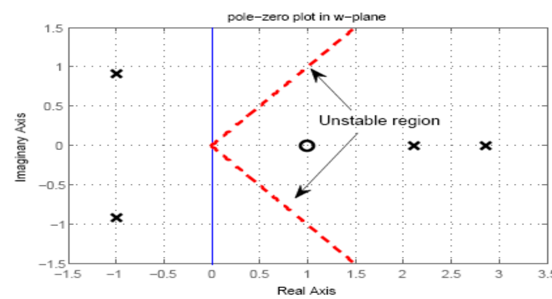

Figure 14. Closed-loop pole-zero plot of Example (4)

Step Response: The closed-loop step response is obtained using invlap subroutine [23] for unity gain as shown in Fig.(15). It shows that the system is unstable.

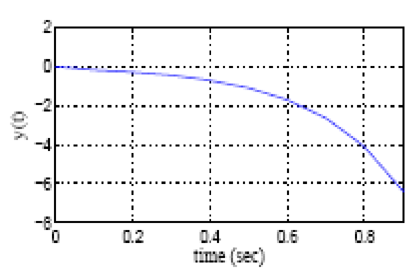

Figure 15. Step response of Example (4)

Frequency Response: Put $s = j\omega$ in the given system function. The magnitude plot and phase plot of the system using MATLAB is plotted as shown in the Fig.(16). The gain margin is about 35dB and phase margin is ∞.

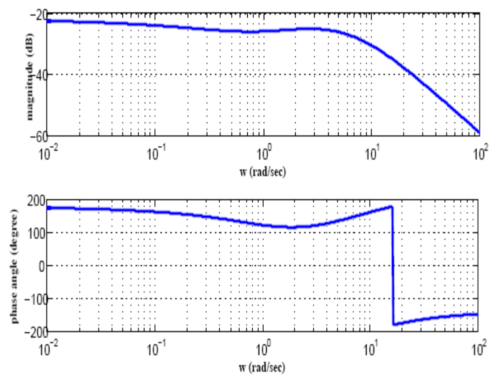

Figure 16. Frequency response of Example (4)

State-space Representation: The canonical form of the system is obtained as,

$$\frac{Y(s)}{X(s)} = \frac{s^{0.5} - 1}{s^2 - 3s^{1.5} - 2s + 2s^{0.5} + 12}, \qquad (47)$$

Using the procedure as given in Section VI, we get,

$$D_t^{0.5}\begin{bmatrix} x_1(t) \\ x_2(t) \\ x_3(t) \\ x_4(t) \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ -12 & -2 & 2 & 3 \end{bmatrix}\begin{bmatrix} x_1(t) \\ x_2(t) \\ x_3(t) \\ x_4(t) \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix} u(t) \qquad (48)$$

$$y(t) = \begin{bmatrix} -1 & 1 & 0 & 0 \end{bmatrix}\begin{bmatrix} x_1(t) \\ x_2(t) \\ x_3(t) \\ x_4(t) \end{bmatrix} + [0]\, u(t) \qquad (49)$$

Where $A = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ -12 & -2 & 2 & 3 \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}$,

$C = \begin{bmatrix} -1 & 1 & 0 & 0 \end{bmatrix}$, $D = [0]$

The system is found to be controllable and observable. From the open-loop and closed loop pole-zero plots, step response we conclude that the system is unstable.

VIII. Conclusion

The fractional-order models of real systems are more adequate than the usually used integer order models. At the same time fractional-order controllers provide better performance in comparison to integer order controllers. The most important features such as stability, controllability, observability, stability margins of linear fractional-order systems are studied during the work. They are discussed using Bode diagrams, time response, state space representation. The time and frequency domain analysis of fractional-order systems is found to be similar to that of integer order systems.

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Color &Texture Based Image Retrieval using Fusion of Modified Block Truncation Coding (MBTC) and Kekre Transform Patterns

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***Abstract* - Content Based Image Retrieval is an interesting topic of research. This paper is about image content-based image search. Specifically, it is on developing technologies for bridging the semantic gap that currently prevents wide-deployment of image content-based search engines. Mostly, content-based methods are based on low-level descriptions, while high-level or semantic descriptions are beyond current capabilities. In this paper a CBIR is proposed based on color & texture based search. Modified Block Truncation Coding (MBTC) is used for color information retrieval. To extract texture information we are using pattern generated by transforms, currently we are considering Kekre Transform. The feature vector is generated by fusion of above mentioned techniques.**

Keywords- Image retrieval, CBIR, MBTC, Kekre's pattern.

I. INTRODUCTION

Retrieval is the wide topic of research from the decades. The concept behind is to get desired data from the database. It may image, text, audio or video as per requirement of user. The basic types of retrievals are mentioned below, from ages images have been the mode of communication for human being. Today we are able to generate, store, transmit and share enormous amount of data because of the exhaustive growth of Information and Communication Technology. Much of this information is multimedia in nature, which consists of digital images, video, audio, graphics, and text data [1], [2]. But all that information is only useful if one can access it efficiently. This does not only mean fast access from a storage management point of view but also means that one should be able to find the desired information without scanning all information manually. Previous method used for image retrieval is Text based image retrieval. The advantage of textual indexing of image is that it can provide user with key word searching, catalogue browsing and even with query interface. But the major drawback of text based image retrieval are, annotation depends on the person who adds it , the user of a Text Based Image Retrieval must describe an image using nearly the same keywords that were used by the annotator in order to retrieve that image [4]. Due to all these drawbacks, Content Based Image Retrieval is introduced.

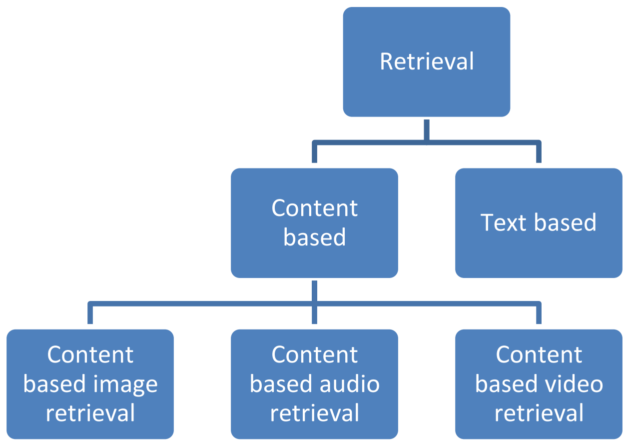

Figure 1. Types of retrieval

Here we will be dealing with features of images such as texture and color.

II. CBIR EXISTING TECHNIQUES

H B Kekre, V A Bharadi et al. have introduced Content Based Image Retrieval using Fusion of Gabor Magnitude and Modified Block Truncation Coding [4]. Gabor filters are a group of wavelets, with each wavelet capturing energy at a specific frequency and a specific direction.

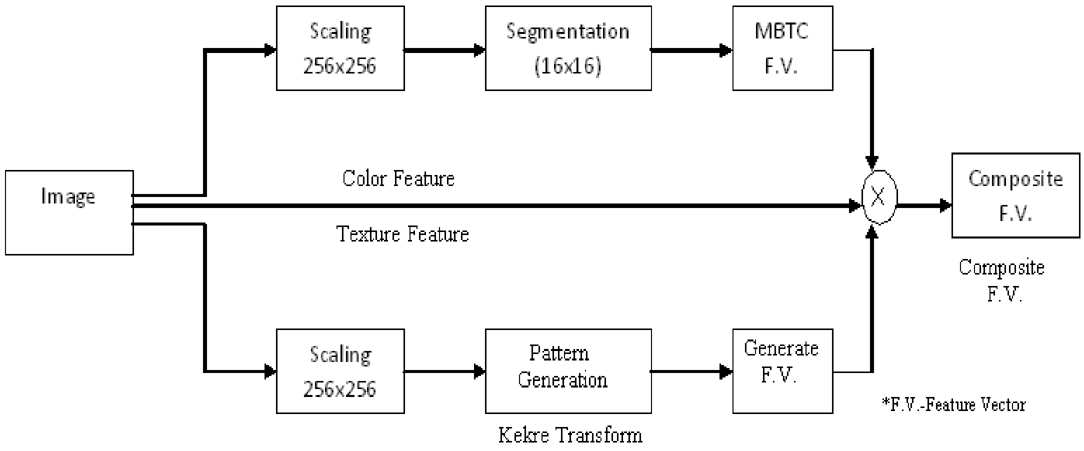

Figure 2. Basic Block Diagram for Planned Work

Expanding a signal using this basis provides a localized frequency description, therefore capturing local features/energy of the signal. Texture features can then be extracted from this group of energy distributions. And modified block truncation is used to retrieve color feature from image. They proved that the proposed system is giving higher Precision and Recall as compared to only Gabor and only MBTC based CBIR. Gabor feature gives good response to texture of the image and Modified BTC give good response to color content of image.

J. Zhang and W. Zou [5] have presented a novel technique that employs both the color and edge direction features for Content-Based Image Retrieval (CBIR). In this method, a given image is first divided into sub-block which has the same size and then the color and edge direction features of each sub block can be extracted. Next, it constructs a codebook of color feature using clustering algorithm and then each sub-block is mapped to the codebook. The color feature is used to retrieve images, and the edge direction feature is the weight of the similarity measure for the color feature.

Rose and Shah carried on a research project to improve the accuracy of CBIR Using Gradient Projections [6]; the image's structural properties were examined to distinguish one image from another. By examining the specific gray level of an image, a gradient can be computed at each pixel. Pixels with a magnitude larger than the thresholds are assigned a value of 1. These binary digits are added across the horizontal, vertical, and diagonal directions to compute three projections. These vectors are then compared with the vectors of the image to be matched using the Euclidean Distance Formula. These numbers are then stored in a bookmark so that the image needs only be examined once. A program has been developed for Matlab that performs this method of projecting gradients. Three databases were amassed for the testing of the proposed system's accuracy: 82 digital camera pictures, 1,000 photographic images, and a set of object orientated photos. The program was tested with 100% accuracy with all submitted images to the database, and was able to distinguish between pictures that fooled previous CBIR engines. The weakness of this project was its color-blindness.

A CBIR method based on color-spatial feature has been proposed by Lei, Fuzong & Zhang [7] . They proposed a fast algorithm which could include several spatial features of color in an image for retrieval because except for the color histogram information, the position information of each color plays an important role too. These features are area and position, which mean the zero-order and the first-order moments, respectively. By computing the moments of each color region the similarity of two images according to the weight of each factor can be computed. In fact, these features are a kind of representation for image in the scale of low resolution, and the sample image given by a user is usually a draft drawn by hand. Moreover, when a user judges the similarity between two pictures, he will firstly judge them in coarse scale. In this sense, this method is close to the vision model of our eyes. Because the features are simple and can be calculated in fast speed, better result can be made easily through training.

H B Kekre , S D Thepade et al. introduced image retrieval with Shape Features Extracted using Gradient Operators and Slope Magnitude Technique with Block Truncation Coding (BTC) [9] and tested on generic image database with 1000 images spread across 11 categories. The average precision and recall of all queries are computed and considered for performance analysis. Gradient operators used for shape extraction were Robert, Prewitt, Sobel and Canny which are known as 'Mask-Shape-BTC' CBIR techniques. The problem with these Mask-Shape-CBIR methods is the need of resizing the database images to match it with the size of query. This drawback is removed using proposed Mask-Shape-BTC-CBIR methods. In proposed image retrieval techniques the feature vectors are formed by applying the block truncation coding (BTC) on the shape image obtained using slope magnitude applied on gradient of the image in both horizontal and vertical direction.

H.B.Kekre, S. D. Thepade concentrated on more precise and faster retrieval techniques [10]. They had applied Walsh transform of different sizes on all images in database to extract the features and the feature vector database is generated. Then Walshlet feature vector of query image is compared with Walshlet feature vectors calculated for database images. The proposed Gray- Walshlet and Color-Walshlet based CBIR techniques are tested using 55 queries fired on the image database with 1000 images spread over 11 categories. Among the different levels of Walshlet transform, Walshlet level-5 had given best results.

III. PROPOSED TECHNIQUE

A. Modified Block Truncation Coding

Block truncation coding (BTC) is a relatively simple image coding technique developed in the early years of digital imaging. This method first divides the image into small non-overlapping image blocks. The small blocks are coded one at a time. For each block, the original pixels within the block are coded using a binary bitmap the same size as the original block and two mean pixel values [4].

The method first computes the mean pixel value of the whole block and then each pixel in that block is compared to the block mean. If a pixel is greater than or equal to the block mean, the corresponding pixel position of the bitmap will have a value of 1; otherwise it will have a value of 0. The simplest extension was to view a colour image as consisting of three independent grey scale images and apply BTC to each colour plane independently. Most colour images are recorded in RGB space, which is perhaps the most well-known colour space [11].

In modified BTC to create a binary bitmap in the RGB space, an inter-band average image (IBAI) is first created and a single scalar value is found as the threshold value.

First we will resize the image in 256*256pixels. Now let X={r(i,j),g(i,j),b(i,j) i =1,2,…..m. j=1,2,……n} be an m x n color block in RGB space where m=n=256.

$$i_b = \frac{1}{3} r(i,j) + g(i,j) + b(i,j) \quad (1)$$

The threshold is computed as the mean of each colour,

$$T_1 = \frac{1}{nxm} \sum_{i=1}^{n} \sum_{j=1}^{m} r(i,j) \quad (2)$$

$$T_2 = \frac{1}{nxm} \sum_{i=1}^{n} \sum_{j=1}^{m} g(i,j) \quad (3)$$

$$T_3 = \frac{1}{nxm} \sum_{i=1}^{n} \sum_{j=1}^{m} b(i,j) \quad (4)$$

The binary bitmap is computed as below,

$$bm_1(i,j) = \begin{cases} 1 & if r(i,j) \geq T_1 \\ 0 & if r(i,j) < T_1 \end{cases} \quad \text{....(5)}$$

$$bm_2(i,j) = \begin{cases} 1 & if g(i,j) \geq T_2 \\ 0 & if g(i,j) < T_2 \end{cases} \quad \text{....(6)}$$

$$bm_3(i,j) = \begin{cases} 1 & if b(i,j) \geq T_3 \\ 0 & if b(i,j) < T_3 \end{cases} \quad \text{....(7)}$$

After the creation of the bitmap, two representative (mean) colors are then computed. The two mean colors are MC1 = {Cr1 ,Cg1 ,Cb1 } and MC2 ={Cr2 ,Cg2 ,Cb2}. Where upper-mean is calculated by,

$$C_{r_1} = \frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{m} b_{m1}(i,j)} \sum_{i=1}^{n}\sum_{j=1}^{m} b_{m1}(i,j) r(i,j) \quad (8)$$

$$C_{g_1} = \frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{m} b_{m2}(i,j)} \sum_{i=1}^{n}\sum_{j=1}^{m} b_{m2}(i,j) g(i,j) \quad (9)$$

$$C_{b_1} = \frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{m} b_{m3}(i,j)} \sum_{i=1}^{n}\sum_{j=1}^{m} b_{m3}(i,j) b(i,j) \quad (10)$$

And lower-mean calculated as below,

$$C_{r_2} = \frac{1}{nxm - \sum_{i=1}^{n}\sum_{j=1}^{m} b_{m1}(i,j)} \sum_{i=1}^{n}\sum_{j=1}^{m} (1 - b_{m1}(i,j)) r(i,j) \quad (11)$$

$$C_{g_2} = \frac{1}{nxm - \sum_{i=1}^{n}\sum_{j=1}^{m} b_{m2}(i,j)} \sum_{i=1}^{n}\sum_{j=1}^{m} (1 - b_{m2}(i,j)) g(i,j) \quad (12)$$

$$C_{g_2} = \frac{1}{nxm - \sum_{i=1}^{n}\sum_{j=1}^{m} b_{m3}(i,j)} \sum_{i=1}^{n}\sum_{j=1}^{m} (1 - b_{m3}(i,j)) b(i,j) \quad (13)$$

B. Pattern Generation for Texture

Patterns are the texture combinations generated from transform basis functions.

Number of patterns can be generated using transform matrices namely 4 pattern, 16 pattern, 64 pattern. NxN matrix can be used to generate N^2 patterns. For example, if we want to generate 16 pattern then 4x4 matrix need to be used. Element wise multiplication of each row of the transform matrix is taken with all possible rows of the same matrix.

The 16 Kekre texture patterns [12] are generated using Kekre transform matrices of size 4x4. Fig. 3 gives 2x2 kekre matrix and generation of four Kekre texture patterns. 2x2 Kekre transform matrix is shown in figure, each row of this matrix is considered one at a time and is multiplied with all rows of the same matrix to generate Kekre texture patterns as shown in figure 4.

The 4x4 Kekre transform matrix is given in figure 5 and visualization of 16 Kekre transform patterns generated using it is shown in figure 9, where black and grey colour scaled between 1 to 256 in the pattern and 0 is represented by white colour.

$$\begin{bmatrix} 1 & 1 \\ -1 & 1 \end{bmatrix}$$

Figure 3. 2x2 Kekre Matrix

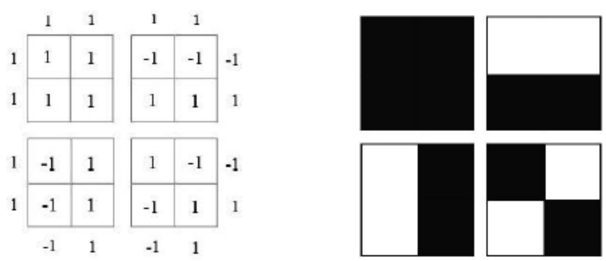

Figure 4. 4-Kekre Pattern Generation

$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ -3 & 1 & 1 & 1 \\ 0 & -2 & 1 & 1 \\ 0 & 0 & -1 & 1 \end{bmatrix}$$

Figure 5. 4x4 Kekre Matrix

C. Fusion of MBTC & Patterns

1. We create a database containing images, the images are registered in the database. These images will be forwarded to Feature Vector Module i.e. fusion of MBTC and patterns generation. The resulted feature vector will be stored in feature vector database.
2. **Feature vector generation:**
   (a) MBTC is applied on each image to calculate uppermean and lowemean.
   (b) Uppermean and lowermean are 3-dimensional matrix i.e. it has three components red, green, blue. Three components are separated from uppermean and lowermean matrix.
   (c) Each component is quantized to equivalent value of pattern matrix.
   (d) Then occurrence of each pattern in six components i.e. uppermean(R,G,B) and lowermean (R,G,B) matrix is counted and arranged as (8x12) matrix for each image in database. This matrix is Feature Vector.
3. Using above procedure feature vector is also calculated for query image.
4. Now feature vector of query image is compared with feature vector of images in database using Euclidian distance concept.
5. Then Euclidian distance is arranged in ascending order and according to Euclidian distances images are retrieved as result.
6. Images are then retrieved according to different thresholds (thresholds for Euclidian distances) and precision, recall calculated for each threshold value. Where,

$$\text{Precision} = \frac{\text{Total number of retrieve relevant images}}{\text{Total number of retrieve images}}$$

$$\text{Recall} = \frac{\text{Total number of retrieve relevant images}}{\text{Total number of relevant images in database}}$$

IV. RESULT AND DISCUSSIONS

For each image red, green and blue components are separated from uppermean and lowermean and quantized in pattern values as shown in Fig. 6, Using 4x4 Kekre matrix 16-pattern transform generated as shown in Fig 7.

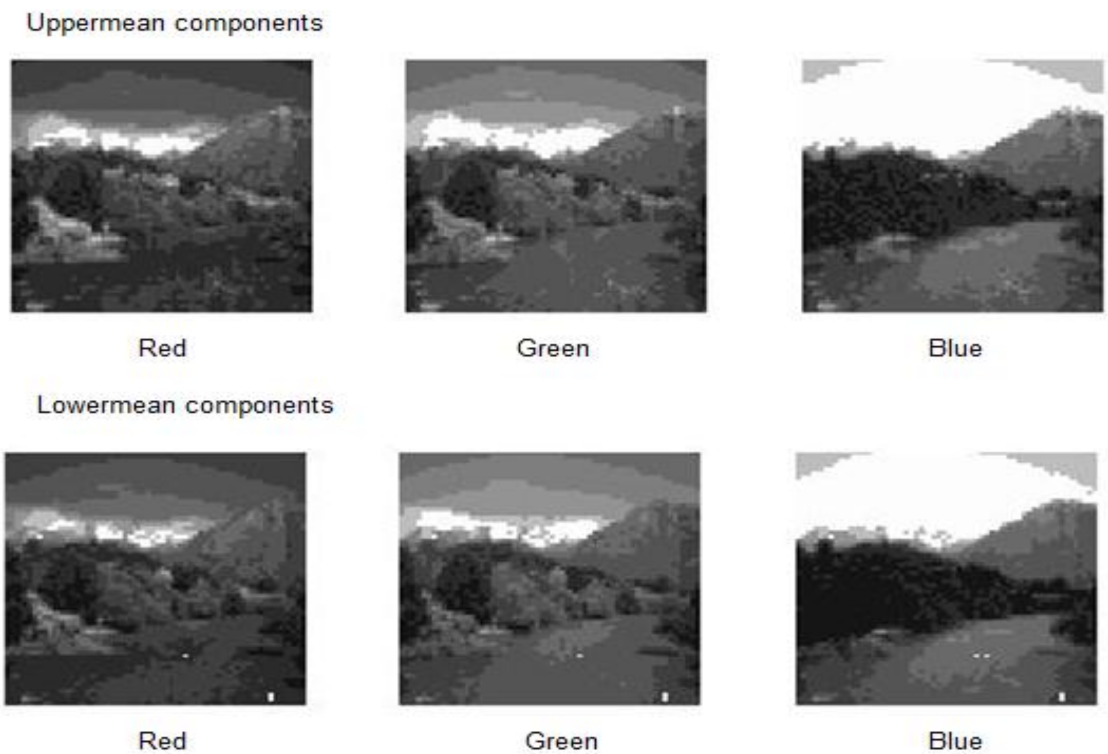

Figure 6. Quantized upperman and lowermean matrix

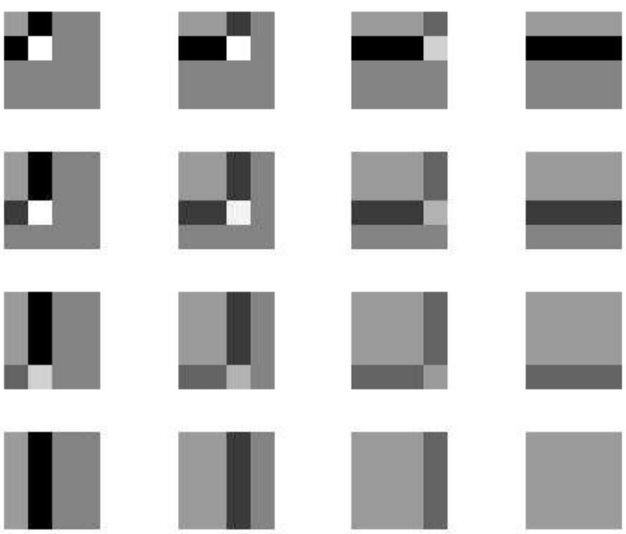

Figure 7. 16-Kekre Pattern Generation

Find co-occurrence of each pattern shown in figure is checked with components in figure. This co-occurrence matrix is nothing but feature vector as show in figure 8,

1888	1651	1262	999	740	514	337	234	1191	1063	957	879
1651	1651	1651	1651	514	514	514	514	1063	1063	1063	1063
1262	1651	1888	2118	337	514	740	944	957	1063	1191	1291
999	1651	2118	2717	234	514	944	1759	879	1063	1291	1573
2062	1831	1270	980	946	704	467	319	1363	1255	1132	1053
1831	1831	1831	1831	704	704	704	704	1255	1255	1255	1255
1270	1831	2062	2277	467	704	946	1160	1132	1255	1363	1451
980	1831	2277	2827	319	704	1160	1998	1053	1255	1451	1787

Figure 8. (8x12) feature vector

Now according to Euclidian distances, images are retrieved for different threshold levels. Precision & recall is calculated for three query images from different classes as shown below in Fig. 9 , 10 & 11. Fig. 12 shows a simple snapshot of the images retrieved for a given query image. The Recall and Precision curves are plotted, the crossover point is important as it gives the threshold at which precision & recall are optimal (Both are at maximum). The crossover range max 25% and min 20%. The results can be further improved by adding localized information to the feature vectors. We can segment the image and extract the feature vector for the segments.

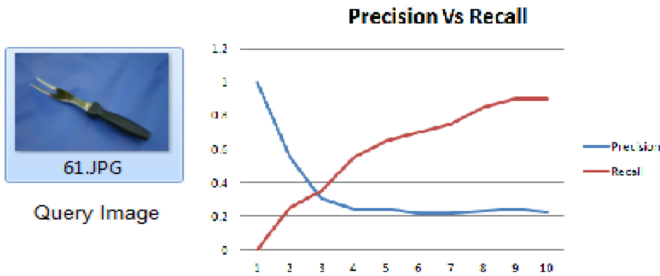

Figure 9. Precision-recall for class 1 (Crossover : 25%)

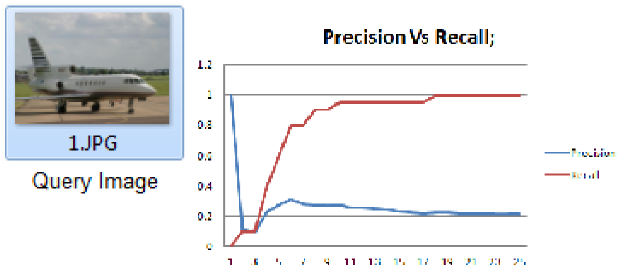

Figure 10. Precision-recall for class 2 Crossover : 10%)

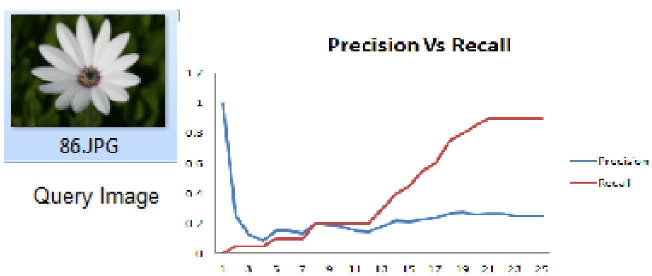

Figure 11. Precision-recall for class 3 Crossover : 20%)

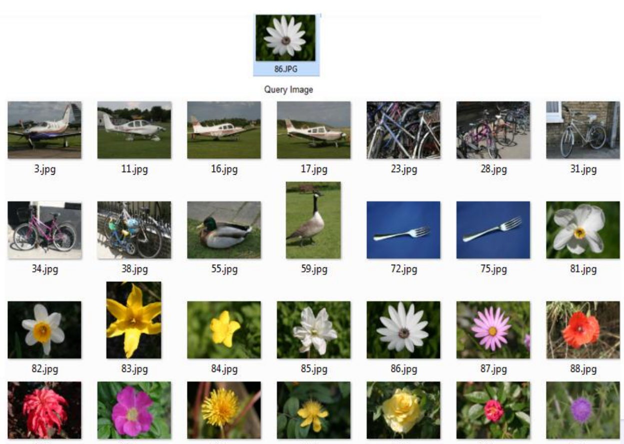

Figure 12. Sample Query Image & Retrieved Images

V. CONCLUSION

In this paper we have proposed a Content based Image Retrieval System based on Modified BTC & Kekre Transform pattern. MBTC extracts the color information and the Kekre Pattern is extracting the texture information. The feature vector is generated by a novel fusion mechanism.

The algorithm is tested on 1000 image database and we have achieved 10-25% Precision Recall crossover. The proposed technique is working satisfactory and can be further improved by adding localization to the feature vector.

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A Fair Queuing Technique for Efficient Content Delivery Over 3G and 4 G Networks in Varying Load Condition

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Abstract— **The challenges of new communication architecture are to offer better quality of service (QoS) in internet Network. A large diversity of services based on packet switching in 3G network and beyond 3G leads dramatic changes in the characteristics and parameter of data traffic. Deployment of application server and resource server has been proposed to support both high data rates and quality of service (QoS) for Next Generation Network (NGN).One important generalization of the Next Generation Network is, it's a queue of network. It is expected that traffic in NGN will undergo both quantitative and qualitative changes. Such networks can model problems of contention that arise when a set of resources is shared. With the rapid transformation of the Internet into a commercial infrastructure, demands for service quality have rapidly developed. In this paper, few components of NGN reference architecture have been taken and system is evaluated in terms of queuing network. This paper gives a comparative analysis of three queuing systems FIFO, PQ and WFQ. Packet end to end delay, packet delay variation and traffic dropped are evaluated through simulation. Results have been evaluated for a light load intermediate load and heavy load condition for constant traffic distribution. Results have been also evaluated for variable bandwidth condition. Result shows WFQ has better quality comparing with other techniques in a voice based services where as PQ a technique is better in Video based services. Simulation is done using OPNET.**

Keywords- QoS-Quality of service; NGN-Next Generation Network; FIFO- First-in-first-out; PQ- Priority queuing; WFQ- Weighted-Fair queuing; VoIP- Voice over Internet Protocol.

I. INTRODUCTION

It is essential to understand and take a deep look in to the future, for a view of what a network may look like and explore how a service or group of services may fit together to form a useful example of where next generation network will take us.

To offer better quality of service in a network a lot of parameter should be considered such as bandwidth, latency, delay, jitter and packet loss etc. NGN's architecture is based on decoupling transport layer and service layer. Basically, that means that whenever a provider wants to enable a new service they can do it straight upon defining it at the service layer without considering it the transport layer. Fig.-1 shows reference architecture of NGN model. Required components of NGN have been extensively discussed in past [1].

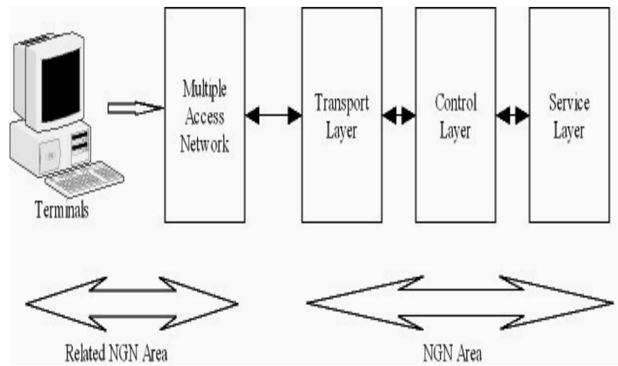

Figure 1. Reference Architecture Diagram of NGN Model

II. METHODOLOGY AND REQUIREMENTS

In next generation proposed architecture, these are following set of requirements.

- Drivers and basic requirements.
- NGN QoS standardization.
- Resource and admission control functions.

In order to meet some of the requirements listed for Next generation Network, some proposal has been discussed in past [2]. Voice and video based QoS is determined by many factors and the most important parameters are packet end-to-end delay, packet delay variations or jitter and packet drop. ITU-T Recommendation G.114 recommends the following limits for one-way end-to-end transmission time [3].

• 0 to 150 ms: Acceptable for most user applications.
• 150 to 400 ms: Acceptable provided that Administrations are aware of the transmission time impact on the transmission quality of user applications.
• Above 400 ms: Unacceptable for general network planning purpose. However, it is recognized that in some exceptional cases this limit will be exceeded.

III. THE ANALYTICAL DECOMPOSITION OF NGN REFERENCE MODEL WITH OPEN QUEUING NETWORK

In the generic model a node or a service center represent each resource. Thus in a model for computer system performance analysis we may have service center for the servers, a service center for each I/O channel [4].

In order to provide a requested QoS, the nodes of a network must perform session initiation phase, reservation setup, admission control, policy control, packet scheduling, and packet classification functions.

A service center may have one or more server associated with it. If a job requesting service finds all the server at a service center busy, it will join the queue associated with the center and a later point in time when a server becomes idle a job from the queue will be selected for service according to some scheduling discipline. After completion of service at one service center the job may move to another service center for further service, reenter the same service center or leave the system [5].

Consider a two stage tandem network. The system consists of application server and resource server with respective service rate $\mu_0 \,\&\, \mu_1$. Observe that application server has a Poisson arrival source of rate λ and exponentially distributed.

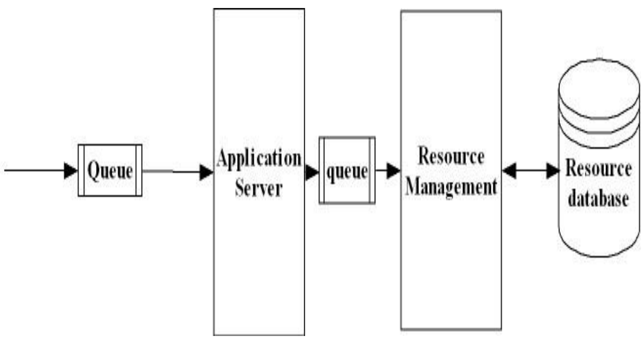

Figure 2. A two stage open queuing network of NGN

This system can be modeled as a stochastic process whose states are specified by pairs ($k_{0,} k_1$).

$$k_0 \geq 0$$

$$k_1 \geq 0$$

Where k_i (i=0, 1) is the no. of jobs completion of the service at one of the two server. The changes of the two servers occur on a completion of service at one of the two servers or an external arrival. Since all interevent times are exponentially distributed, it follows that the stochastic process is a homogeneous continuous time Markov chain [6].

Let p ($k_{0,} k_1$) is the joint probability of k_0 jobs at application server and k_1 Jobs at resource server in the steady state. Equating the rates of flow into and out of the state, we obtain the following balance equations [7].

$$(\mu_0 + \mu_1 + \lambda)\, p(k_0, k_{1)} = \mu_0\, p(k_0 + 1, k_1 - 1) +$$

$$\mu_1 p(k_0, k_1 + 1) + \lambda\, p(k_0 - 1, k_1) - -(1)$$

For the boundary state we have

$$(\mu_0 + \lambda)\, p(k_0, 0) = \mu_1\, p(k_0, 1) + \lambda\, p(k_0 - 1)$$

Where $k_0 > 0$

$$(\mu_1 + \lambda)\, p(0, k_{1)} = \mu_0\, p(1 - k_1 - 1) + \mu_1 p(0, k_1 + 1)$$

Where k1>0

$$\lambda . p(0,0) = \mu_{1.}\, p(0,1) - - - - (2)$$

The normalization is provided by

$$\sum_{k0 \geq 0} \sum_{k1 \geq 0} p(k_{0.} k_1) = 1$$

The Solution of the preceding balance equation is

Where $\rho_0 = \lambda \,/\, \mu_0$ and $\rho_1 = \lambda / \mu_1$ ----- (3)

The equation shows a stability condition of the network as condition for stability of the system is that both $\rho_0 \,\&\, \rho_1$ are less than unity. Equation (3) is a product form solution to M/M/1 queue. Many efficient algorithms for calculating performance measure for closed queuing network have been developed and discussed in past [8] [9] [10].

IV. VARIOUS QUEUING TECHNIQUES

There are number of elementary queuing models. Attention is paid to methods for the analysis of these models, and also to applications of queuing models on 3G and 4G network.

Various queuing disciplines can be used to control which packets get transmitted and which packets which packets get dropped. The queuing disciplines are:

- First-in-first-out (FIFO) queuing.
- Priority queuing (PQ)
- Weighted-Fair queuing. (WFQ)

FIFO is an acronym for First in First Out. This expression describes the principle of a queue or first-come first serve behavior: what comes in first is handled first, what comes in next waits until the first is finished etc. Thus it is analogous to the behavior of persons “standing in a line” or “Queue” where the persons leave the queue in the order they arrive. First In First out (FIFO) is the most basic queuing discipline. In FIFO queuing all packets are treated equally by placing them into a single queue, then servicing them in the same order they were placed in the queue. FIFO queuing is also referred to as First Come First Serve (FCFS) queuing [11]. Although a single FIFO queue seems to provide no QoS features at all, it actually does affect drop, delay, and jitter. Because there is only one queue, the router need not classify traffic to place it into different queues and router need not worry about how to decide from which queue it should take the next packet—there is only one choice. Due to this single queue uses FIFO logic, the router need not reorder the packets inside the queue. With a longer queue, however, the average delay increases, because packets may be enqueued behind a larger number of other packets. In most cases when the average delay increases, the average jitter increases as well.

Priority Queuing assigns multiple queues to a network interface with each queue being given a priority level. A queue with higher priority is processed earlier than a queue with lower priority. Priority Queuing has four preconfigured queues, high medium, normal and low priority queue. Queues are serviced in strict order of queue priority, so the high queue always is serviced first, then the next-lower priority and so on. If a lower-priority queue is being serviced and a packet enters a higher queue, that queue is serviced immediately. This mechanism is good for important traffic, but can lead to queue starvation. If packets arrive in the high queue then priority queuing drops everything its doing in order to transmit those packets, and the packets in other queue is again empty. When a packet is sent out an interface, the priority queues on that interface are scanned for packets in descending order for priority. The high priority queues is scanned first, then the medium priority queue and then so on. The packet at the head of the highest queue is chosen for transmission. This procedure is repeated every time when a packet is to be sent. The maximum length of a queue is defined by the length limit. When a queue is longer the limit packets are dropped [12].

The idea of the fair queuing (FQ) discipline is to maintain a separate queue for each flow currently being handled by the router. The router then services these queues in a round robin manner. WFQ allows a weight to be assigned to each flow (queue). This weight effectively controls the percentage of the link's bandwidth each flow will get. WFQ is a generalization of fair queuing (FQ) [13] [14] [15]. Both in WFQ and FQ, each data flow has a separate FIFO queue.

V. NETWORK DESIGN AND CONFIGURATION

The following network design has been taken into consideration to evaluate network performance on various queuing network. At the first step single traffic is used for each of the functions such as Ftp, Video Conferencing and VoIP which is shown in Fig 3. Fig 4 and Fig 5 shows intermediate and heavy traffic load condition and it uses three and four routers. For 3G and 4G requirement the basic architecture can be modified with reference of bandwidth. The network model has been configured for constant traffic condition result has been explored for voice and video application using FIFO, PQ, and WFQ queuing discipline.

Performance based on queuing network has been discussed in past using various queuing policy but failed to achieve wide acceptance due to various complexity [16] [17].

The below configurations applied in the Opnet Modeler and simulated to get results.

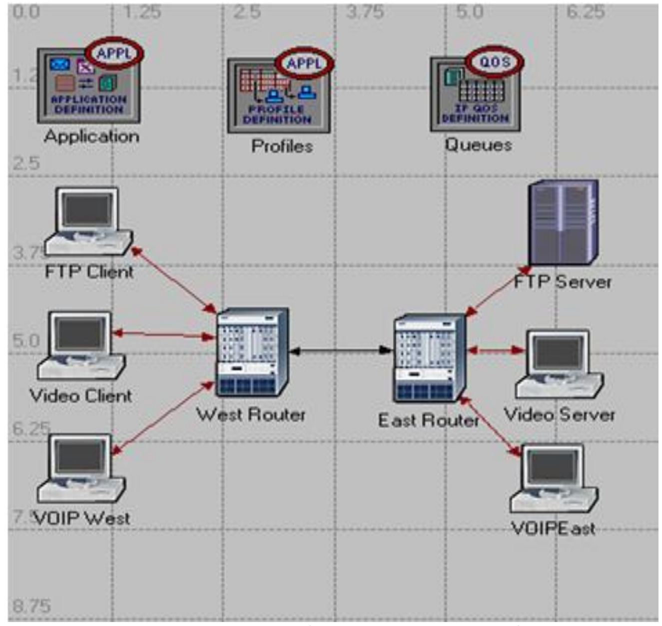

Figure 3. Network architecture for FIFO, PQ and WFQ for light load.

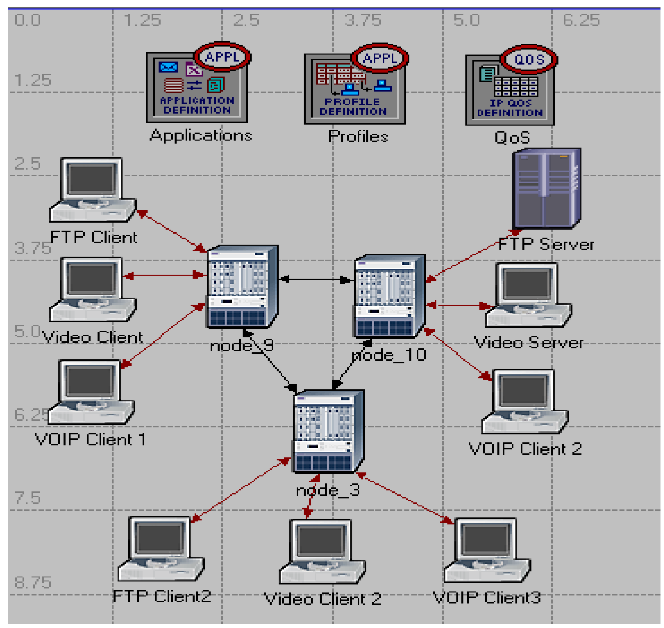

Figure 4. Network architecture for FIFO, PQ and WFQ for Intermediate load

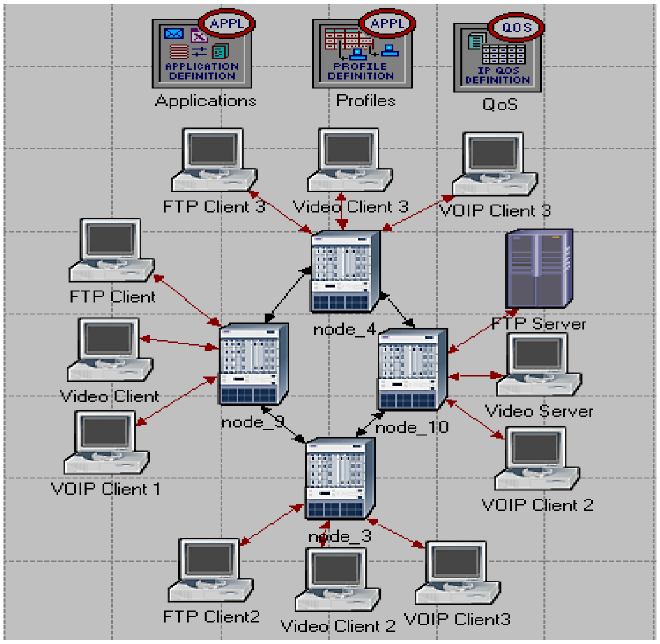

Figure 5. Network architecture for FIFO, PQ and WFQ for heavy load

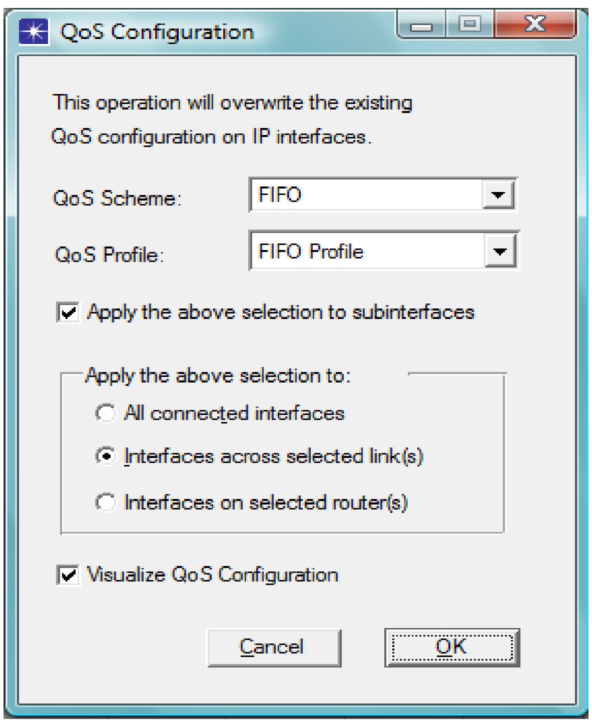

Figure 6. QoS Configuration

The architecture has been further modified and a bandwidth of 50 Mbps to 100 Mbps has been considered for 3G network and tested multimedia content delivery over this network.

For 4G networks the architecture has been modified and considered bandwidth up to 1Gbps and tested for multimedia content delivery over this network. Packet end to end delay and packet delay variation has been evaluated for all the network configuration model using different queuing discipline.

Different queuing discipline in the routers can affect the performance of the applications and the utilization of the network resources. Routers need to be configured for those three Queuing disciplines. The configurations are given Fig.6

VI. SIMULATIONS RESULTS AND ANALYSIS

Simulation has been done using OPNET software for every queuing scheme and packet end to end delay, packet delay variation and traffic dropped is measured for variable bandwidth. It is tested for voice traffic and video conferencing.

Table 1, 2, 3 shows packet end to end delay and packet delay variation for FIFO, PQ and WFQ scheme for audio and video over variable bandwidth. These results have been evaluated for light load condition network configuration model. It has been also observed that results are similar for intermediated load and heavy load network configuration model for 100 Mbps and 1Gbps.

Fig 7, 8 and 9 shows packet end to end delay in case of voice transmission for light load, intermediate load and heavy load configuration model. Packet end to end time delay is nearly zero for both PQ and WFQ scheme. As the time increases PQ and WFQ groups packet shows same characteristic. Packet end to end delay is always higher in case of FIFO scheme.

TABLE 1. STATISTICS OF FIFO SCHEME OVER VARIABLE BANDWIDTH

Bandwidth	FIFO (Audio)		FIFO (Video)	
	Packet End To End Delay (Sec)	**Packet Delay Variation (Sec)**	**Packet End To End Delay (Sec)**	**Packet Delay Variation (Sec)**
10 Mbps	0.9208	0.0684	0.845	0.056
100 Mbps	0.915479	0.0693365	0.864995	0.057727
1 Gbps	0.794608	0.057637	0.748554	0.0432041

TABLE 2. STATISTICS OF PQ SCHEME OVER VARIABLE BANDWIDTH

Bandwidth	PQ (Voice)		PQ (Video)	
	Packet End To End Delay (Sec)	Packet Delay Variation (Sec)	Packet End To End Delay (Sec)	Packet Delay Variation (Sec)
10 Mbps	0.364336	0.00728955	0.00428886	0.0000050662
100 Mbps	0.338956	0.00623114	0.00414799	0.000005106
1 Gbps	0.32047	0.00529942	0.00412595	0.0000050861

TABLE 3. STATISTICS OF PQ SCHEME OVER VARIABLE BANDWIDTH

Bandwidth	WFQ (Voice)		WFQ (Video)	
	Packet End To End Delay (Sec)	Packet Delay Variation (Sec)	Packet End To End Delay (Sec)	Packet Delay Variation (Sec)
10 Mbps	0.0042	0.0000050265	3.83405	1.50679
100 Mbps	0.00416661	0.0000050066	3.97437	1.50678
1 Gbps	0.00413858	0.0000050265	2.08074	0.524183

Fig 10, 11 and 12 shows packet delay variation in case of voice transmission for light load, intermediate load and heavy load configuration model. Packet delay variation is nearly zero for both PQ and WFQ scheme. As the time increases PQ and WFQ groups packet shows same characteristic. Packet delay variation is always higher in case of FIFO scheme.

Fig. 13, 14 and 15 shows packet end to end delay for video transmission for light load, intermediate load and heavy load configuration model. Here packet end to end time delay is higher for WFQ scheme where as it is lower for PQ scheme. Packet end to end delay is always higher in case of FIFO scheme.

Fig 16, 17 and 18 shows packet delay variation in case of video transmission for light load, intermediate load and heavy load configuration model. Here packet delay variation is higher for WFQ scheme where as it is lower for PQ scheme. Packet delay variation is always higher in case of FIFO scheme.

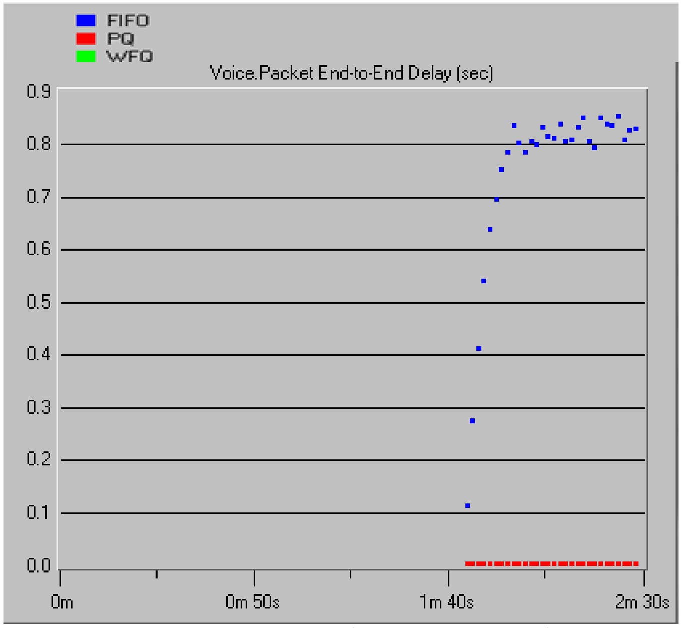

Figure 7. Packet end to end delay for FIFO, PQ & WFQ for light load

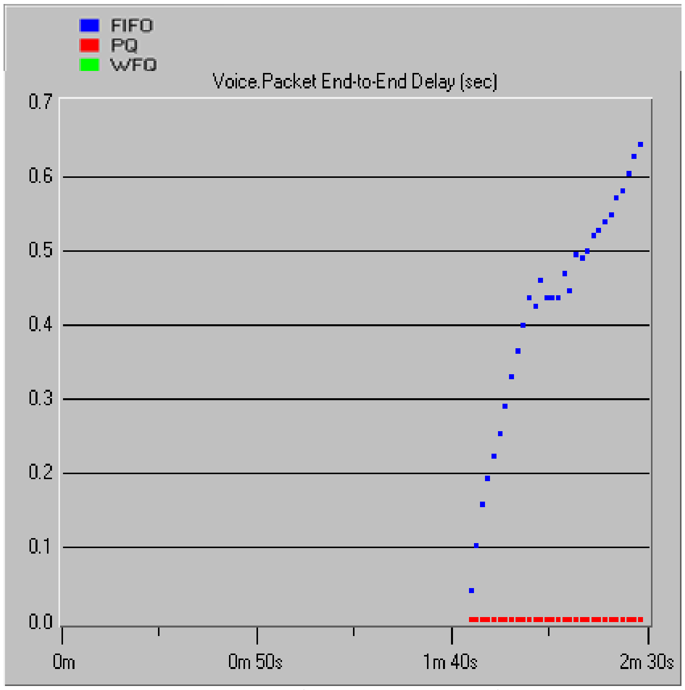

Figure 8. Packet end to end delay for FIFO, PQ & WFQ for intermediate load

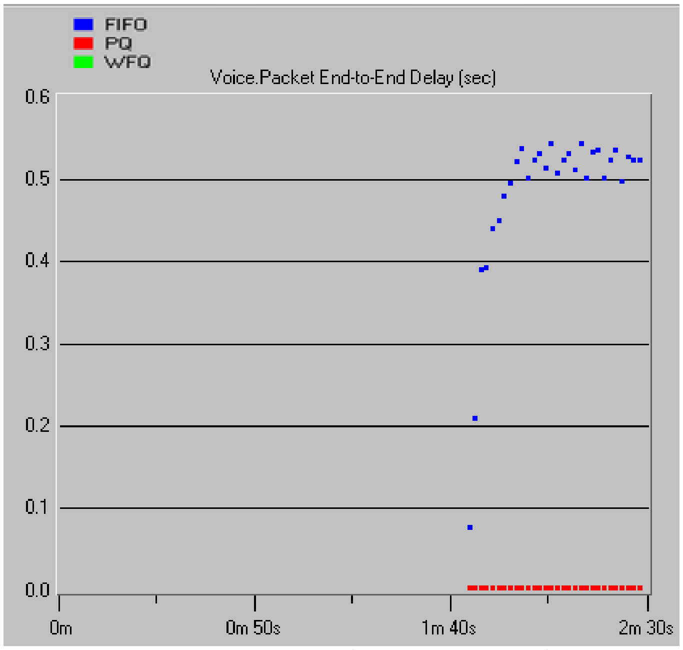

Figure 9. Packet end to end delay for FIFO, PQ & WFQ for heavy load

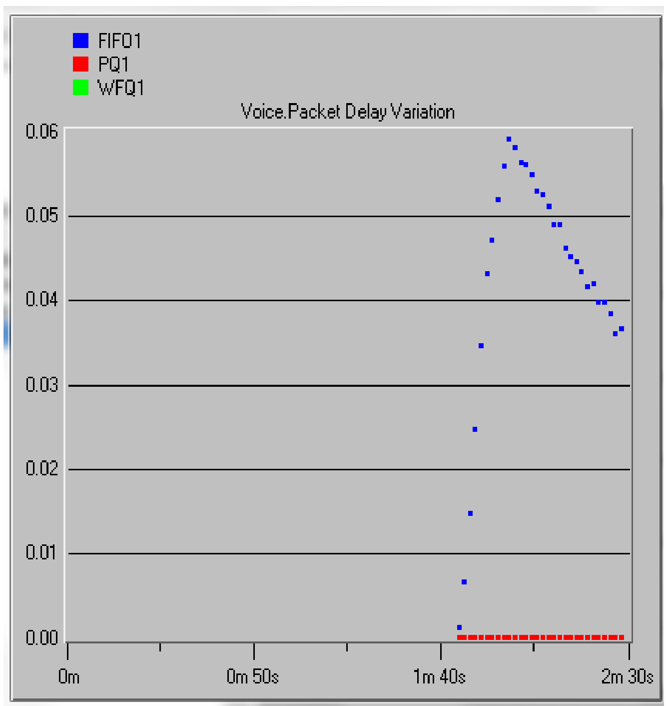

Figure 10. Packet Delay Variation for FIFO, PQ & WFQ for light load

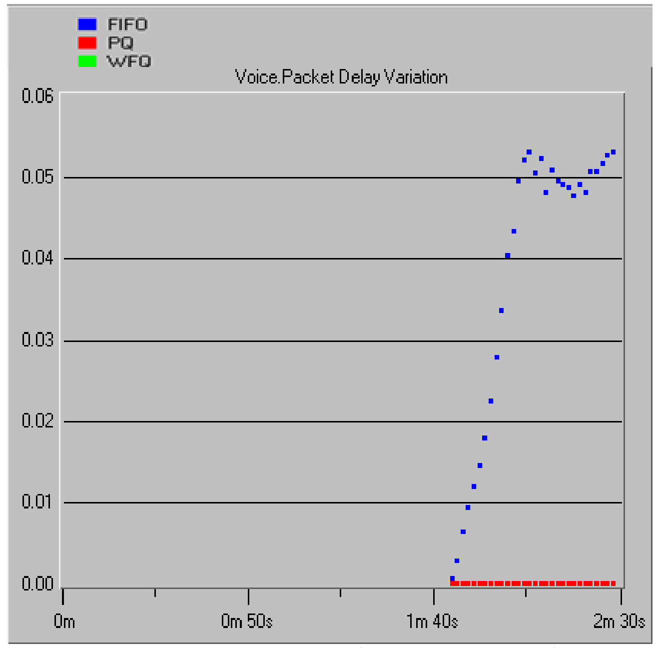

Figure 11. Packet Delay Variation for FIFO, PQ & WFQ for intermediate load

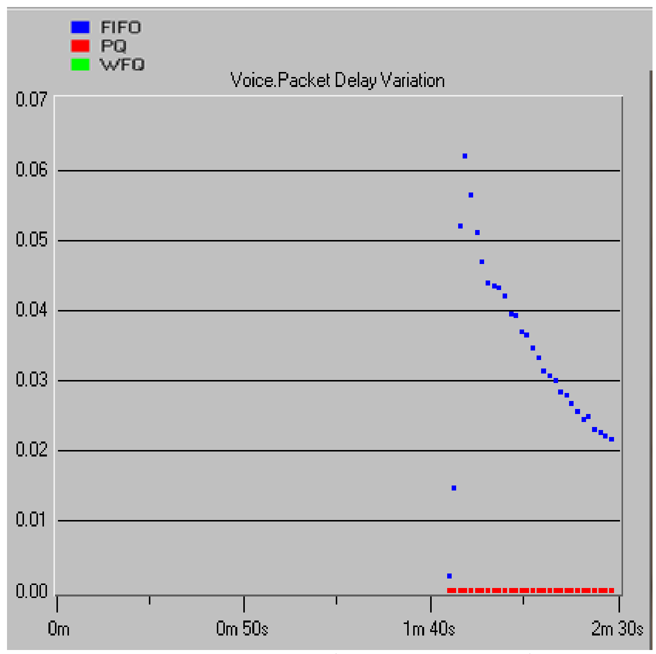

Figure 12. Packet Delay Variation for FIFO, PQ & WFQ for heavy load.

Table 4. Statistics of Packet End to End Delay for voice application

Network Configuration	Packet End To End delay (Sec) FIFO	PQ	WFQ
Light load	0.853373	0.00427152	0.00427152
Intermediate load	0.643753	0.00300662	0.00300662
Heavy load	0.543209	0.00281125	0.00275496

Table 5. Statistics of Packet Delay Variation for voice application

Network Configuration	Packet Delay Variation (Sec) FIFO	PQ	WFQ
Light load	0.36158940	0.000005086	0.000005026
Intermediate load	0.05344370	0.00000331	0.000005132
Heavy load	0.02201986	0.00000373	0.000003874

Table 4 and Table 5 shows packet end to end delay and packet delay variation for FIFO, PQ and WFQ scheme for voice applications.

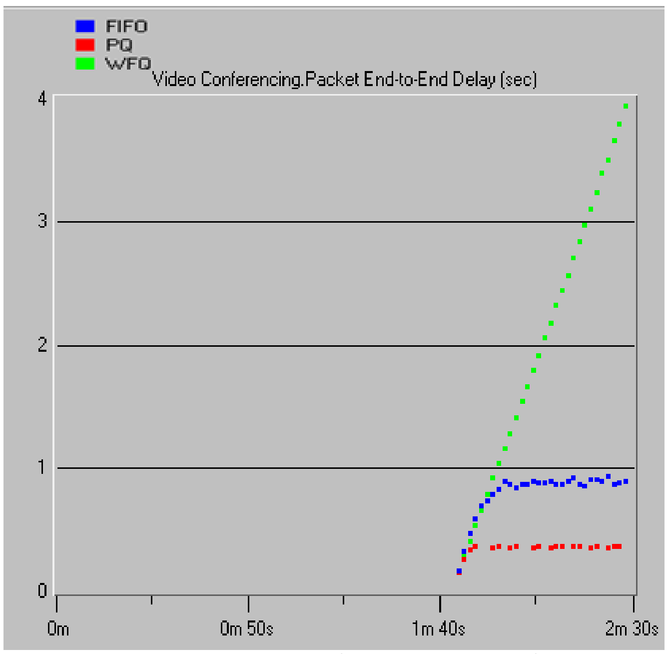

Figure 13. Packet end to end delay for FIFO, PQ & WFQ for light load

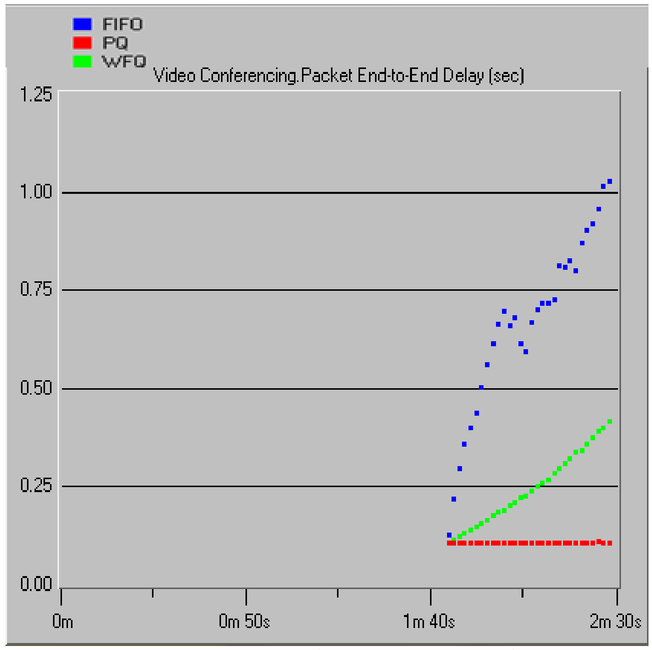

Figure 14. Packet end to end delay for FIFO, PQ & WFQ for intermediate load

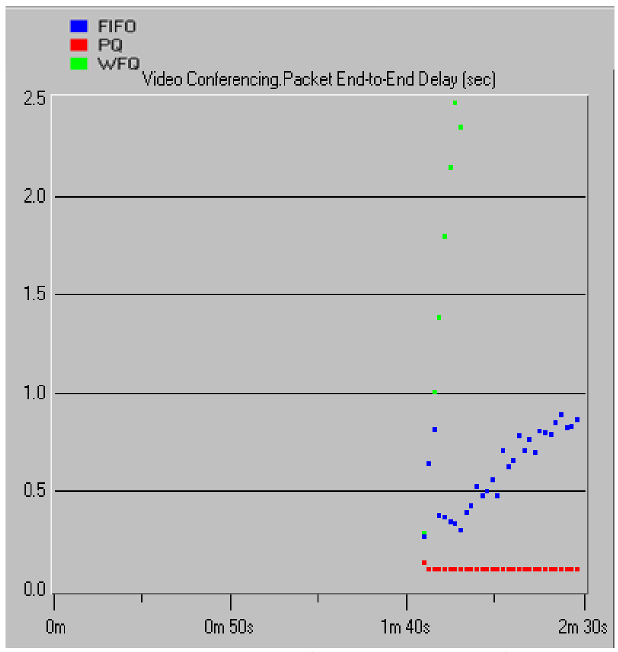

Figure 15. Packet end to end delay for FIFO, PQ & WFQ for heavy load.

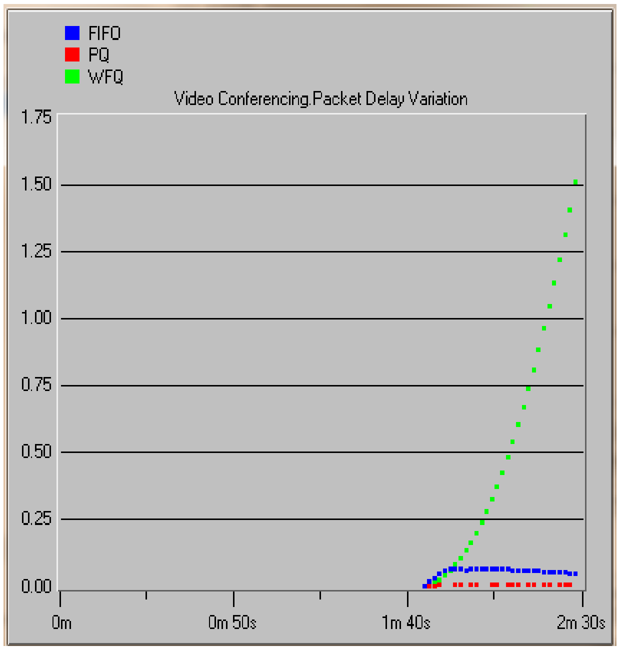

Figure 16. Packet Delay Variation for FIFO, PQ & WFQ for light load

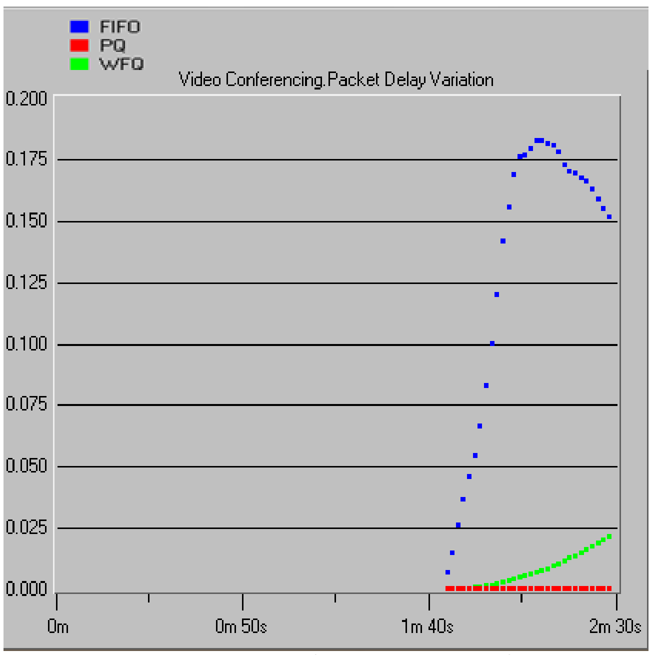

Figure 17. Packet Delay Variation for FIFO, PQ & WFQ for intermediate load.

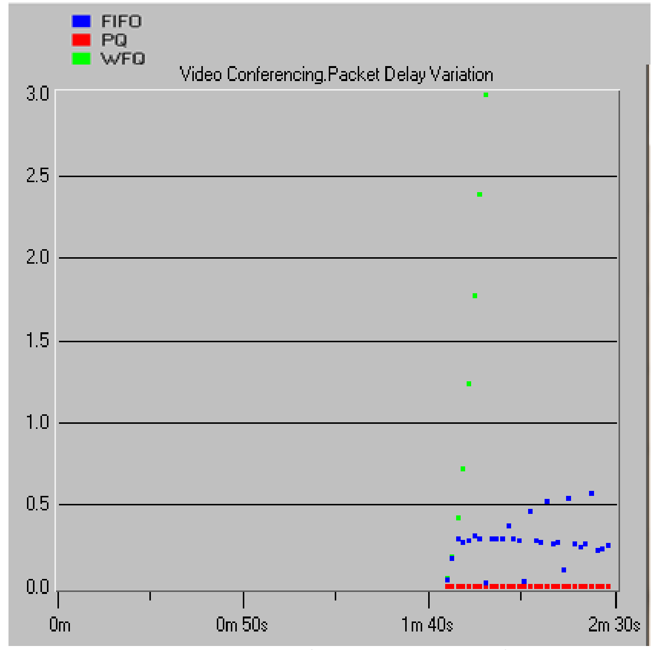

Figure 18. Packet Delay Variation for FIFO, PQ & WFQ for heavy load.

Table 6. Statistics of Packet End to End Delay for video application

Network Configuration	Packet End To End delay (Sec) FIFO	PQ	WFQ
Light load	0.92777	0.364327	3.93516
Intermediate load	1.02772	0.106788079	0.417723
Heavy load	0.890911	0.105298013	0.11589403

Table 7. Statistics of Packet Delay Variation for video application

Network Configuration	Packet Delay Variation (Sec) FIFO	PQ	WFQ
Light load	0.054039735	0.007205298	1.50697
Intermediate load	0.15231788	0.0000063576	0.0214625
Heavy load	0.569669	0.0000463576	0.01986754

Table 6 and Table 7 shows packet end to end delay and packet delay variation for FIFO, PQ and WFQ scheme for video applications.

It is observed that, both packet end to end delay and packet delay variation are higher in all the cases for FIFO. On other side, PQ and WFQ gives the same results when implemented in the above configuration model. The packet end to end delay and packet delay variation comes out to be 4ms and 0.005ms which is less and are acceptable for voice applications.

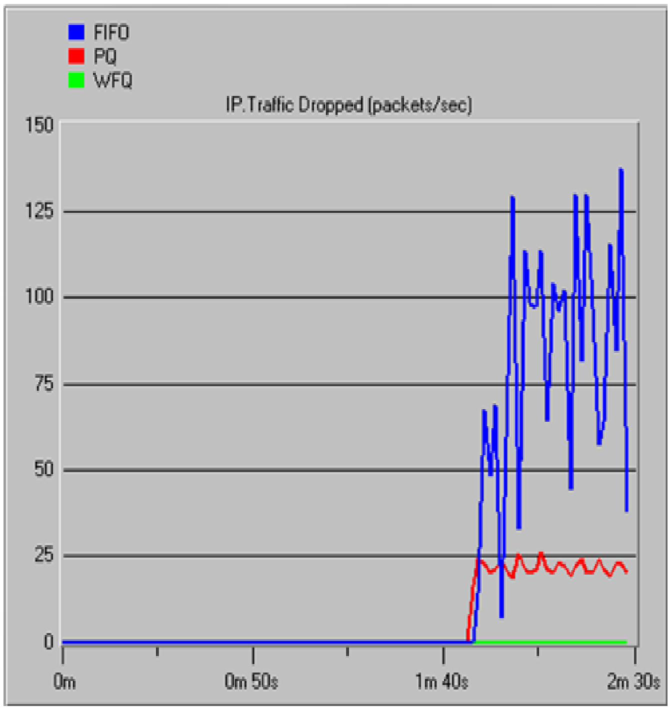

Figure 19. Traffic dropped for FIFO, PQ and WFQ for light load configuration.

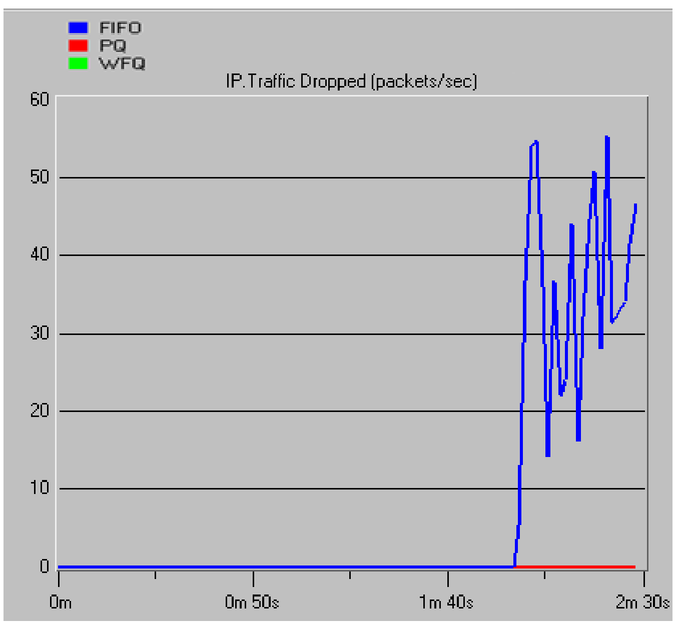

Figure 20. Traffic dropped for FIFO, PQ and WFQ for intermediate load configuration.

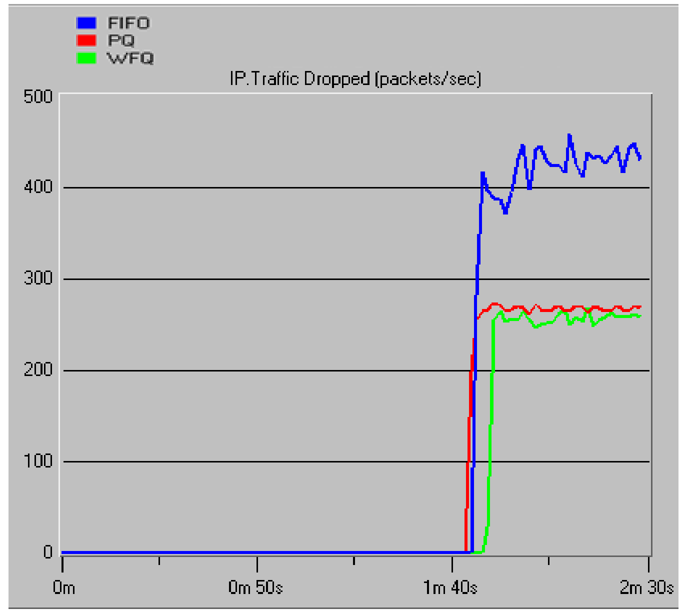

Figure 21. Traffic dropped for FIFO, PQ and WFQ for heavy load configuration.

Table 8. Statistics for IP Traffic Dropped

Network Configuration	**No. of Packets Dropped**		
	FIFO	**PQ**	**WFQ**
Light load	139	26	1
Intermediate load	55	1	1
Heavy load	458	273	267

Fig 19, 20 shows traffic drop statistic. Fig 21 shows traffic drop statistic for heavy load condition and also Table V shows the statistical figures for the traffic dropped.

It has been observed that as the traffic drop is higher in FIFO scheme for all the network configuration model. For WFQ scheme it is minimum in all the network configuration model.

VII. CONCLUSION

It has been observed after comparing the detail statistics of the result that packet end to end delay, packet delay variation and Traffic dropped is always higher in case of FIFO scheme for both voice and video based content deliver over network. Results have been evaluated for light load, intermediated load and heavy load configuration model.

PQ scheme gives better result in case of video based content delivery over the network. However WFQ gives best result among them. Result shows that traffic drop is almost zero in case of WFQ scheme.

As per the presented result here in case of WFQ scheme packet end to end delay and packet delay variation are proper for audio based content but for video it is bit higher. Bandwidth of 10Mbps, 100 Mbps and 1 Gbps has been considered to do the critical analysis of above configuration model. Results are useful for performance modeling for 3G and 4G network.

VIII. ACKNOWLEDGEMENT

Our sincere thanks to Thakur educational trust and management to provide all the facilities and infrastructure to carried out the research work.

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Performance Modeling of Queuing Techniques for Enhance QoS Support for Uniform and Exponential VoIP & Video based Traffic Distribution

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***Abstract*— In the near future there will be demand for seamless service across different types of network, so it's a significant issue of how to guarantee the quality of service (QoS) and support a variety of services. One important generalization of the Next Generation Network is it's a queue of network. It is expected that traffic in NGN will undergo both quantitative and qualitative changes. Such networks can model problems of contention that arise when a set of resources is shared. With the rapid transformation of the Internet into a commercial infrastructure, demands for service quality have rapidly developed. This paper gives a comparative analysis of three queuing systems FIFO, PQ and WFQ with different traffic distribution. Different traffic distribution includes constant, uniform and exponential traffic distribution. Packet end to end delay, traffic drop and packet delay variation is evaluated through simulation. Results have been evaluated for uniform and exponential traffic distribution. Result shows WFQ has better quality comparing with other techniques in a voice based services and having minimum traffic drop where as PQ techniques is better in Video based services. Simulation is done using OPNET.**

Keywords- QoS-Quality of service; NGN-Next Generation Network; FIFO- First-in-first-out; PQ- Priority queuing; WFQ- Weighted-Fair queuing; VoIP- Voice over Internet Protocol.

I. INTRODUCTION

It is desirable to impose some traffic-control policy at a network node which depends only on the external traffic loads on the input and output links, but not on the detailed addressing or distribution of packets from inputs to outputs. It should be possible to guarantee the grade of-service of an input-output connection by controlling the aggregate loads on the input and output. There are three type of traffic distribution possible. It is constant, uniform and exponential. Exponential distribution produces heavy traffic as compared to uniform distribution. Hence the amount of traffic dropped is more in exponential distribution [1].

To offer better quality of service in a network a lot of parameter should be considered such as bandwidth, latency, delay, jitter and packet loss etc. These issues have been discussed extensively in past [2] [3]. There are two types of networks.

- Open Queuing network: It is characterized by one or more sources of job arrivals and correspondingly one or more sinks that absorb jobs departing from the network.
- Close Queuing network: In this type of network job neither enters nor depart from the network. The probability of transition between service centers and the distribution of job service time characterized the behavior of jobs within the network. For each center the no. of servers the scheduling discipline and the size of the queue must be specified. We assume that the scheduling is FCFS and that each server has a queue of unlimited capacity.

Output of a queuing system and various algorithms on performance evaluation has been discussed extensively in past through many research papers [4] [5] [6].

II. VARIOUS QUEUING TECHNIQUES

In the generic model a node or a service center represent each resource. A service center may have one or more server associated with it. If a job requesting service finds all the server at a service center busy, it will join the queue associated with the center and a later point in time when a server becomes idle a job from the queue will be selected for service according to some scheduling discipline.

There are many elementary queuing models. Attention is paid to methods for the analysis of these models, and also to applications of queuing models on 3G and 4G network. Various queuing disciplines can be used to control which packets get transmitted and which packets get dropped. The queuing disciplines are:

- First-in-first-out (FIFO) queuing.
- Priority queuing (PQ)
- Weighted-Fair queuing. (WFQ)

First In First out (FIFO) is the most basic queuing discipline. This expression describes the principle of a queue or first-come first serve behavior: what comes in first is handled first, what comes in next waits until the first is finished etc.

In FIFO queuing all packets are treated equally by placing them into a single queue, then servicing them in the same order they were placed in the queue. FIFO queuing is also referred to as First Come First Serve (FCFS) queuing. Although a single FIFO queue seems to provide no QoS features at all, it actually does affect drop, delay, and jitter. Because there is only one queue, the router need not classify traffic to place it into different queues and router need not worry about how to decide from which queue it should take the next packet—there is only one choice. Due to this single queue uses FIFO logic, the router need not reorder the packets inside the queue. With a longer queue, however, the average delay increases, because packets may be enqueued behind a larger number of other packets. In most cases when the average delay and average jitter increases [7].

Priority Queuing assigns multiple queues to a network interface with each queue being given a priority level. A queue with higher priority is processed earlier than a queue with lower priority. Priority Queuing has four preconfigured queues, high medium, normal and low priority queue. Queues are serviced in strict order of queue priority, so the high queue always is serviced first, then the next-lower priority and so on. If a lower-priority queue is being serviced and a packet enters a higher queue, that queue is serviced immediately. This mechanism is good for important traffic, but can lead to queue starvation. If packets arrive in the high queue then priority queuing drops everything its doing in order to transmit those packets, and the packets in other queue is again empty. When a packet is sent out an interface, the priority queues on that interface are scanned for packets in descending order for priority. The high priority queues are scanned first, then the medium priority queue and then so on. The packet at the head of the highest queue is chosen for transmission. This procedure is repeated every time when a packet is to be sent. The maximum length of a queue is defined by the length limit. When a queue is longer the limit packets are dropped [8].

The idea of the fair queuing (FQ) discipline is to maintain a separate queue for each flow currently being handled by the router. The router then services these queues in a round robin manner. WFQ allows a weight to be assigned to each flow (queue). This weight effectively controls the percentage of the link's bandwidth each flow will get. WFQ is a generalization of fair queuing (FQ) [9] [10] [11]. Both in WFQ and FQ, each data flow has a separate FIFO queue.

III. Network Design and Configuration

Various performance modeling on queuing network and mathematical analysis of getting exact solution has been presented via various research papers in past [12] [13]. The following network design has been taken into consideration to evaluate network performance on various queuing network. As shown in Fig 1, the network model consists of two routers having three kinds of traffic sources, FTP traffic, VoIP traffic and video conferencing traffic. The network has been configured for uniform and exponential traffic distribution and result has been explored for voice and video application using FIFO, PQ, and WFQ queuing discipline.

Fig. 2 and 3, shows a heavy traffic load condition and it uses three routers and four routers respectively. For all the network configuration packet end to end delay, traffic drop and packet delay variation has been measured for different queuing discipline. Performance based on queuing network has been discussed in past using various queuing policy but failed to achieve wide acceptance due to various complexity [14] [15] [16].

The below configurations applied in the OPNET IT Guru Academic Edition and simulated to get results.

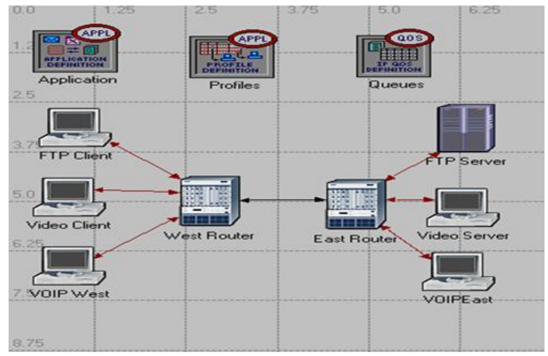

Figure 1. Network Model with 2 Routers

The link connecting the two routers is the bottleneck in the communication. The capacity of this link is 1.54 Mbps whereas all the other links have a capacity of 10Mbps. The following network model is modified by adding one more router to simulate heavy traffic load which is shown in Fig 2. One more router along with three clients is added to the network to increase the traffic load. Further as shown in Fig 3, the number of routers and clients have been almost doubled as compared to the first scenario. Different queuing discipline in the routers can affect the performance of the applications and the utilization of the network resources.

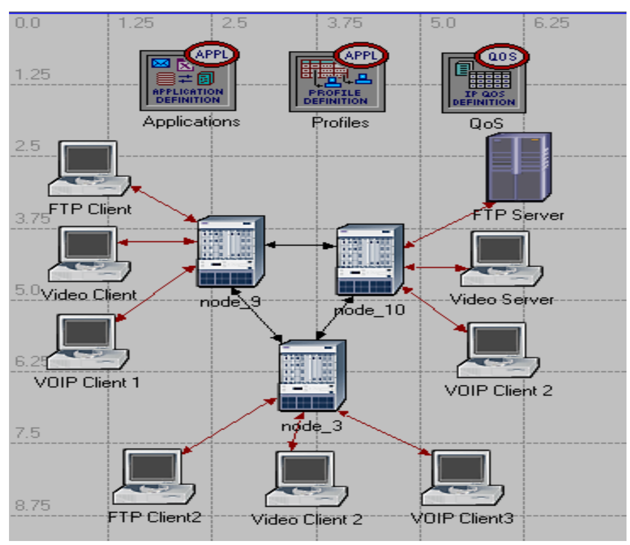

Figure 2. Network Model with 3 Routers

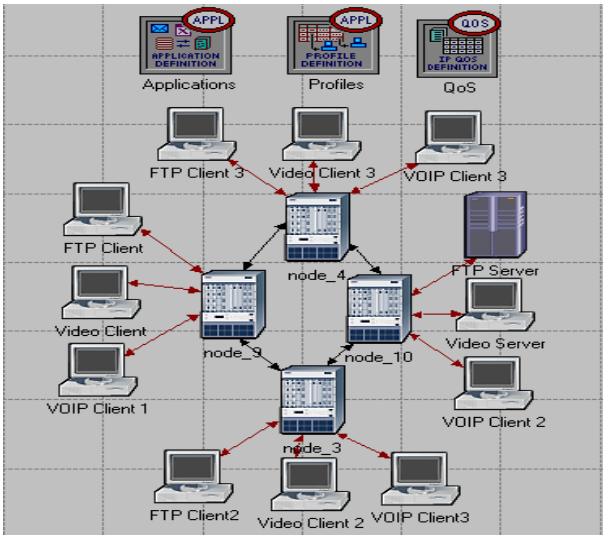

Figure 3. Network Model with 4 Routers

IV. ROUTER CONFIGURATION

Different queuing discipline in the routers can affect the performance of the applications and the utilization of the network resources. Routers need to be configured for FIFO, PQ and WFQ. The configurations are given Fig 4, 5, 6. Network architecture has been tested for multimedia content delivery and packet end to end delay packet delay variation and traffic dropped has been measured for different queuing discipline.

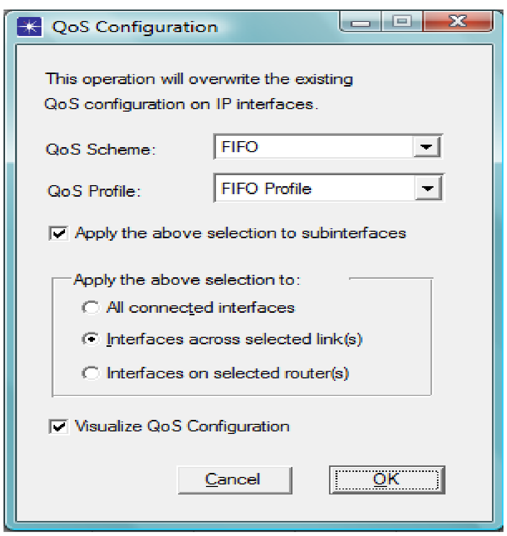

Figure 4. Router Configuration for FIFO

V. SIMULATIONS RESULTS AND ANALYSIS

Simulation has been done using OPNET software for every queuing scheme and packet end to end delay packet delay variation and traffic dropped is measured for variable bandwidth. It is tested for voice based and video traffic.

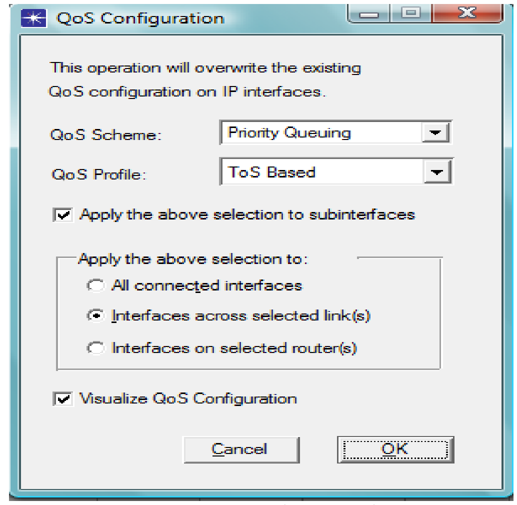

Figure 5. Router Configuration for PQ

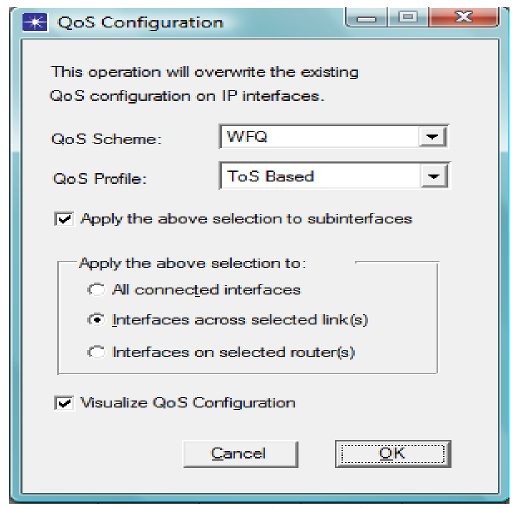

Figure 6. Router Configuration for WFQ

Table 1, 2 and 3 shows statistics for IP traffic dropped, packet end to end delay and delay variation for voice application.

Fig 7, 8, 9 shows individual traffic drop in case of voice transmission for various queuing discipline. Individual traffic drop is nearly zero for WFQ scheme. Individual traffic drop is always higher in case of FIFO scheme Table 1 shows that only packet was drooped when WFQ was implemented whereas 213 packets were dropped for FIFO under two router network model.

Fig 10, 11, 12 shows packet end to end delay in case of voice transmission. Packet end to end delay is nearly zero for both PQ and WFQ scheme. Packet end to end delay is always higher in case of FIFO scheme. From Table 2, packet end to end delay is approximately 744 ms for FIFO whereas it's just 5ms for WFQ.

A. Uniform Distribution Analysis

1) Voice Application

Table 1 Statistics for IP Traffic Dropped for Uniform Distribution

Number Of Routers	FIFO	PQ	WFQ
2	213	73	1
3	107	52	1
4	171	65	1

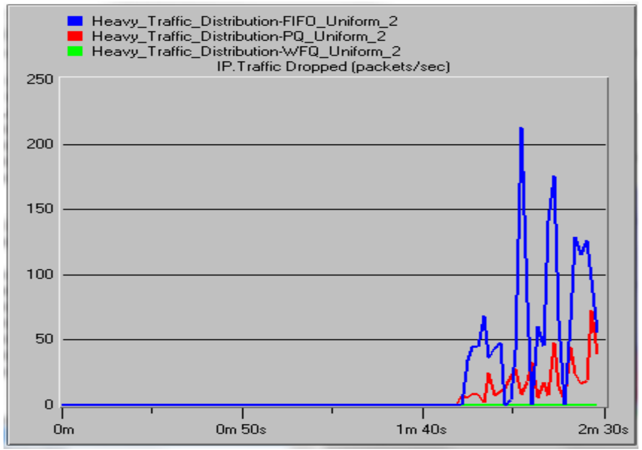

Figure 7. Traffic Dropped for 2 Routers

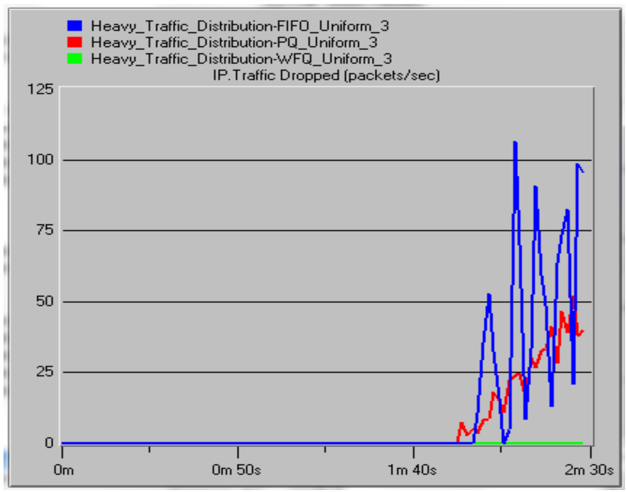

Figure 8. Traffic Dropped for 3 routers

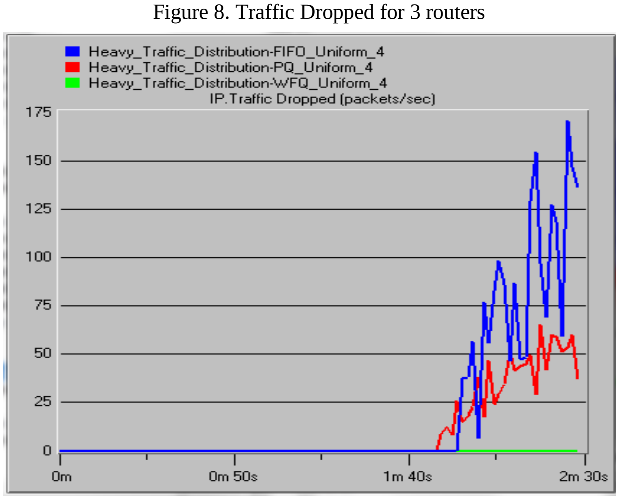

Figure 9. Traffic Dropped for 4 Routers

Table 2. Statistics for Packet End to End Delay for Uniform Distribution

Voice Applications	Packet End to End Delay (Sec)		
	FIFO	PQ	WFQ
2 Routers	0.744296	0.00433287	0.00599595
3 Routers	0.454643	0.00249817	0.00362311
4 Routers	0.229768	0.0029926	0.00412265

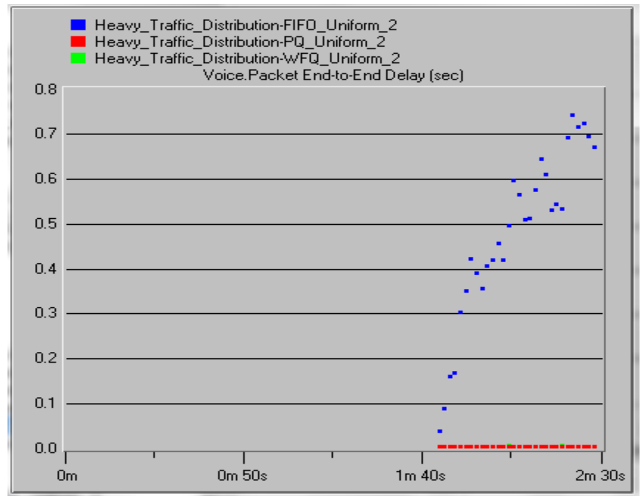

Figure 10. Packet end to end delay 2 Router network configuration

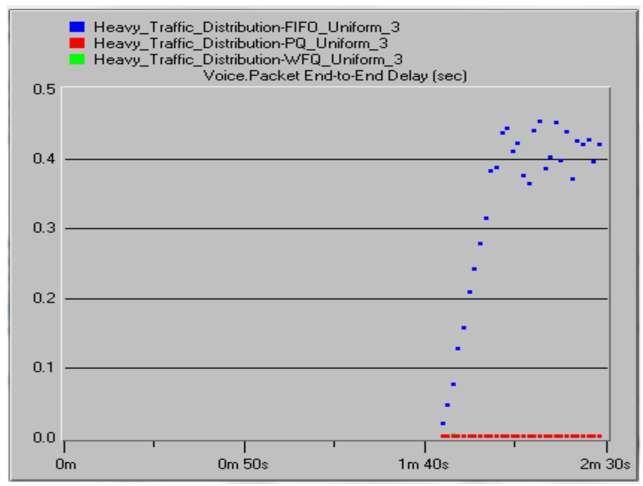

Figure 11. Packet end to end delay for 3 router configuration model.

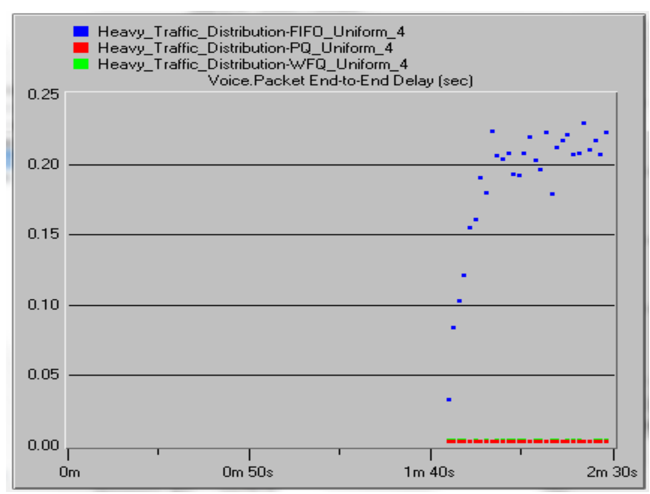

Figure 12. Packet end to end delay for 4 Router configuration model.

Table 3 Statistics for Packet Delay Variation for Uniform Distribution

Voice Applications	Packet Delay Variation (Sec) FIFO	PQ	WFQ
2 Routers	0.0694031	0.0000059404	0.0000339073
3 Routers	0.0715849	0.000003642	0.0000208609
4 Routers	0.0143389	0.0000057815	0.0000240066

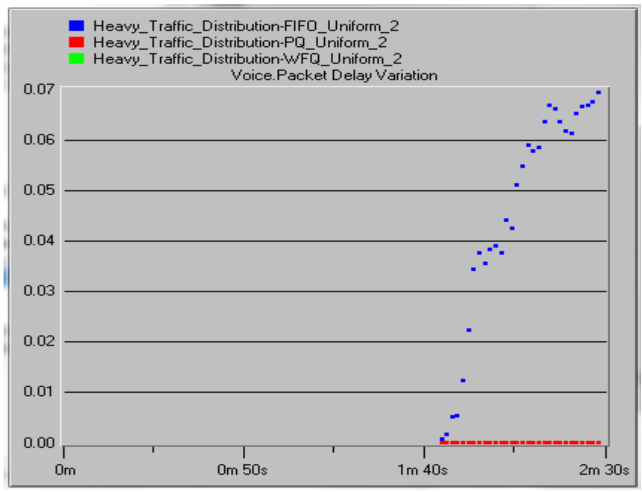

Figure 13. Packet delay variation 2 Router configuration model.

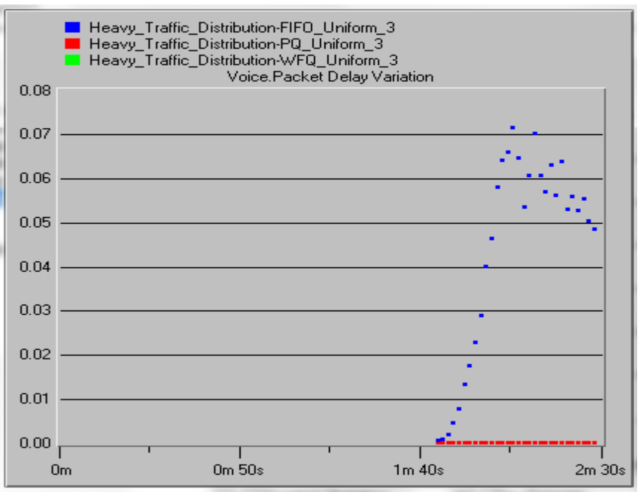

Figure 14. Packet delay variation for 3 Router configuration model.

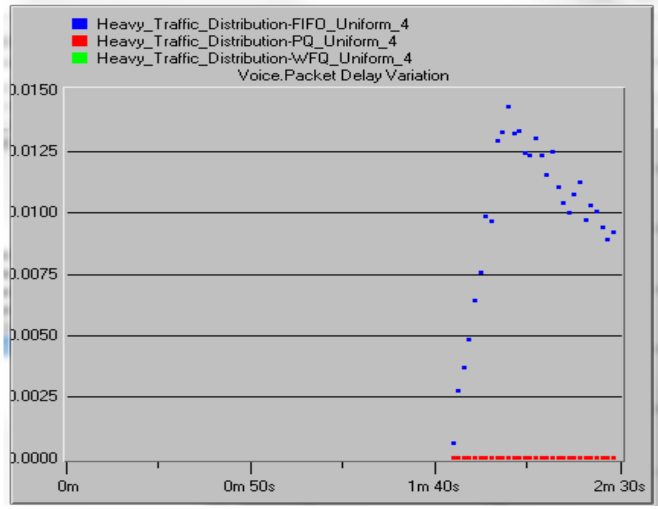

Figure 15. Packet delay variation for 4 Router configuration model.

Fig 13, 14, 15 shows packet delay variation of VoIP transmission for two router, three router and four router configuration model. Packet delay variation is nearly zero for both PQ and WFQ scheme. Packet delay variation is always higher in case of FIFO scheme. It comes out to be 69 ms whereas 0.03 ms for WFQ as shown in Table 3.

2) Video Application

Table 4. Statistics for Packet End to End Delay for Uniform Distribution

Video Application	Packet End To End Delay (Sec) FIFO	PQ	WFQ
2 Routers	0.84052	0.114292	0.11387
3 Routers	0.764052	0.103841	0.104795
4 Routers	1.34993	0.13636	0.132879

Table 4, 5 shows statistics for packet end to end delay and delay variation for video application.

Fig 16, 17, 18 shows packet end to end delay for all the three network architecture. Packet end to end delay is nearly zero for both PQ and WFQ scheme. Packet end to end delay is always higher in case of FIFO scheme. From Table 4, packet end to end delay is approximately 840 ms for FIFO whereas it’s 113ms for WFQ and 114ms for PQ which is quite less as compared to FIFO.

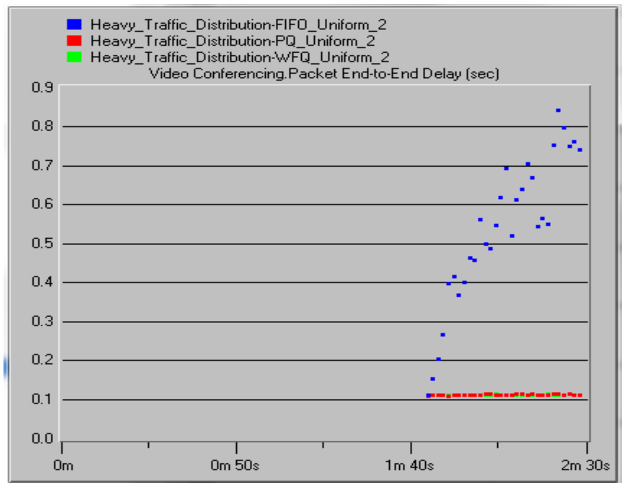

Figure 16. Packet end to end delay 2 Router network configuration

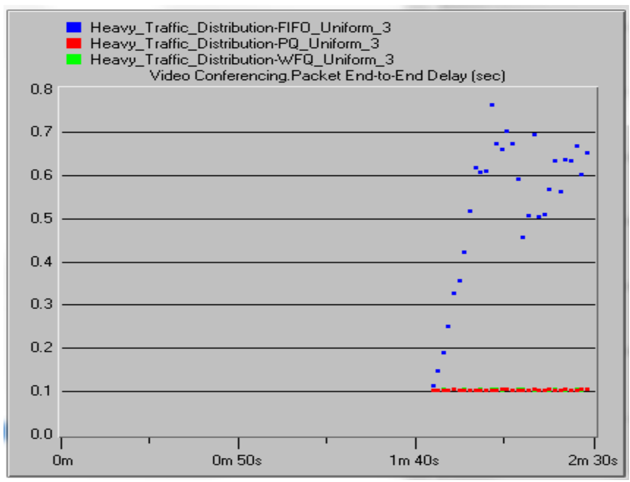

Figure 17. Packet end to end delay 3 Router network configuration

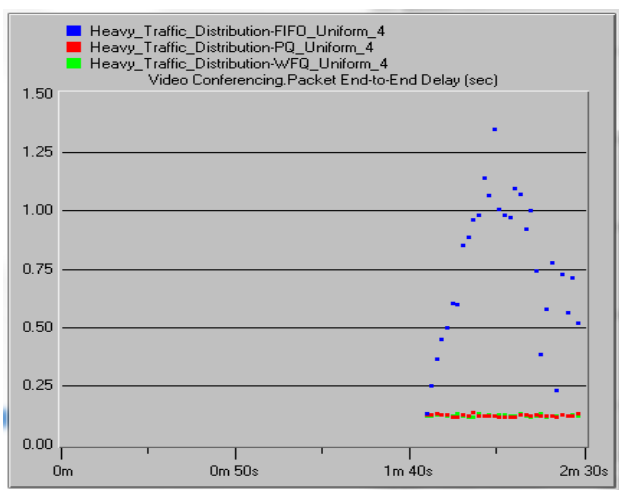

Figure 18. Packet end to end delay 4 Router network configuration

Table 5. Statistics for Packet Delay Variation for Uniform Distribution

Video Application	**Packet Delay Variation (Sec)** **FIFO**	**PQ**	**WFQ**
2 Routers	0.083246	0.0000092384	0.000016311
3 Routers	0.209997	0.0000556291	0.0000540397
4 Routers	1.18769	0.00227008	0.00207855

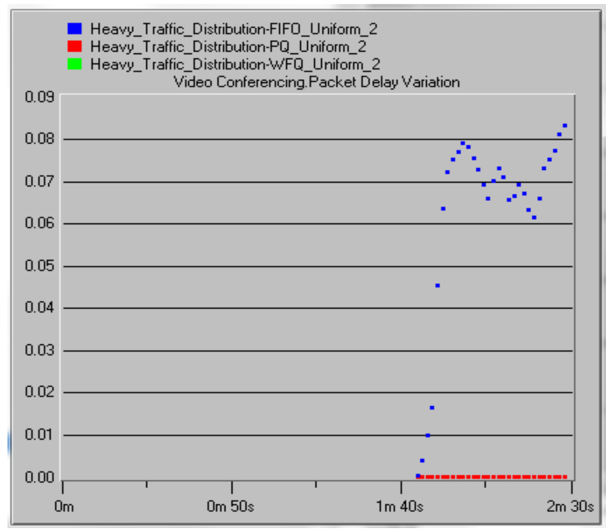

Figure 19. Packet delay variation for 2 Router configuration model.

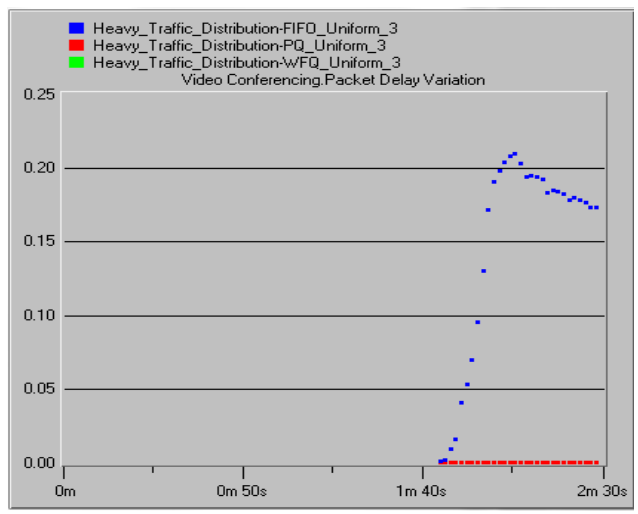

Figure 20. Packet delay variation for 3 Router configuration model.

Fig 19, 20, 21 shows packet delay variation of Video transmission for two router, three router and four router configuration model. Packet delay variation is nearly zero for both PQ and WFQ scheme. Packet delay variation is always higher in case of FIFO scheme. It comes out to be 83 ms whereas 0.01 ms for WFQ and 0.009 ms for PQ as shown in Table 5.

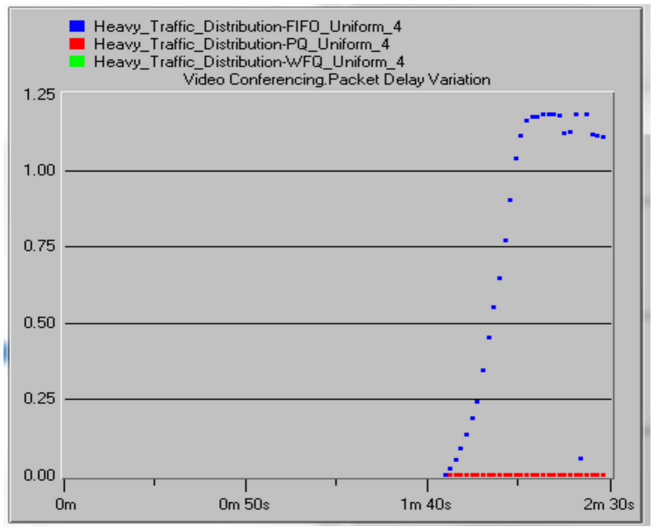

Figure 21. Packet delay variation for 4 Router configuration model.

B. *Exponential Traffic Distribution Analysis*

As Exponential distribution produces heavy traffic as compared to uniform distribution so the amount of traffic dropped is more in exponential distribution as shown in Fig 22, 23, 24 for all the three network model. Individual traffic drop is less for WFQ scheme.

Individual traffic drop is always higher in case of FIFO scheme.

Table 6, 7 and 8 shows statistics for IP traffic dropped, packet end to end delay and delay variation for voice application.

Fig 25, 26, 27 shows packet end to end delay in case of voice transmission. Packet end to end time delay is nearly zero for both PQ and WFQ scheme. Packet end to end delay is always higher in case of FIFO scheme.

1) *Voice Application*

Table 6. Statistics for IP Traffic Dropped for Exponential Distribution

Number Of Routers	FIFO	PQ	WFQ
2	579	163	70
3	409	281	120
4	821	515	519

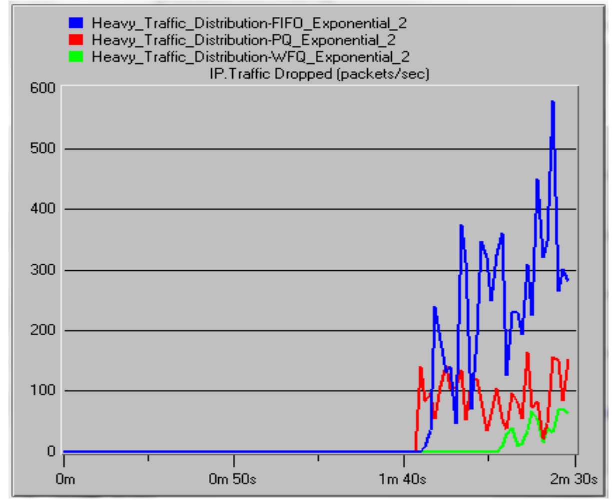

Figure 22. Traffic drop for 2 Router configuration model

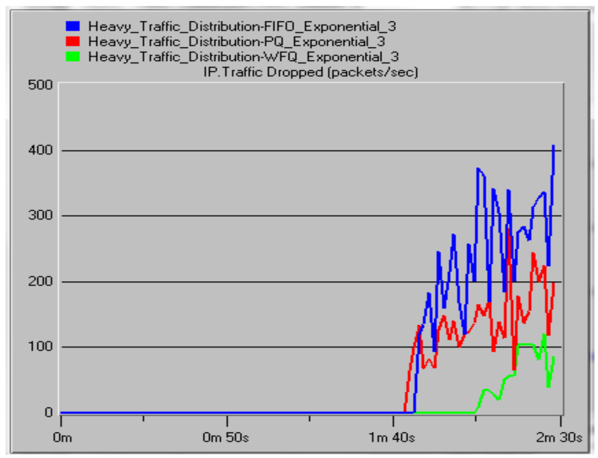

Figure 23. Traffic drop for 3 router configuration network model.

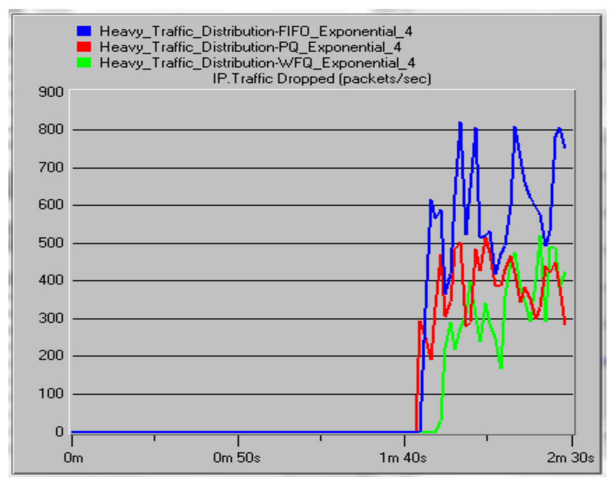

Figure 24. Traffic drop for 4 router configuration network model.

Table 7. Statistics for Packet End to End Delay for Exponential Distribution

Voice Applications	Packet End To End Delay (Sec) FIFO	PQ	WFQ
2 Routers	0.989209	0.00427783	0.00509089
3 Routers	0.735591	0.00302299	0.00325629
4 Routers	0.539466	0.0031793	0.00319812

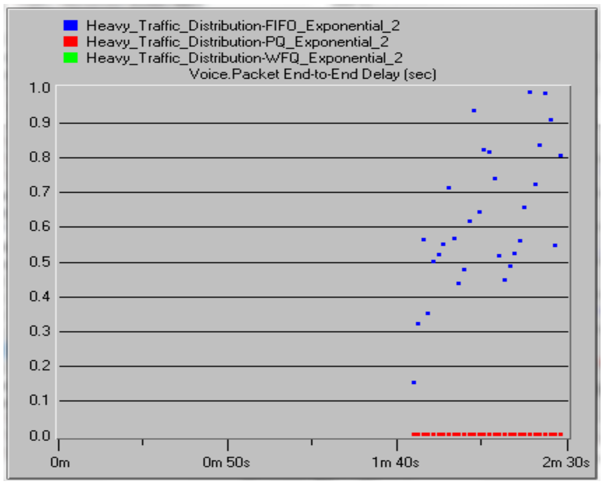

Figure 25. Packet end to end delay for 2 router configuration model.

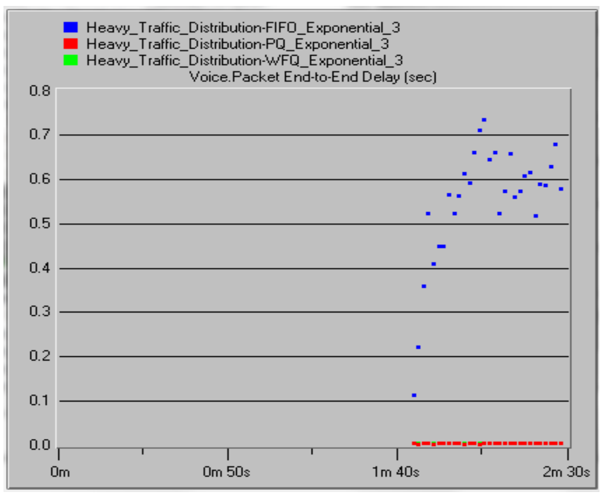

Figure 26. Packet end to end delay for 3 router configuration model.

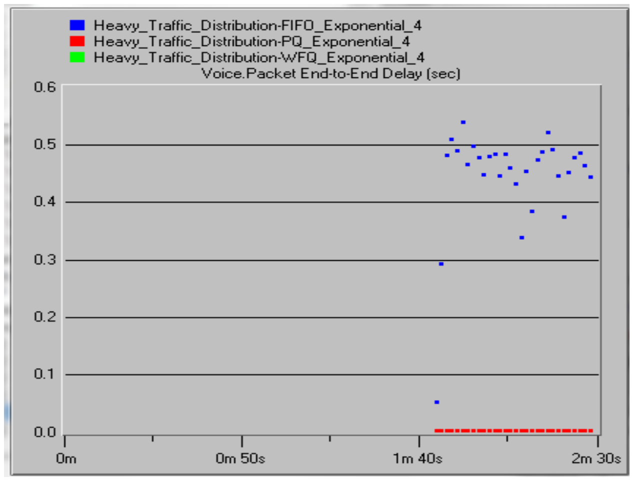

Figure 27. Packet end to end delay for 4 router configuration model.

Table 8. Statistics for Packet Delay Variation for Exponential Distribution

Voice Applications	Packet Delay Variation (Sec) FIFO	PQ	WFQ
2 Routers	0.081209	0.0000054636	0.0000115066
3 Routers	0.112362	0.000002987	0.0000115894
4 Routers	0.0989509	0.0000044536	0.0000096026

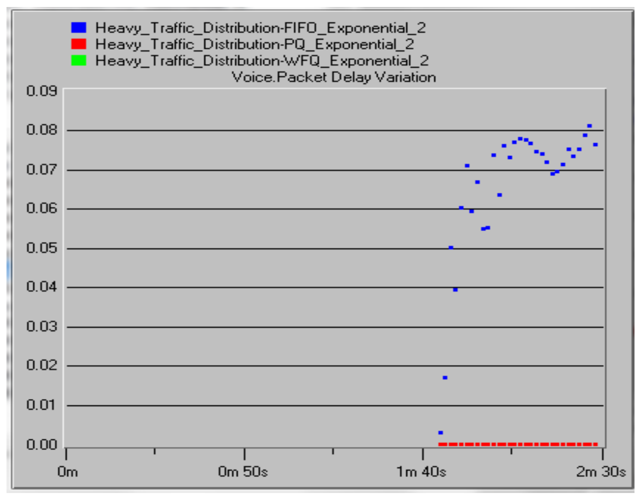

Figure 28. Packet delay variation for 2 router configuration model.

Packet delay variation is always higher in case of FIFO scheme.

Fig 28, 29, 30 shows packet delay variation of VoIP transmission for two router, three router and four router configuration models. Packet delay variation is nearly zero for both PQ and WFQ scheme.

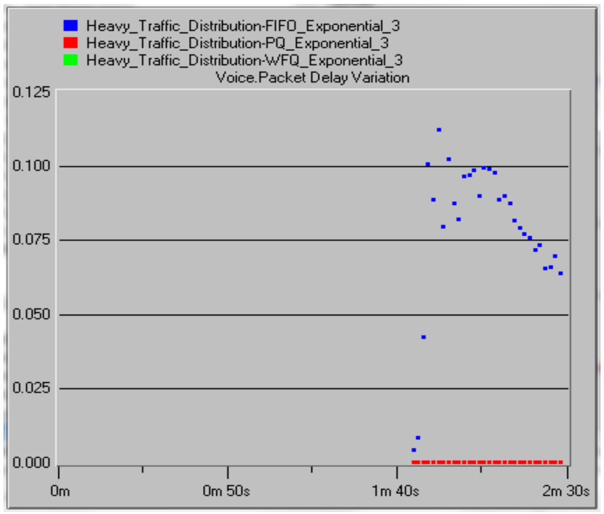

Figure 29. Packet delay variation for 3 router configuration model.

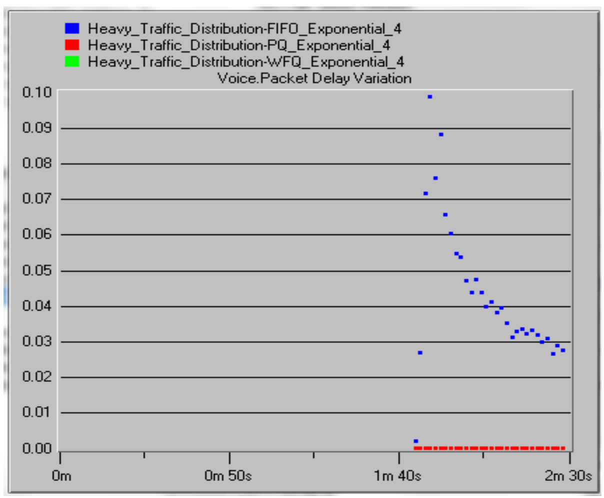

Figure 30. Packet delay variation for 4 router configuration model.

2) *Video Application*

Table 9, 10 shows statistics for packet end to end delay and delay variation for video application under Exponential Distribution.

Fig 31, 32 and 33 shows packet end to end delay for all the three network architecture. Unlike voice application, end to end delay comes out be much higher for video application when WFQ was implemented as compared to other two queuing algorithms. It more as video packets are transferred frame by frame and frames are nothing but still images having larger size.

So router takes more time to process these video packets there by increasing overall processing and queuing delay.

With PQ, video packets are transferred with higher priority. Thus end to end delay for PQ is less, it's almost 284 ms as shown in Table 9.

Table 9. Statistics for Packet End to End Delay Exponential Distribution

Video Applications	Packet End To End Delay (Sec) FIFO	PQ	WFQ
2 Routers	1.03799	0.284392	2.3843
3 Routers	1.15523	0.224697	1.9307
4 Routers	1.58502	0.265281	2.86008

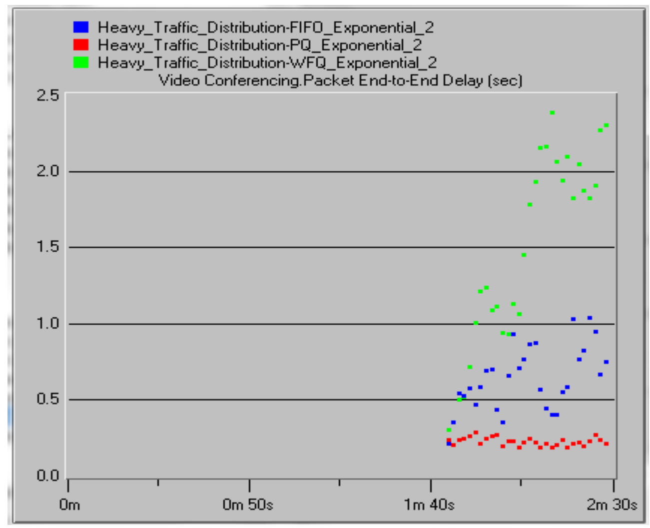

Figure 31. Packet end to end delay for 2 router configuration model.

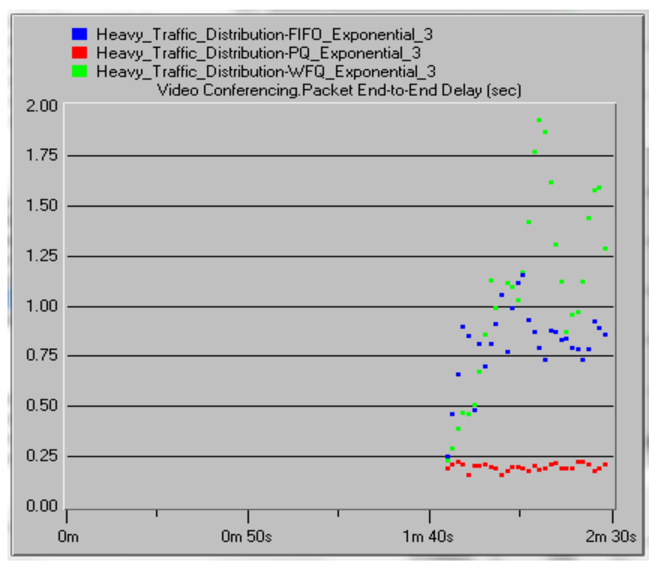

Figure 32. Packet end to end delay for 3 router configuration model.

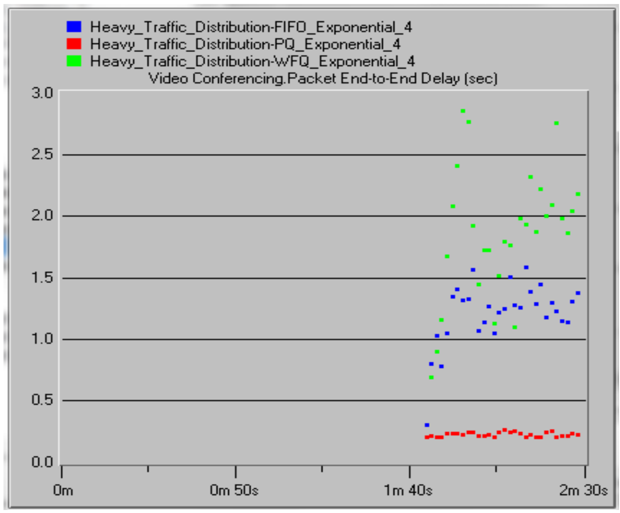

Figure 33. Packet end to end delay for 4 router configuration model.

Table 10. Statistics for Packet Delay Variation Exponential Distribution

Video Applications	Packet Delay Variation (Sec) PQ	WFQ	FIFO
2 Routers	0.12046	0.00722699	0.53762
3 Routers	0.283801	0.00758157	0.781538
4 Routers	1.22297	0.0156975	5.28668

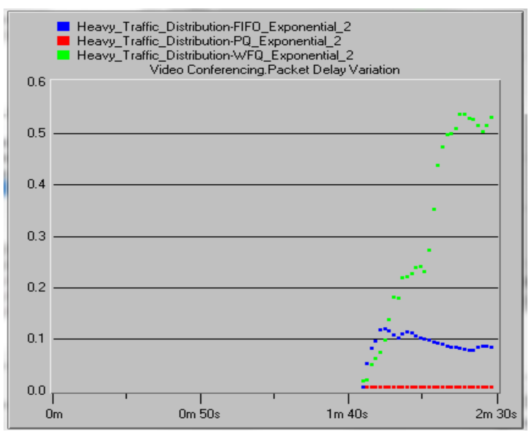

Figure 34. Packet delay variation for 2 router configuration model.

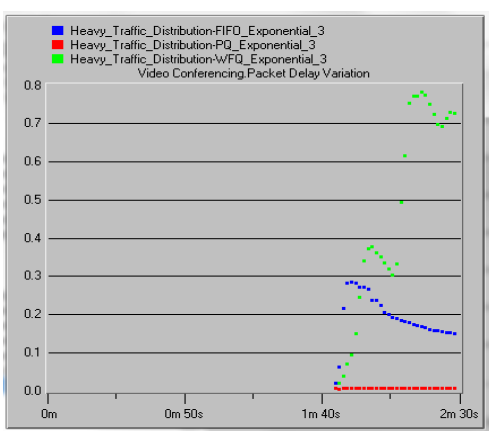

Figure 35. Packet delay variation for 3 router configuration model.

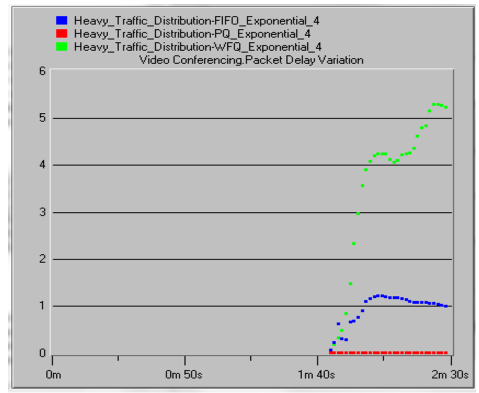

Figure 36. Packet delay variation for 4 router configuration model.

Packet delay variation is higher in case of WFQ scheme for video application. Fig 34, 35, 36 shows packet delay variation of Video transmission for two router, three router and four router configuration models. Packet delay variation is nearly zero for PQ scheme.

VI. CONCLUSION

Generally internet traffic is bursty in nature. Due to this reason in this current research work two distributions uniform and exponential has been consider which generate bursty data. It has been observed after comparing the detail statistics of the result that packet end to end delay, traffic drop and packet delay variation is always higher in case of FIFO scheme for both voice and video based content delivery over network. For voice application PQ and WFQ schemes produces acceptable results whereas for video application PQ scheme proves to be better.

VII. ACKNOWLEDGEMENT

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Texture Feature Extraction For Biometric Authentication using Partitioned Complex Planes in Transform Domain

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***Abstract*—Feature vector generation is an important step in biometric authentication. Biometric traits such as fingerprint, finger-knuckle prints, palmprint, and iris are rich in texture. This texture is unique and the feature vector extraction algorithm should correctly represent the texture pattern. In this paper a texture feature extraction methodology is proposed for these biometric traits. This method is based on one step transform of the two dimensional images and then using the intermediate transformation data to generate complex planes for feature vector generation. This method is implemented using Walsh, DCT, Hartley, Kekre Transform & Kekre Wavelets. Results indicate the effectiveness of the feature vector for biometric authentication.**

Keywords- Biometrics; Transforms; DCT; FFT; Kekre Transform; Hartley Transform; Kekre Wavelets.

I. INTRODUCTION

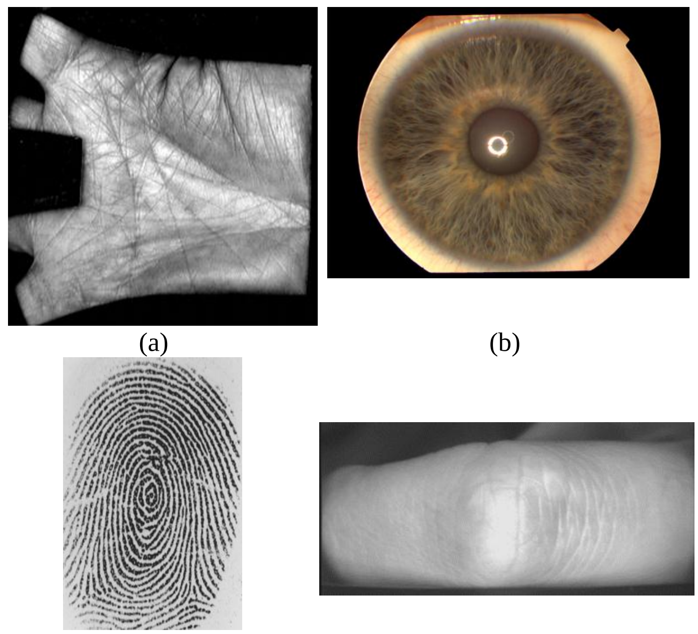
Biometric Authentication systems take the advantage of the uniqueness of the human body. They derive the classifying function from what a person is than what a person carries (like smartcard, token etc.). Biometrics comprises methods for uniquely recognizing humans based upon one or more intrinsic physical and/or behavioral traits. In computer science, in particular, biometrics is used as a form of identity access management and access control. It is also used to identify individuals in groups that are under surveillance [1].

Biometric characteristics can be divided in two main classes:

- Physiological are related to the shape of the body. Examples include, but are not limited to fingerprint, face recognition, DNA, Palmprint, hand geometry, iris recognition, which has largely replaced retina, and odor/scent [1], [2], [3].

- Behavioral are related to the behavior of a person. Examples include, but are not limited to typing rhythm, gait, and voice & handwritten signatures. Some researchers have coined the term behaviometrics for this class of biometrics [2]. In this paper mainly palmprints & iris are considered, which come under physiological biometric traits.

Palmprints and iris are rich in texture features, this information must be extracted in terms of feature vector for classification of these biometric traits. Sample of palmprint and iris from the database used for research is given below, Fig.1Shows palmprint sample from PolyU palmprint database [4] and iris image from Phoenix iris database [5].



(a) (b) (c) (d)

Figure 1. (a) Palmprint Image for PolyU Database [4] (b) Iris Image form Phoenix Iris Database[5]. (c) Fingerprint (d) Finger-Knuckle Print

Fingerprints, Palmprints & iris are believed to have the critical properties of universality, uniqueness, permanence and collectability for personal authentication [1], Finger-knuckle prints are one of the emerging biometric traits [6]. What's more, palmprints have some advantages over other hand-based biometric technologies, such as fingerprints and hand geometry. Palms are large in size and contain abundant features of different levels, such as creases, palm lines, texture, ridges, delta points and minutiae. Faking a palmprint is more difficult than faking a fingerprint because the palmprint texture is more complicated; and one seldom leaves his/her complete palmprint somewhere unintentionally.

Iris also have high degree of uniqueness due to the stricture formed by muscles controlling the cornea of human eye, but higher degree of user cooperation is required in case of iris based systems [1],[6].

Fingerprints are used widely for authorization as well as for forensic purpose, Finger-knuckles are also rich in texture and this property can be used for biometric authentication.

In this paper we have proposed a feature vector extraction method based on intermediate Walsh transform. Where instead of taking full 2D transform, intermediate transform is taken to generate the CAL & SAL functions of Walsh transform [7]. This information is used for generating complex Walsh plane [8] and feature vector is extracted from this. This method will be discussed in the coming section.

II. Existing Methods

Palmprints are very rich in texture. We can form the feature vector by extracting texture information. Various approaches are followed by researchers. Pan & Ruan [9] used 2D Gabor filters at different angles to extract the feature information. A phase based palmprint matching approach is suggested by T. Aokit et al. [10]. They used a Band Pass phase only correlation method to extract the spectral information. Another correlation based method is presented by N. E. Othman et al. [11]. They proposed an approach based on the application of unconstrained minimum average correlation energy (UMACE) filter for palmprint feature extraction and representation [11]. The UMACE methodology determines a different filter for each palmprint of authentic class, the correlation function gives peak for authentic palmprint, and this property is used for classification.

Principal component analysis based approaches are suggested in [12], [13], [14], [15], [16]. They include PCA on PCA & 2D PCA analysis of Gabor Wavelets, Moment invariants etc. Wavelet energy based feature vector are also possible for palmprints [17]. K. Wong, G. Sainarayanan and A. Chekima [18] used wavelet energy of the palmprint ROI. Palmprint image was decomposed using different types of wavelets for six decomposition levels. Two different wavelet energy representations were tested. The feature vectors were compared to the database using Euclidean distance or classified using feed-forward back-propagation neural network.

X. Wu, K. Wang, D. Zhang [19] used 3 level decomposition of palmprint and formed the wavelet energy based feature vector for matching. We have proposed a feature based on wavelet energy entropy. We have used Kekre’s Wavelet for extraction of feature vector and the palmprint was decomposed into five levels. For classification relative wavelet energy entropy as well as Euclidian distance based classifier is used [20].

The iris texture contains information which should be extracted and represented using selected feature vector. S Attrachi & K Faez [21] have used a complex mapping procedure and best-fitting line for the iris segmentation and 1D Gabor filter with two dimensional Principal Component Analysis (2DPCA) for the recognition approach. In the recognition procedure, they used the real term of 1D Gabor filter. In order to reduce the dimensionality of the extracted features, the new introduced 2DPCA method was used. Another such system using Gabor filter, 2DPCA & Gabor Wavelet Neural Network (GWNN) was proposed by Zhou et al. [22].

Koh et al. have proposed multimodal iris recognition system [23] using two iris recognitions and also the levels of fusion and the integration strategies to improve overall system accuracy. This technique first implements the Daugman’s iris system using the Gabor transform and Hamming distance. Second, they proposed an iris feature extraction method having a property of size invariant through the Fuzzy-LDA with five types of Contourlet transform. This gives a multimodal biometric system based on two iris recognition systems. To effectively integrate two systems, they used statistical distribution models based on matching values for genuine and impostor, respectively. Iris recognition based on linear discriminant analysis (LDA) and Linear Predictive Cepstral Coding (LPCC) was proposed by Chu & Ching [24]. In addition, a simple and fast training algorithm, particle swarm optimization (PSO), was also introduced for training the Probabilistic Neural Network (PNN) [24].

Automatic Fingerprint Identification Systems (AFIS) try to match fingerprint by matching these ridge valley structure. Mainly two types are systems are there [1], [6], they are Minutiae based matching and Correlation based matching. Fingerprint matching has been also approached from several different strategies, like image-based [6] and ridge pattern matching of fingerprint representations. There also exist graph-based schemes [1], [3], [6], [8] for fingerprint matching. Minutiae based system try to identify the location and type of minutia and match it with database template. The accuracy is totally dependent on the identification of minutia point.

In fact, the image pattern in the finger-knuckle surface is highly unique and thus can serve as a distinctive biometric identifier [35], [36]. FKP being recent has been yet to be thoroughly explored. The current research has shown great potential in FKP to be used as an efficient and accurate biometric trait [35], [36], [37], [38]. In [38] they have proposed a local-global feature fusion for FKP verification; Local features are extracted using a bank of Gabor filters convolved with FKP ROI and global features are taken from band limited phase only correlation function. Authors have proposed use of wavelet based features [6], specifically wavelet energy of the FKP ROI for verification purpose. This is a faster approach attractive for online verification.

In this paper we are using texture based feature extraction for above mentioned biometric traits. This feature extraction mechanism is explained in the next section.

III. Partitioned Complex Walsh Plane In Transform Domain

Here we discuss a method which deals with palmprint identification in the transform domain. The one-step Walsh transform i.e. either the row or the column transforms of the fingerprint is subjected to partitioning to generate the feature vector. This process is based on Cal & Sal Functions of Walsh Transform, next we discuss the Walsh transform & it’s Cal, Sal functions.

A. Walsh Functions [25]

Walsh functions are a set of orthogonal functions which can be used to represent any discrete-time signal. The Walsh functions (W0 - W7) as shown in the Fig. 2 are generated from square wave functions of different sequency.

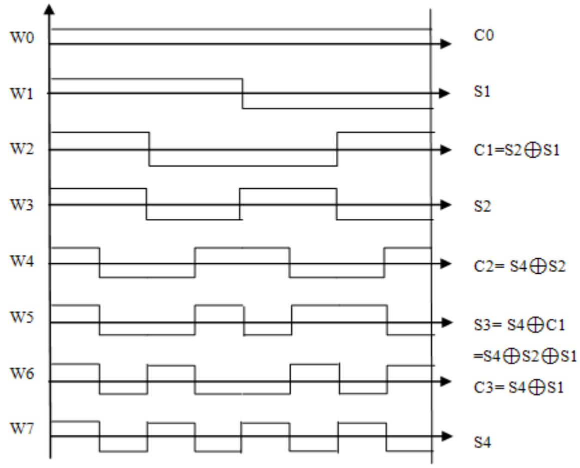


Figure 2. First Eight Walsh Functions

The even functions (C0 - C3) are called Cal functions and the odd functions (S1-S4) are called Sal functions. The basic square wave functions are S1, S2 and S4. C0 is DC component and the remaining functions are generated from the basic square waves by EX-OR operation (equivalent to multiplication). This operation generates only the difference sequency functions (as opposed to the case of sinusoidal signals where both difference and sum frequencies are generated) e.g. C1 = S1 ⊕ S2, here S1 and S2 being odd function, their EX-OR operation results in an even function (C1). Similarly EX-OR operation of an even and odd function generates an odd function e.g. S3 = S4 ⊕ C1, which can further be simplified to S3 = S4 ⊕ S2 ⊕ S1, showing that all functions are generated from the basic square waves S1, S2 and S4.

Walsh functions can be ordered in a number of ways. The sequency 'k' of a Walsh function is defined as half the number of zero crossings in one cycle of the time base. Walsh functions with non-identical sequencies are orthogonal, as are the functions W(n, 2k) and W(n, 2k+1). The product of two Walsh functions is also a Walsh function. Harmuth in [25] designates the even Walsh functions Cal(k) and the odd Walsh functions Sal(k)[26],

$$\text{Cal}\,(n, k) = W(n, 2k) \quad (1)$$

$$\text{Sal}\,(n, k) = W(n, 2k+1) \quad (2)$$

where 'k' is the sequency.

The Walsh transform matrix (W) is then generated by sampling these Walsh functions at the middle of the smallest time interval. The matrix, as in Eqn. (3) is obtained, which can be directly used to generate the transform coefficients of a discrete signal both of 1-D and 2-D as shown in Eqn. 1 and Eqn. 2 respectively,

$$W = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \end{pmatrix} \quad (3)$$

$$F_{1D} = W.f \quad (4)$$

$$F_{2D} = W.f.W^T \quad (5)$$

The interpretation of Walsh transform of a 2-D signal can be understood by Fig. 3, where first the row transform is calculated and then the column transform. The final output has DC component in the top left corner and the sequency components increase leftwards and downwards. In the current approach, we are first generating the intermediate transform, i.e. the row transform (or column transform) of a Region of Interest (ROI) image as shown in Fig. 4, which have DC component as its first row (or column) and higher sequency components (Sal and Cal) as the following rows (or columns).

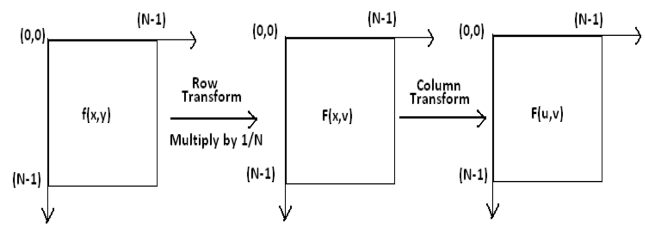
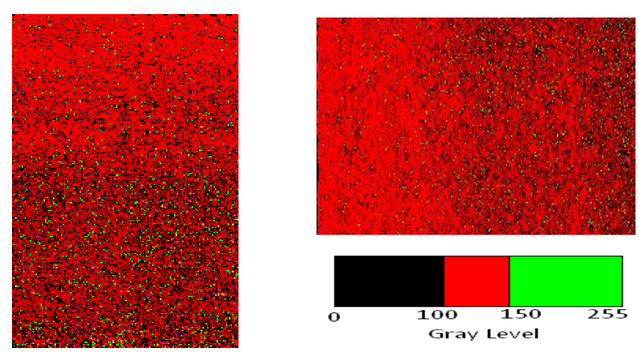


Figure 3. Transform of a 2D Function



(a) (b)

Figure 4. (a) Row Transform and (b) Column Transform of a Palmprint

IV. COMPLEX WALSH PLANE [27] & FEATURE VECTOR GENERATION

The Cal and the Sal components of the same sequency are grouped together and are considered to be in the four quadrants of 2-D complex coordinate plane as listed in Fig.5. This complex plane is now partitioned into different numbers of blocks.

The complex plane consisting of same-sequency (Sal, Cal) components is now partitioned 256 square blocks as shown in Fig. 7. For each block a feature vector is generated which is the mean value of all the transform coefficients in that block, as well as the number of points i.e. the density is also considered.

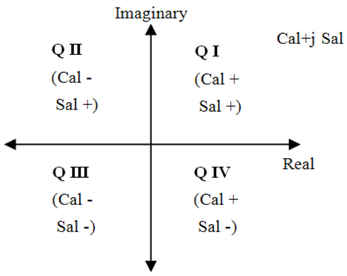
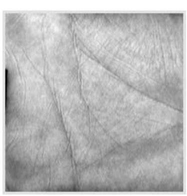


Figure 5. Complex Walsh Plane

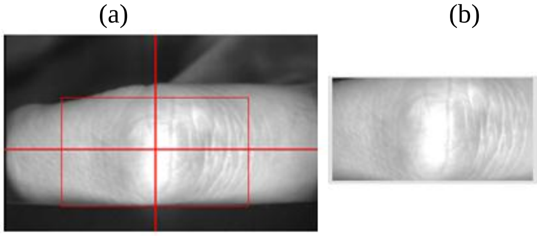
This value is unique for each biometric trait's ROI (Region of Interest) as the sequency distribution of each ROI is unique in different blocks. As compared to all or those transform coefficients which contain major part of signal energy feature vectors generated using partitioning are much less in number and hence the reduction in processing time and complexity. The blocks generated are square shaped and the mean values of the transform coefficients in each block are calculated as in Eqn. 6, where M_k is the mean and N is the number of coefficients in a block, which form the features. The DC component, separate means of the Sal and Cal component and the last sequency component together form the feature vector, and hence the number of features is 2S+2, where S is the number of blocks.

$$M_k = \frac{1}{N}\sum_{i=1}^{n} W_i \qquad (6)$$

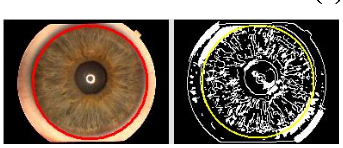


(a)

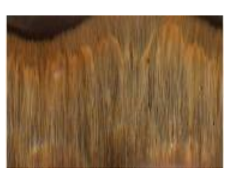
(b)



(c)



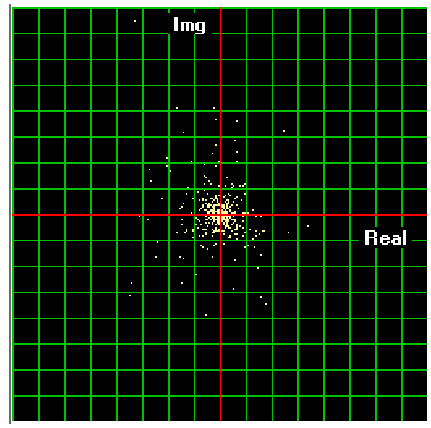
(d)



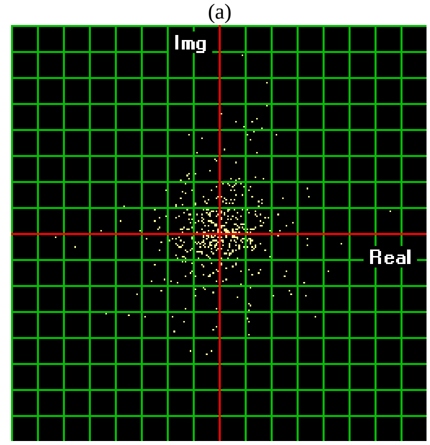
(e)

Figure 6. ROI Extraction for Palmprint & Iris (a) Palmprint ROI (b) Fingerprint ROI(c) Finger-knuckle Print ROI (d) Iris Localization (e) Unwrapped Iris ROI

The features obtained from the test image are compared with those obtained from the stored Biometric trait in the database and the results matched. The Euclidian distances between the feature vectors of the test image and the database images are calculated. The minimum distance gives the best match.



(a)



(b)

Figure 7. Complex Walsh Plane (a) Partitioned Cal+jSal Function Plot of Row Transform (b) Partitioned Cal+jSal Function Plot for Column Transform

We have selected 192*192 pixels size region of interest for the palmprint as discussed by Kekre & Bharadi [31]. The Fingerprint ROI is 144*144 pixels in size, The Finger-knuckle print ROI is 256*128 pixels size. The iris image is also localized and ROI of size 240*360 pixels is selected by unwrapping of the localized iris [28]. These ROI's are shown in Fig. 6. All of these ROI's are used for intermediate transform & complex plane generation. While taking the intermediate transform scaling at appropriate level is done wherever required.

As discussed earlier each plot gives 2S+2 coefficients, we have 256 blocks in each plot, hence one plot gives 514 (256*2 +2) coefficients. For each type of input i.e. segmented ROI we have two plots, one for row and one for column transform hence we have 1028 (514 *2) coefficients for each type of fingerprint input. Finally we have 1028 coefficients in the feature vector of ROI. Similar Feature vector is generated for Density of the points in complex Walsh Plane for each fingerprint input. This feature vectors are used for enrollment and matching of the biometric traits displayed in Fig. 6. For each normalized iris ROI input the feature vector is generated in following variations, for Iris Left (L) & Right (R) iris ROI's are considered. For Palmprint, Finger-knuckle prints & fingerprints only first five feature vector variations are considered.

1. Row transform feature vector
   (Row TRF –L, Row TRF –R)
2. Column transform feature vector
   (Col TRF –L, Col TRF –R)
3. Row density feature vector
   (Row-Density-L, Row-Density-R)
4. Column density feature vector
   (Col-Density-L, Col-Density-R)
5. Fusion of above mention feature vectors with DC & Sequency components.
   (Row TRF + Density + DC SEQ Left, Row TRF + Density + DC SEQ Right)
6. Final Fusion of Left & Right Iris Feature Vectors-(Fusion)

The extracted feature vectors are stired in database. We are using K-NN classifier classification. We are using Hongkong Polytechnic University's POLYU Database [29] for palmprint & Finger-knuckle print testing. Phoenix iris database [30] is used for iris testing. The results are discussed in the next section.

V. RESULTS

We have enrolled total 100 persons in the database, 6 palmprints per person are used for training. Total 358 tests are performed for intra class matching and 2491 tests are performed for inter class matching. Similar method is followed for other biometrics also. For iris we use left as well as right iris sample for enrollment. We are using Performance Index (PI) as a metric for performance comparison the crossover rate (EER) for FAR-FRR (False Acceptance Rate & False Rejection Rate) analysis is found and PI is defined as:

$$PI=100-EER \qquad (7)$$

Higher the PI, better is the performance of specific feature vector extraction mechanism. The details of PI & CCR (Correct Classification Ratio) of above mentioned feature vectors are summarized in Fig. 8, 9 & 10. Fig. 8 shows FAR-FRR Analysis of fusion based feature vector. We have achieved 10% EER.

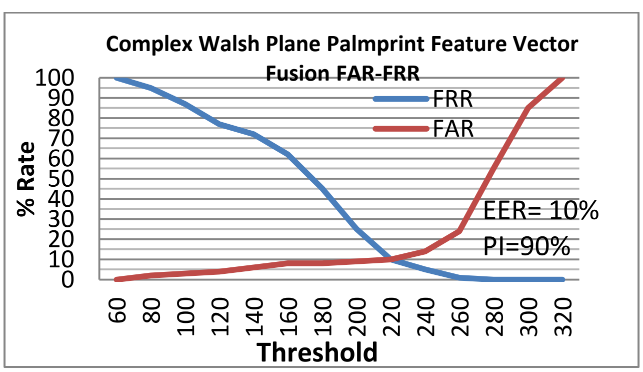


Figure 8. FAR-FRR Analysis for Walsh Cal-Sal based Fused Feature Vector

Fusion of Row & Column Transform mean & Density with DC & Sequency coefficient gives 90% PI. The individual Row & column transform mean based feature vectors have 82% & 87% PI, this shows that due to fusion of feature vector with DC & Sequency component the performance has improved.

Fig. 9 shows comparative analysis of the different variations of the feature vectors. The correct classification ratio (CCR) for the matching tests is 84.23% In case of palmprint the CCR is lower than fingerprint; this is due to the fact that the database images have prominent details about major principle lines and the ridge and minute lines on the palms are not captured properly in the database image. The fingerprints are scanned at higher resolution of 500dpi and the PolyU palmprint database images are captured by a CCD camera at 75dpi. In the next section a new biometric called as finger-knuckle print is discussed.

Fig. 10 shows the analysis of results for fingerprint recognition using above mentioned method extended for Hartley transform, DCT, Kekre Transform & Kekre Wavelets. The recognition is performed with full fingerprint as well as fingerprint ROI (Core Point based). The fusion of feature vector gives best PI. Maximum performance is given by Walsh transform followed by Hartley & Kekre Wavelet Transform.

Fig. 11 shows Performance Comparison of Partitioned Complex Walsh Plane Based Fingerprint, Palmprint & FKP Matching Techniques, It is shows that the multi-algorithmic fusion based feature vector gives best performance (Last Columns) and among the three hands based biometric traits, fingerprints give the best performance.

Fig. 12 & 13 show the results for Iris recognition. For this biometric we have performed study in two modes. Multi-algorithmic feature vector consisting of the fusion of partitioned complex plane based feature vectors, and multi-instance feature vector consisting of left & right iris. Multi-instance feature vector gives best performance; Walsh transform based feature vector gives highest accuracy followed by DCT & Kekre Wavelets.

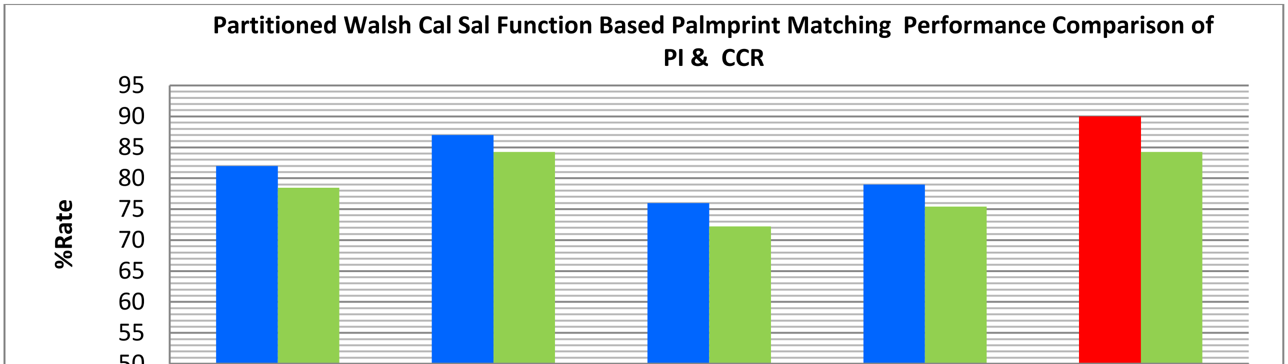
VI. CONCLUSION

In this paper we have discussed a feature extraction mechanism based on partitioned complex plane of Walsh transform along with its extension to Hartley, DCT, Kekre Transform & Kekre Wavelets. This feature extraction mechanism was implemented for Fingerprints, Finger-knuckle prints, palmprint & iris feature vector generation.

It is observed that the proposed method performs well for classification of genuine and forgery inputs.

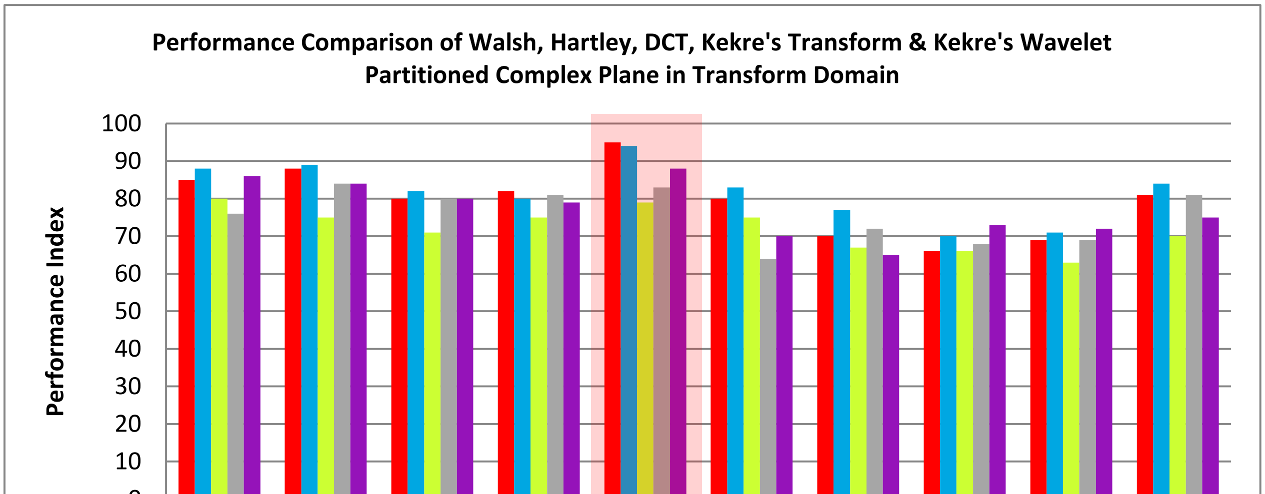
Best performance was given by Walsh transform followed by Kekre wavelet DCT etc.This shows the superiority of proposed method for texture feature based feature vector extraction.

The proposed method is tested in both unimodal & multi-algorithmic (involving fusion of multiple feature vectors) & multi-instance (involving left & right iris sample instances). Fusion improves the performance the various biometric systems tested.



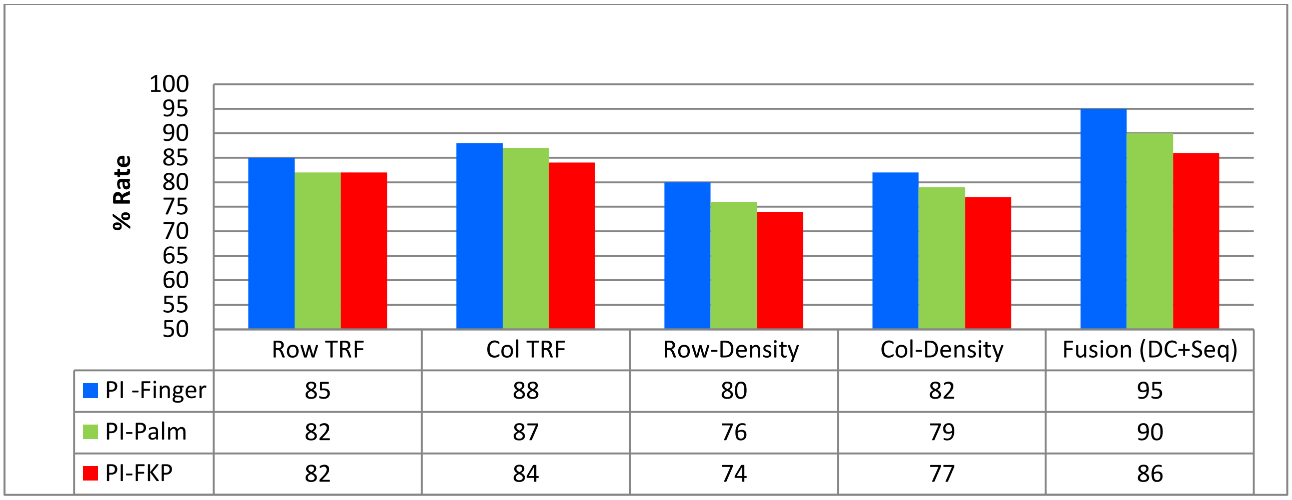
	Row TRF	Col TRF	Row-Density	Col-Density	Fusion (DC+Seq)
PI	82	87	76	79	90
CCR	78.45	84.25	72.21	75.44	84.23

Figure 9. Performance Comparison for Feature Vector Variants of Partitioned Walsh Cal-Sal Function Palmprint Matching
Score Fusion based Matching Gives Higher Performance Index; this is Indicated by Bar in Red Colour. (TRF: Transform, DC-DC Coefficient, Seq- Sequency)



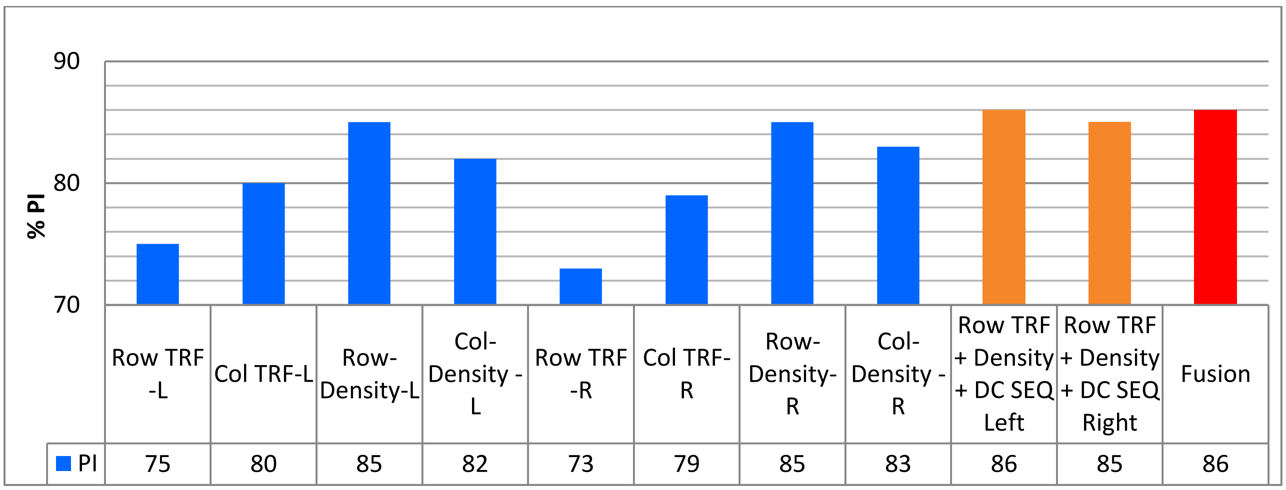
	Row TRF-Core Point	Col TRF-Core Point	Row-Density -Core Point	Col-Density -Core Point	Fusion-Core Point FV	Row TRF-Full Finger	Col TRF-Full Finger	Row-Density -Full Finger	Col-Density -Full Finger	Fusion - Full Finger FV
Walsh	85	88	80	82	95	80	70	66	69	81
Hartley	88	89	82	80	94	83	77	70	71	84
DCT	80	75	71	75	79	75	67	66	63	70
Kekre	76	84	80	81	83	64	72	68	69	81
KWT	86	84	80	79	88	70	65	73	72	75

Figure 10. Performance Comparison for Feature Vector Variants of Partitioned Walsh, Hartley, DCT, Kekre's Transform & Kekre's Wavelet.
(Performance Index is Compared)



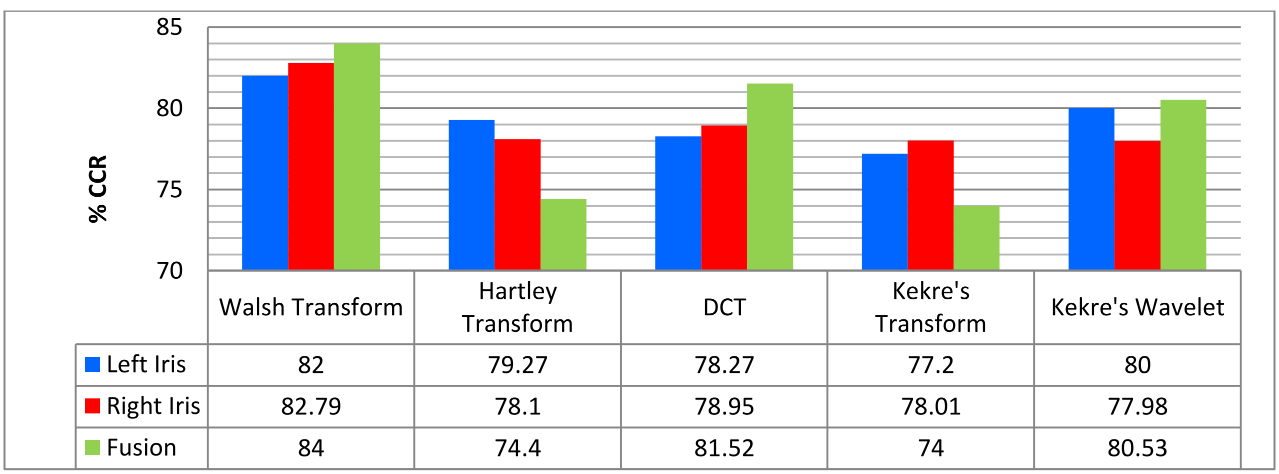
	Row TRF	Col TRF	Row-Density	Col-Density	Fusion (DC+Seq)
PI -Finger	85	88	80	82	95
PI-Palm	82	87	76	79	90
PI-FKP	82	84	74	77	86

Figure 11. Performance Comparison of Partitioned Complex Walsh Plane Based Fingerprint, Palmprint & FKP Matching Techniques



	Row TRF -L	Col TRF-L	Row-Density-L	Col-Density -L	Row TRF -R	Col TRF-R	Row-Density-R	Col-Density -R	Row TRF + Density + DC SEQ Left	Row TRF + Density + DC SEQ Right	Fusion
PI	75	80	85	82	73	79	85	83	86	85	86

Figure 12. Performance Comparison for Feature Vector Variants of Partitioned Walsh Cal-Sal Functions Iris Recognition
Score Fusion based Matching Gives Higher Performance this is Indicated by Bar in Red Colour. The Orange Colour Bar Indicate the PI for Individual Left and Right Iris Feature Vector Fusion (TRF: Transform, FV: Feature Vector)



	Walsh Transform	Hartley Transform	DCT	Kekre's Transform	Kekre's Wavelet
Left Iris	82	79.27	78.27	77.2	80
Right Iris	82.79	78.1	78.95	78.01	77.98
Fusion	84	74.4	81.52	74	80.53

Figure 13. Performance Comparison for Feature Vector Variants of Partitioned Complex Plane based Iris Feature Vectors

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A Comparative Study on Retrieved Images by Content Based Image Retrieval System based on Binary Tree, Color, Texture and Canny Edge Detection Approach

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***Abstract*—Content based image retrieval (CBIR) is a technique in which images are indexed by extracting their low level features or high level features or both. This paper presents performance & comparative study of the result obtained by the two different approaches of CBIR system. The resultant retrieved images by the CBIR system is based on two approaches. Both approaches of the system using two major processes one as feature extraction and other as search and retrieval. The first approach is based on extracting the features using binary tree structure, color & texture and the second approach is based on extracting shape features using Canny Edge Detection. In both the approaches the feature vector of the query image is compared with the feature vector of the each image present in the database. In the first approach the images are retrieved and arranged according to their matching score or rank value and in the second approach retrieved images are arranged according to their mean and correlation values**.

Keywords-Binary tree structure, Content Based Image Retrieval, canny edge detection, Mean, Correlation.

I. Introduction

Since 1990s, the demand for information indexing and retrieval is increased because of rapid growth of available multimedia contents, that's why efforts have been done on text extraction in images and videos. The collection of images in the web are growing larger and becoming more diverse. Retrieving images from such large collections is a challenging problem in front of us. To organize and classify such large amount of images is time consuming task. Therefore it is required to design a system to organize and classify the images in a database, so that the images can be retrieve fast with little amount of time. To implement this idea, the CBIR system is introduced. It is an automated system that searches query image in an image database and retrieving the relevant images of using similarity measure between it and every image in the image data base.

It can simplify many tasks in many application areas such as biomedicine, forensics, artificial intelligence, military, education, web image searching.

A. Need of CBIR System

In recent years, there has been a growing interest in developing effective methods for content based image clustering and retrieval. This interest has been motivated by the need to efficiently manage large image databases and efficiently run image retrieval to get the best results without exhaustively searching the global database each time. This leads to huge savings in time and money, especially in fields where the bulk of working databases are image files or any kind of media whose contents cannot be described by simple keywords or short texts. With image retrieval system such as Content Based Image retrieval this limitation will not exist and system will retrieve the images as per the human can perceive, and too much responsibility on the end-user, problem of abstract needs, the queries that cannot be described at all, but tap into the visual features of images.

Most of the CBIR systems perform the search based on following:

- Keywords - This is a search in which the user poses a simple query in the form of a word or bigram. This is currently the most popular way to search images, for example, the Google and Yahoo! image search engines.
- Text - This is where the user frames a complex
- Text-phrase, sentence, question, or story about what user desires from the system.
- Image - Here, the user wishes to search for an image similar to a query image. Using an example image is perhaps the most representative way of querying a CBIR system in the absence of reliable metadata.
- Graphics-This consists of a hand-drawn or computer-generated picture, or graphics could be presented as query.
- Composite- These are methods that involve using one or more of the above mentioned that is image and keywords, or text, keyword and image for querying a system. This

also covers interactive querying such as in relevance feedback approach [2].

From the above mentioned our CBIR system is based on color, shape and texture, binary tree.

The CBIR system is divided into following stages:

- Preprocessing: The image is first processed in order to extract the features, which describe its contents. The processing involves filtering, normalization, segmentation, and object identification. The output of this stage is a set of significant regions and objects.

- Feature Extraction: Features such as shape, texture, color, etc. are used to describe the content of the image. Image features can be classified into primitives.

II. TYPICAL CBIR STRUCTURE

The overall structure of a typical image retrieval system is shown in fig. 1. It consists of images, feature extraction and retrieval process. First the images are obtained from different sources. One of the images from the existing source is considered as query image and remaining images forms an image database. The feature extraction process is applied on images in the database and the query image and the feature vector is obtained. The search & retrieval process search the query image matched with images in the database. Finally images are received and arranged according to their matching score.

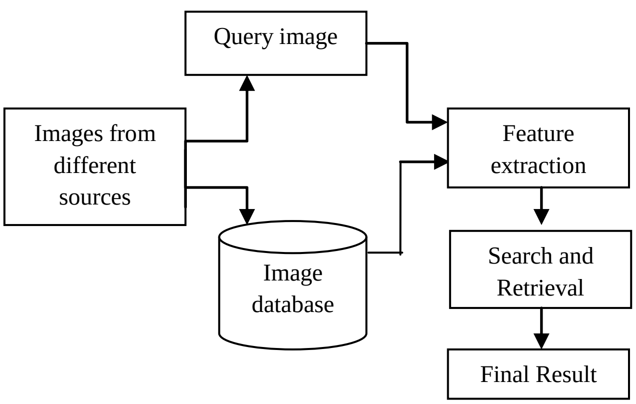

Fig. 1: Structure of CBIR

III. QUERY PROCESSING FOR THE CBIR

In the CBIR systems the query processing is based on the following:

- Text-Based: - Text-based query processing usually boils down to performing one or more simple keyword-based searches and then retrieving matching pictures. Processing a free text could involve parsing, processing, and understanding the query as a whole.

- Content-Based: - Content-based query processing lies at the heart of all CBIR systems. Processing of query (image or graphics) involves extraction of visual features and/or Segmentation and search in the visual feature space for similar images. An appropriate feature representation and a similarity measure to rank pictures, given a query, are essential here.

- Composite: - Composite processing may involve both content and text-based processing in varying proportions. An example of a system which supports such processing is the story picturing engine. [Joshi et al 2006b]

- Interactive-Simple: - User interaction using a single modality needs to be supported by a system. An example is a relevance-feedback based image retrieval system.

- Interactive-Composite: - The user may query using more than one modality example text and images. This can be considered as the more advanced form of query processing required for searching a query image in huge database to be performed by an image retrieval system.

Processing text-based queries involves keyword matching using simple set-theoretic operations, and therefore a response can be generated very quickly. However, in very large systems working with millions of pictures and keywords, efficient indexing methods may be required. Indexing of text has been studied in database research for decades now. Efficient indexing is critical to the building and functioning of very large text based databases and search engines. Research on efficient ways to index images by content has been largely overshadowed by research on efficient visual representation and similarity measures. Most of the methods used for visual indexing are adopted from text-indexing research [2].

IV. RELATED WORK

There are several excellent surveys of CBIR systems. We mention here some of the more notable systems.

This paper uses a CBIR approach to retrieve building images. First, the canny edge detector is used to extract edge information from the images. Then, the Hough transform is applied to the edge map in order to reveal the linear edge distribution in the Hough transform domain. Then by using a band-wise matching (BWM) algorithm, the Hough transform domain into a number of bands and calculate the centroid of the Hough peaks in each band by partitioning. By carrying out the same aforementioned procedures on a query image and the images in the database, the similarity between the centroid of the query image and the images in the database is measured. Finally, based on the similarity measures, the CBIR system ranks the images in the database and retrieves a specified number of images with the highest rank values [3].

In this paper, the performance comparison between shape & color features in content-based image retrieval is studied. There is a great need for developing an efficient technique for finding the images. In order to find an image, image has to be represented with certain features. In this paper an efficient image retrieval technique is used which uses dynamic dominant color, and shape features of an image [4].

The CBIR systems can also provide an efficient medical image data retrieval from a huge content of medical database using one of the images content such as image shape. The main objective of this paper is to provide an efficient tool which is used for efficient medical image retrieval from a huge content of medical image database and which is used for further medical diagnosis purposes [5].

The paper on CBIR using the knowledge of texture, color, and binary tree structure says that in recent years, Content Based Image Retrieval (CBIR) has played an important role in many fields, such as medicine, geography, security, etc. General approaches in CBIR are based on visual attributes of images such as color, texture, shape, and layout and object [7]. Most of CBIR systems are designed to find the top N images that are most similar to the input query image. In this paper the approach is to combine color, texture and a customized binary partitioning tree in order to find the images similar to a specific query image. The above mentioned tree is a customized binary partitioning tree which keeps a combination of color and layout information of an image. To extract color information, two histograms of the image in HSV color space are used with 360 and 100 bins. Also a 2-levels Wavelet decomposition of image blocks is used to attain texture. The binary tree is used to maintain the image layout information [8].

V. PROPOSED SYSTEM

The main objective of the proposed system to provide an efficient tool for efficient image retrieval from a huge content of image database using features based on Color, Texture , Binary tree structure and Canny edge detection method and retrieve the images to identify the most similar images to the query image. The terms and methods used in both the approaches are explained below.

A. Features Used by CBIR System

Following are the features used by proposed CBIR system

1) Shape

Shape is an important and most powerful feature used for image classification, indexing and retrievals. Shape information extracted using histogram of edge detection. In this paper, the edge information in the image is obtained by using the canny edge detection .Other techniques for shape feature extraction are elementary descriptor, Fourier descriptor, template matching, Quantized descriptors and so on[5].

2) Color

Color may be one of the most straightforward features utilized by humans for visual recognition and discrimination. However, people show the natural ability of using different levels of color specificity in different contexts. For example, people would typically describe an apple as being 'red', probably implying some type of reddish hue. But in the context of describing the color of a car a person may choose to be more specific instead using the terms 'dark red' or 'maroon'. Color extraction by computer is performed without benefit of a context. Lack of knowledge also makes it difficult to cull the color information from the color distortion .The appearance of the color of real world objects is generally altered by surface texture, lighting and shading effects, and viewing conditions. The color feature is one of the most widely used visual features in image retrieval. Images characterized by color features have many advantages like robustness, effectiveness, implementation simplicity, computational simplicity, low storage requirement [6].

3) Texture

Texture features are intended to capture the granularity and repetitive patterns of surfaces within a picture. For instance, grassland, brick walls, teddy bears, and flower petals differ in texture, by smoothness as well as patterns. This feature used in domain specific image retrieval, such as in aerial imagery and medical imaging, is particularly vital due to their close relation to the underlying semantics in these cases. Texture features have long been studied in image processing, computer vision, and computer graphics [Haralick 1979], such as multi orientation filter banks [Malik and Perona 1990] and wavelet transforms [Unser 1995]. In image processing, a popular way to form texture features is by using the coefficients of a certain transform on the original pixel values, or, more sophisticatedly, by statistics computed from these coefficients. Examples of texture features using the *wavelet transform* and the discrete cosine transform can be found in Do and Vetterli [2002] and Li et al [2000].

4) Binary Tree Structure

Binary partition tree is a structure used to represent the regions of an image. A binary tree is used as a base for each region of each image in the database. In the binary partitioning tree leaves represents regions belonging to the initial partition. The root node corresponds to the entire image.

To construct a binary tree, the algorithm starts from an arbitrary region which considered as the first node and then selecting a neighbor region as its sibling, these nodes are added as children of their parent. This process is repeated until all regions have been added to the binary partitioning tree. To have more precise measure, each image in the database is divided into equal fixed-sized squared blocks. A distinct tree should be created for each block. For each node of the constructed binary partitioning tree, calculate the mean color and area of its corresponding region. These values i.e. mean color and mean area for all nodes are concatenated to construct a feature vector representing one block. The process of concatenating feature vectors of a block is repeated for all blocks to construct a feature vector for entire image.

5) Mean

To find out the Mean value we used the median filter which is also called sliding window spatial filter. It replaces the center value in the window with the median of all the pixel values in the window

6) Correlation

Correlation is used to determine the degree of similarity between data sets. One application of correlation is to perform template matching. The idea is to find the position where a best match exists between a small pattern or template and a set of patterns in a larger image. Similar to convolution, correlation also has a theorem that relates spatial domain processing with frequency domain processing via the Discrete

Fourier Transform (DFT). Thus, correlation can be performed either in the spatial domain or frequency domain.

VI. Proposed Approach

The proposed approach is described with the help of fig. 2. Initially images from the different available sources were taken as an input to the system. These images can be preprocessed to reduce noise by filtering. In canny edge detection approach the median filtering is used. The main idea of median filter is to run through the signal entry by entry, replacing each entry with median of neighboring entries. The pattern of neighbors is called the "window", which slides, entry by entry, over the entire signal.

From the images input to the system, one of the images will be considered as query image and the remaining images forms image database. An image is a spatial representation of an object and represented by a matrix of intensity value. It is sampled at points known as pixels and represented by color intensity in RGB color model. A basic color image could be described as three layered image with each layer as Red, Green and Blue. These three colors constitute an image pixel.

Next the image feature database is created using two different approaches. First method uses the feature extraction process using the features as color, texture and binary tree structure. The second method extracts the feature shape using Canny Edge Detection (CED) algorithm. Canny edge detection out performs many of the newer algorithms that have been developed in the industry.

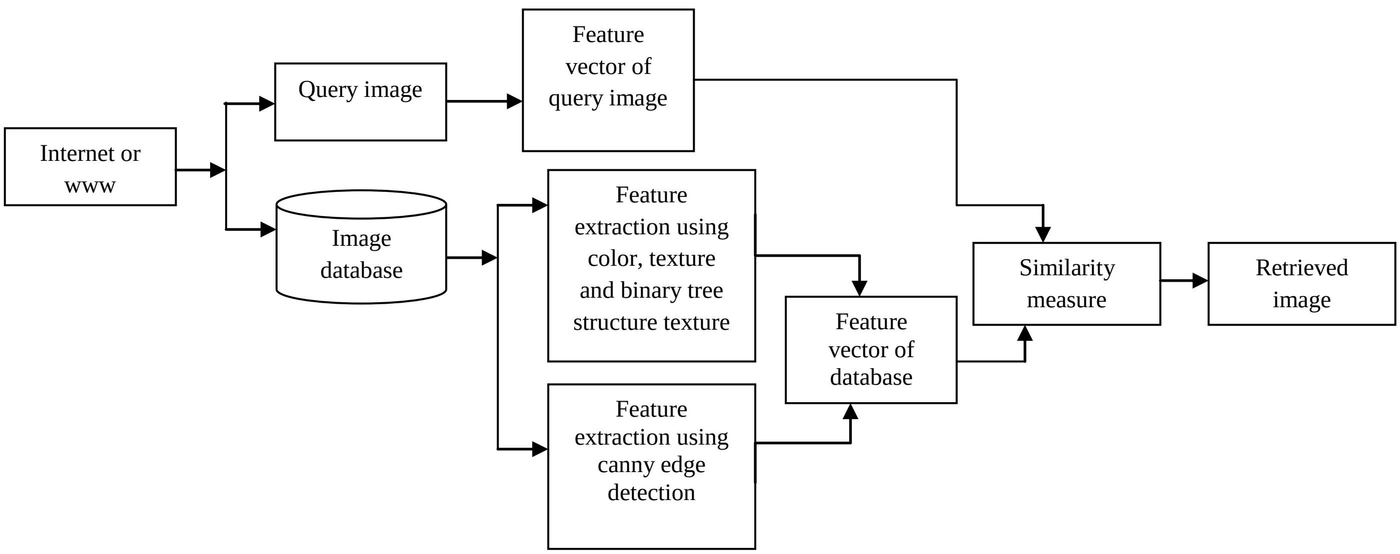

Fig. 2: Proposed CBIR Structure

The steps involved in CED algorithm for detecting edges are:

- Smoothing: Smooth the image with a two dimensional Gaussian. In most cases the computation of a two dimensional Gaussian is costly, so it is approximated by two one dimensional Gaussians.
- Finding Gradients: Take the gradient of the image this shows changes in intensity, which indicates the presence of edges. This actually gives two results, the gradient in the x direction and the gradient in the y direction.
- Non-maximal suppression: Edges will occur at points where the gradient is at a maximum. The magnitude and direction of the gradient is computed at each pixel.
- Edge Threshold**:** The method of threshold used by the Canny Edge Detector is referred to as "hysteresis". It makes use of both a high threshold and a low threshold.
- The feature vector of query image is also created. Next the similarity comparison technique has been carried out between feature vector of database images and the query image in both the approaches. After comparison, resulting images are indexed according to matching score value associated to each retrieved images in the first approach and in the second approach resulting images are indexed according to mean and correlation value.

VII. RESULT AND CONCLUSION

The result of the CBIR system using two different approaches are shown in figure 3 and figure 4 which shows the retrieved images after the calculating the distance between the query image and the images from the database. In the first approach using Minkowski distance and second approach using Euclidean distance.

The result shows that retrieved images using both the approaches are quite same and if both the approaches are combined together it may increase the retrieval efficiency of the system. The two snapshot shows that the first two images retrieved by both the approaches are same but other images are different. To improve the result and achieve more efficient retrieval both the approaches can be combined and tested on the huge amount of images.

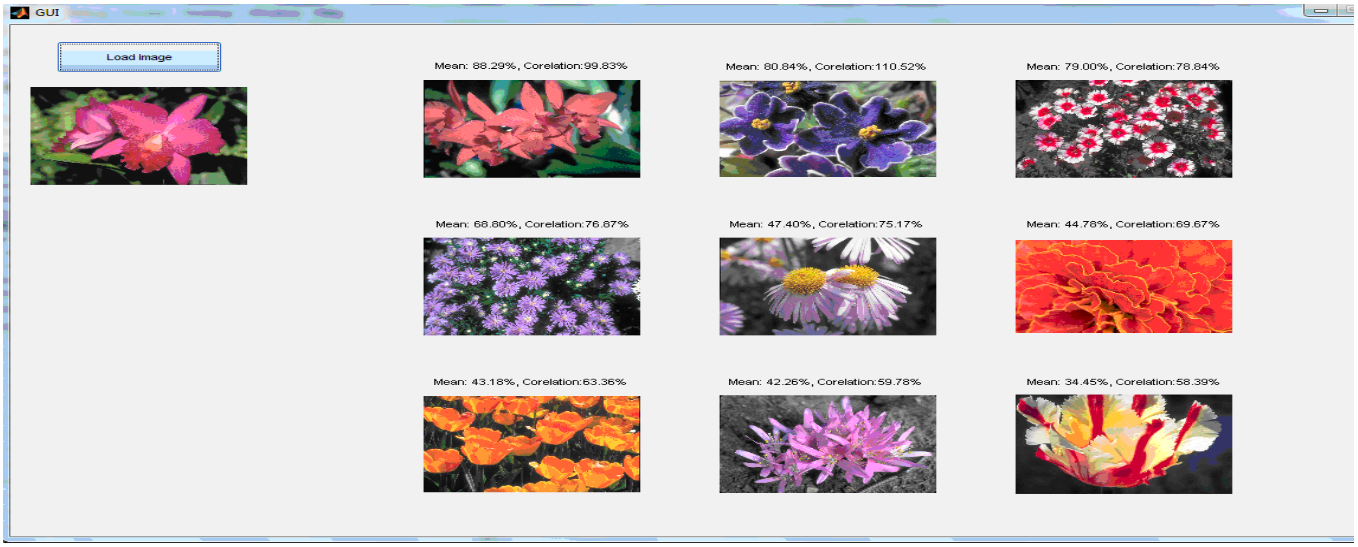

Fig. 3: Retrieved images using canny edge detection

Fig. 4: Retrieved images using texture, color and binary tree structure

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EtranS- A Complete Framework for English To Sanskrit Machine Translation

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***Abstract*— Machine Translation has been a topic of research from the past many years. Many methods and techniques have been proposed and developed. However, quality of translation has always been a matter of concern. In this paper, we outline a target language generation mechanism with the help of language English-Sanskrit language pair using rule based machine translation technique [1]. Rule Based Machine Translation provides high quality translation and requires in depth knowledge of the language apart from real world knowledge and the differences in cultural background and conceptual divisions. A string of English sentence can be translated into string of Sanskrit ones. The methodology for design and development is implemented in the form of software named as "EtranS".**

Keywords- Analysis, Machine translation, translation theory, Interlingua, language divergence, Sanskrit, natural language processing.

I. INTRODUCTION

English is a widely spoken language across the globe and most official communication and documentation is being done in this language. In India, there exist several regional languages including Hindi, where a lot of documentation exists in this language. The Sanskrit is considered to be mother of all Indian languages and is one of the oldest synthetic language in which a lot of ancient literature exists. Since English is modern day "global language", it has always been a challenge before natural language processing community to find efficient mechanism for this translation pair [2, 3, 4].

We compare and analyze differences between the two languages which are pre-requisite before getting into translation technique. There are four major parameters namely, essence, tense, number and translational equivalence, that are needed to be considered for the translation of this language pair. The essence of English is that it is evolved, therefore, it is a natural language. Sanskrit is formulated by sages like Panini hence it is an Artificial or Synthetic language. The English language has twelve tenses in all primarily Past, Present and Future. All three have a Perfect, Indefinite, Continuous and Perfect Continuous and it makes twelve forms of tenses. Sanskrit has primarily six tenses, Present, Past, Future, Order, Blessing and Inspiration. The English have two numbers i.e., Singular and Plural whereas, Sanskrit has three numbers Singular, Dual and Plural [6,9,10,11]. In general, we can state that the model consists of array of translation rules to translate from source to target sentence, which is the frame of Rule based Machine Translation System. The approach is simple and effective. The rules are framed, keeping in view the grammar of the source and the target language (Translational Equivalence) [2].

We have discussed different types of sentences considered for translation, sources from which sentences are taken, formation of rules pattern, provisions for extension of rules and lexicon and features of the software developed. We have also discussed on robustness of the rules and limitation of the software. We begin with simple statements; subsequently translation of compound statements is done.

II. THE REASEARCH APPROCH

The translation model from English to Sanskrit is primarily based on formulation of Synchronous Context Free Grammar (SCFG), a sub set of Context Free Grammar (CFG). SCFG helps in linguistics representation of the syntax. A CFG (N, T, and P) consists of set of non-terminals N, terminals T and Productions P [7].

$$P= \{N \rightarrow \{N \cup T\}^*\}$$

The productions in the right hand side are replaced by that of left hand side sequence of terminal and non-terminals. Non terminals are written recursively until only terminal symbols remain [8]. In our case terminal symbols are words and non-terminal symbols are syntactic categories, i.e., a sentence will have a start symbol S which searches through different routes to rewrite the symbols until all the possibilities have been explored or input sentence is generated. The tree representation is shown in Figure 1.

III. THE PROCESS ENGINE

The functional approach to translation is developed on the basis of the process engine shown in Figure 2, further for implementation of the same "The Two Way Translation Model"[1] shown in Figure 3 is developed. This model states that for the translation from source to target language first Top Down and then Bottom UP approach is adopted.

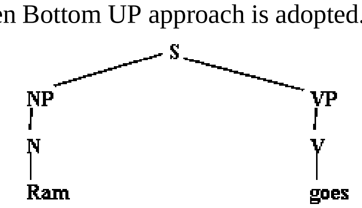
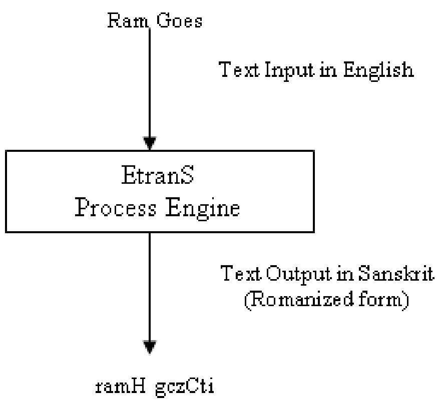


Figure1. Tree representation of "Ram goes"

It presents a simple technique for translation. It has two phases, the first phase follows, the Top Down approach. Here, we begin with syntax analysis, followed by semantic analysis and then mapping of tokens is done, which are generated during syntax analysis. The second phase, does Bottom to Top analysis. It begins with intermediate process of mapping, felicitated by first phase, which is followed by morphological analysis and finally target language is generated.



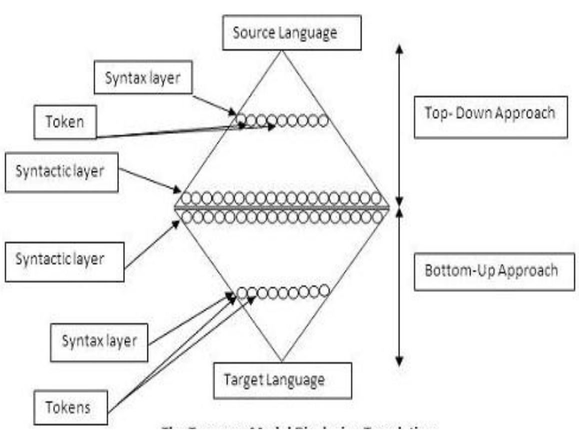


Figure 3. Two Way Model

The flow chart shown Figure 4 is based on the on the Two-way model. The model can be adopted in general for the translation from L1 to L2 language.

IV. GRAMMARS AND SENTENCE STRUCTURES

In this section, we have outline, how a sentence can be broken into major subparts and end up in forming a tree. Here each node represents phrases, such as, Noun Phrase or Verb Phrase and leaves represent parts of speech like noun, verb, adjective etc. Top down parsing is started from the sentence of source language and ends up to symbol list. A lexicon is used to store possible categories of words. Simple Top-Down parsing algorithm is used to generate possibilities list. The first element is a current state, which consist of symbol list and a word position in the sentence and the remaining elements are the back-up states, e.g., consider sentence Ram goes. As shown in Table 1.

Ram: N

Goes:V

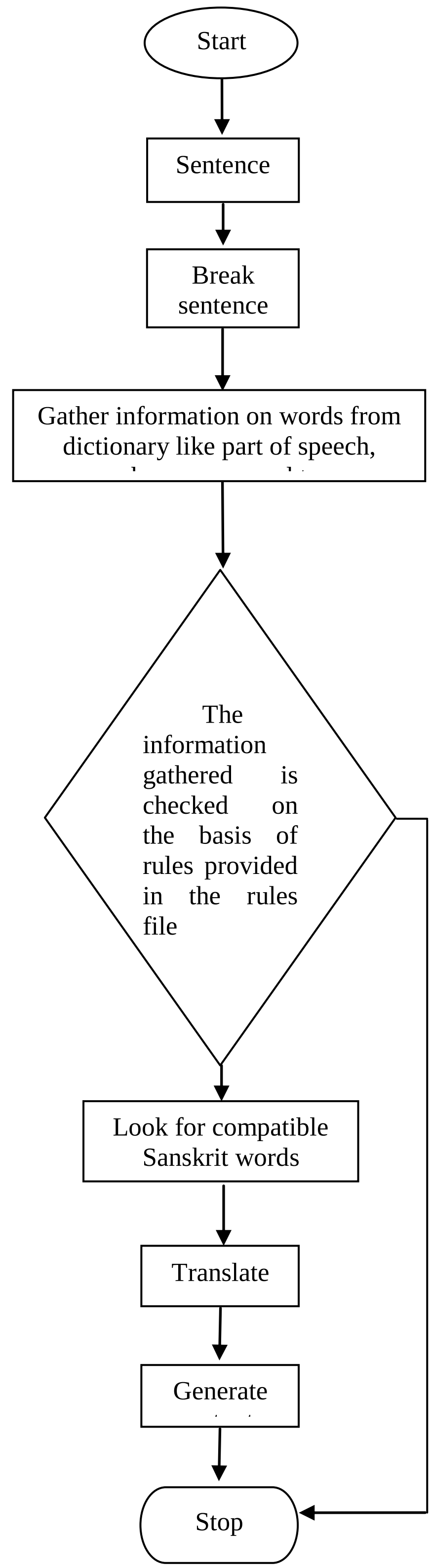


Figure 4. Translation Process

TABLE I. TOP DOWN PARSING OF THE SENTENCE "RAM GOES"

Step	**Current State**	**Backup state**	**Comment**
1	(S)1		
2	NP VP		S rewritten to NP VP
3	(N VP)1	((N VP)1)	NP rewritten
4	*((N VP)2)*	*((N V)1)*	*The back up state remains*
5	*(())*		*Success*

V. MORPHOLOGICAL PROCESSING

A word may consist of single morpheme (a smallest single meaningful unit) or may have root word comprising of an affix or suffix. Lexicon lists all forms of the word. An input sentence can be processed into sequence of morphemes. At times words may be ambiguous and have multiple decompositions into morphemes. E.g., "Ram brought pen", this sentence depicts past form of buy therefore the lexicon provides grammatical information related to it both in English and Sanskrit.

VI. THE FUNCTIONAL APPROACH

The process engine shown in Figure 2 can be divided into two major components and are the foundation of EtranS system, given below:

i. The parsing process

ii. The generator process

A. The Parsing Process

As shown in Figure 5, the process is responsible for the top to bottom analysis phase. It has following sub processes:

i. The Input Process
ii. Sentence Analyzer Process
iii. Morphological Analysis Process
iv. The EtranS Lexicon
v. The Parse Tree

1) The Input Process

Input process is the first small step towards translation process. It takes sentence as input in a text box developed as a part of GUI for the translation process.

2) Sentence Analyzer Process

Sentence Analyzer process does analyses the sentences taken by the Input process and state the category of the input sentence, i.e., whether the sentence is small, large or extra-large. The sentence is divided into tokens (e.g. Ram goes to the market.

For this sentence, tokens would be generated as ram, goes, to, the, market). Tokens can also have more than one word e.g. (take off, in case of). It also extracts the root words from the tokens. E.g., from "goes" "go" is extracted. The tokens are identified and morphological analysis is done.

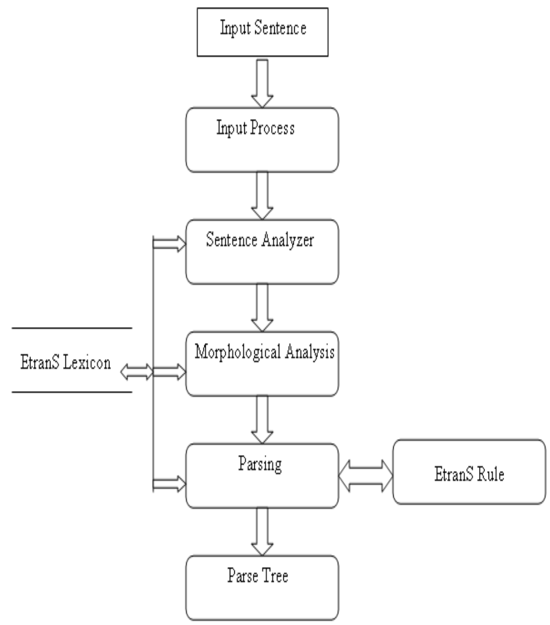


Figure 5. Parsing Process

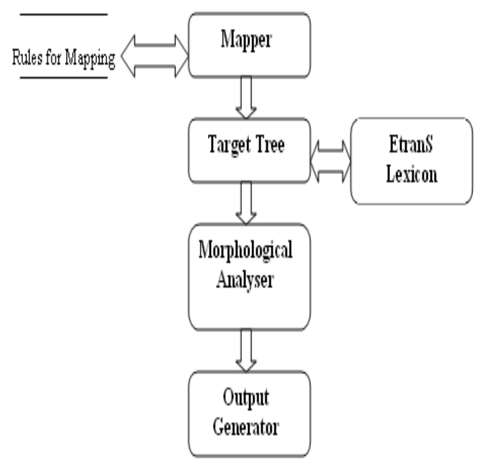


Figure 6. Generator Process

3) Morphological Analysis Process

The lexicon or the database developed plays a pivotal role for Morphological analysis. As it searches through the lexicon to gather above mentioned categories of the part of speech and its sub categories.

This process takes the tokens as input and gathers grammatical information on that. E.g., Morphological analysis for tokens like Ram, is, eating would provide following information is shown in Table 2.

TABLE 2. MORPHOLOGICAL ANALYSIS OF "RAM IS EATING"

Noun	Verb	Root Word
Ram- name of a person Proper noun , Masculine gender, Singular	Is auxiliary verb Eating-to eat transitive verb, animate, continuous word	Eat

4) The EtranS Lexicon

A bilingual lexicon is developed as a bridge between the source as well as the target language [1]. Structure of the lexicon contains various categories and sub categories pertaining to the source and the target language. The database consists of words, their grammatical characteristics like part of speech, tense, number and gender. The database in Sanskrit is stored in the same manner though emphasis is on phonemes like akarant[1], Akarant, ikarant, Ikarant, ukarant etc words and on the gender, e.g., we can take up akarant masculine words like ram[2], shyam, ghat etc, to make it vibhakti[3] ekvachan[4], we have to add "H" as suffix therefore the words can be like

Ram +H	ramH

The information on verb is grouped on the basis gan[5] which are ten in number and have further three types atmaypad[6],parasmaypad[7] and ubhaypad[8].These in turn, have different types of tenses for e.g., in case of lat lakar or present tense root word is taken and appropriate suffix is added to it, to obtain the desired result taking care of exception. For example,

Gam	gczC+ti=gczCti

Gam is a root word which forms gachti means to go.

5) The Parse Tree

This process checks whether the input sentence is grammatically correct with the help of EtranS rule bank, as shown in Figure 5. The information gathered from above mentioned process helps in analyzing the grammatical aspect of the sentence and on the basis of the rules assessment is done for e.g. for sentences "Ram is eating" as shown in Figure 7 and "Ram are eating" as shown in Figure 8 we have the following analysis respectively

i. This is a rule in Present Continuous tense, therefore the sentence stands to be true both at morphological as well as parser level.

ii. Hence, this sentence is correct.

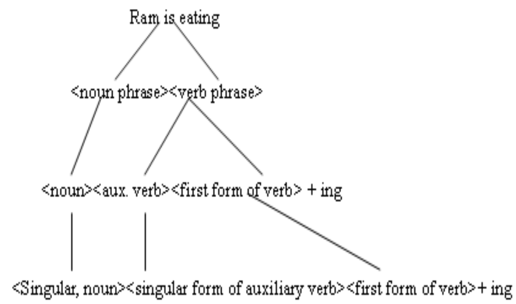


Figure 7.Tree Showing analysis of "*Ram is eating*"

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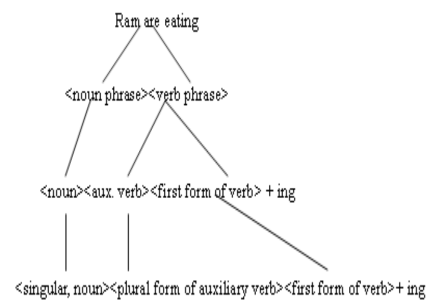

Figure 8.Tree Showing analysis of "*Ram are eating*"

i. This is not matching rule meant for Present Continuous tense, therefore the sentence stands to be true at morphological level but false at parser level.

ii. Hence, this sentence is not correct.

B. THE GENERATOR PROCESS

As shown in Figure 6, the Generator process is the second phase of translation process which is reverse of the parsing process. It is composed of following processes:

i. Mapping Process

ii. Morphological Analysis

iii. Output Process

1) Mapping Process

Mapping process looks for grammatical compatibility between the source and the target language, as both have different grammatical approach[1], e.g., English have preposition and conjunction in separate, while in Sanskrit prepositions and conjunctions are in-built with the respective words itself.

In Figure 9(A), tree is showing parsing of the sentence "Ram goes to school" and Figure 9(B) displays its translation after parsing and mapping process.

---

[1] These are noun categories in Sanskrit.
[2] These are examples of noun.
[3] It represents number of noun.
[4] Is singular form of noun.
[5] Main group of verb
[6] Is a type within karak or verb.
[7] Is a type within karak or verb.
[8] Is a type within karak or verb.

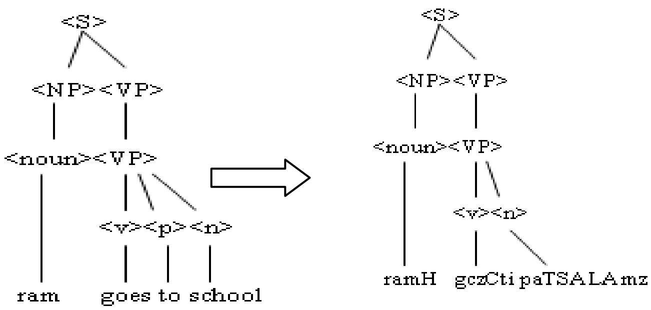

Figure 9(A) Figure 9(B)

Trees showing translation (mapping) process from source to target language

2) Morphological Analysis

The Morphological Analysis looks for the root word in the target language and, on the basis of the above, mentioned mapping information, it maps with respective grammar to make the complete sense. As we can see in the Figure 9(A) that ram is a singular noun, therefore, in Figure 9(B) it is mapped with ramH (ram+H) [In Romanized form] which means root word + vibhakti [1].

3) Output Process

Output process gathers the information from the leaves of the trees generated after above processes. The leaves contains translated text which is finally taken as output to generate translated text.

VII. ETRANS SYSTEM

The system comprises of user interface developed using .NET framework and the lexicon using MS-Access 2007. The modules are developed on the basis of process engine. The user interface is responsible for taking input and generating the output. It is heavily dependent on the tables created in the database for generating output and the programming done to extract the information based on the logic developed.

The software comprises of following modules:

i. Parse Module

ii. Generator Module

A. PARSE MODULE

Parse module is responsible for taking sentences as input, analyzing and parsing; therefore a sentence has to go through the module to generate tokens, grammatical characteristics and syntax analysis :

i. Input Module

ii. Sentence Analyzer Module

iii. Morphological Analysis Module

iv. Parse Module

v. Parse Tree

1) Input Module

This module takes the sentences and submits it to the sentence analyzer module. It considers punctuation marks like comma (,) as it have a very prominent role in conveying meaning of sentence.

2) Sentence Analyzer Module

The sentences are divided into tokens and the category of the sentence is decided. The length of the sentence assists the software program in deciding the number of times loop have to be generated, for searching the grammatical information related to the tokens as shown in Table 3.

TABLE 3. ANALYSIS OF SENTENCE

Sentence	Number of Tokens	Category	Comments
Ram goes to school with his friend by car	9	Extra Large	Number of tokens extracted
Sita dances at annual function of the school with students	10	Extra Large	-do-

3) Morphological Module

Morphological analyzer generate token specific semantic information with the help of lexicon. The analysis of the above mentioned sentences is shown in Table 4.

TABLE 4. MORPHOLOGICAL ANALYSIS

Sentence	Token	Semantic Information	Comments
Ram goes to school with his friend by car	Ram goes to school with his friend by car	noun, third person, singular, masculine gender verb, present, singular preposition noun, singular, neutral gender preposition possessive pronoun noun, singular, third, neutral gender preposition noun, singular, neutral gender	Tokens extracted and semantic Information gathered
Sita dances at annual function of the school with students	Sita dances at annual functi on of the school with studen ts	noun, third person, singular, feminine gender verb, present, singular preposition adjective noun, singular, third, neutral gender preposition article noun, singular, third, neutral gender preposition noun, plural, neutral gender	-do-

4) Parse Module

The semantic analysis is performed in this part of translation. The analysis is done on the basis of EtranS rule bank, which helps to ascertain whether a sentence is grammatically correct or not as shown in Table 5.

TABLE 5. PARSING OF SENTENCE

Sentence	Token	Number	Rule id	Comments
Ram goes to school with his friend by car	*Ram*	*99*	*a27*	*Numbers are generated and rules are matched*
	goes	*101*		
	to	*401*		
	school	*99*		
	with	*499*		
	his	*801*		
	friend	*3*		
	by	*403*		
	car	*3*		
Sita dances at annual function of the school with students	*Sita*	*99*	*a29*	*-do-*
	dances	*101*		
	at	*402*		
	annual	*601*		
	function	*3*		
	of	*406*		
	the	*703*		
	school	*3*		
	with	*499*		
	students	*3*		

5) Parse Tree

The parse tree is based on minimal attachment principal according to which the preference is given to syntactic analysis that creates the least number of nodes in the parse tree. Thus, based on the minimal attachment principal, following trees are prepared for the statements mentioned above. In particular a parsing tree on the left hand side depicts structure of the source and the corresponding target language tree is shown in the right hand side along with replacements done(for conjunction, preposition etc.) as show in Figure 10 and 11.

B. GENERATOR MODULE

Generator module takes semantic information from the morphological analysis module and does mapping followed by searching for the correct form of the words from the lexicon by considering root words to generate output of the source language.

1) Mapping

Mapping is done purely on the basis of the information passed from the morphological module. Since in Sanskrit a word contains conjunction, preposition and other information therefore this needs to be considered while mapping process as shown in Table 6

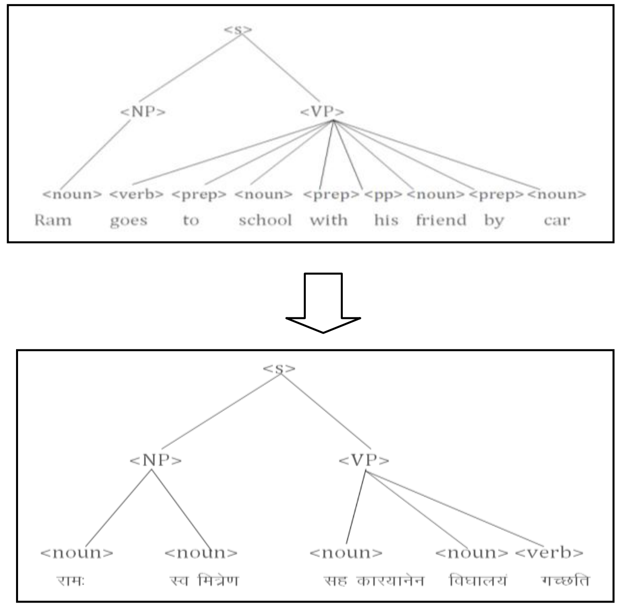

Figure 10[9] ParseTree of source and destination language

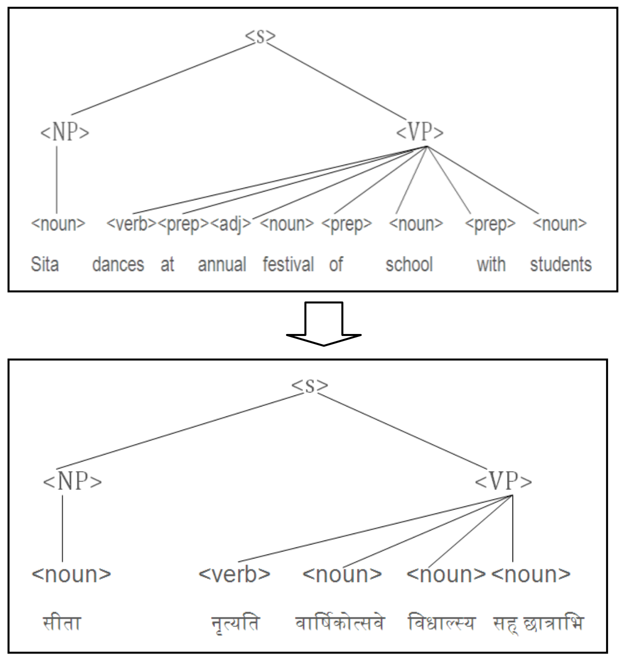

Figure 11.[10] ParseTree of source and destination language

[9] Figure.10 we can see that “his friend” is replaced by “Lo fe=s.k” , “by car” is replaced by “lg dkj;kusu” and “to school” is replaced by “fo?kky;a”.

[10] Figure.11 we can see that “at annual festival” is replaced by “वार्षिकोत्सवे” and “of school” is replaced by “विधाल्स्य”.

2) Output Module

This module is provides the translated text produced after going through above mentioned modules, as shown in Figure 12 and 13.

Figure 12.Translation of "Ram goes to school with his friend by car" is "रामः स्वमित्रेण् सह कारयानेन् विधालयम् ग्च्छति".

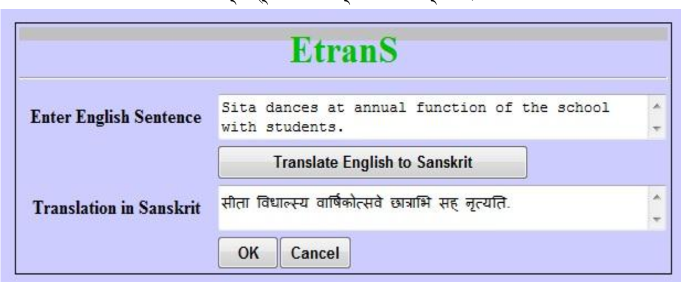

Figure 13.Translation of "Sita dances at annual festival of the school with students" is "सीता विधाल्स्य वार्षिकोत्सवे छात्राभि सह नृत्यति"

VIII. FORMATION OF RULES PATTERN

The rules formation is the most challenging task of the machine translation as it is the back bone of the whole process. It covers the entire process of translation starting from syntax analysis ending up to translation; we also covered the mapping process from source to target language.

The rules are framed in ascending order. We have started formation of rules starting with simple sentences and ending up to compound sentences. The size of the sentences ranges from small to large.

A. Extension of rule base and lexicon

The rule base can be extended on requirement basis or if we want to add complex sentences also. The extension of lexicon is also a simple affair as for all the groups present in Sanskrit and English language ids have been provided. The new word can be added keeping in view the grammatical information of the word to be added, e.g. if we need to add a noun like bucket dictionary can be referred and the number assigned would be 3

IX. FEATURES OF THE SOFTWARE

The software developed has following features.

i. The system can translate Simple and compound sentences from English to Sanskrit.
ii. The sentences can be simple and compound with affirmative and imperative type or of active or passive voice having any of the three tenses i.e. Present, Past and Future.
iii. Rule base is easy to expand as we have divided sentence into three categories namely Subject, Verb and Object and have provided identification numbers accordingly. The Rule base looks for number combination for making new additions.
iv. The lexicon is capable for new framing and following features have been added to the lexicon
   a. Identification number has been assigned to all the groups available in English and Sanskrit.
   b. New words can be added to the database by identifying the identification number both in English and Sanskrit.
   c. Sanskrit is a strong typed language therefore word order is not a matter of concern.

X. RESULT AND CONCLUSION

In this paper, the complete framework for Rule Based Translation is outlined. The chosen language pair is English and Sanskrit, as a source and target language. The system (EtranS) supports both English and Sanskrit grammar such as noun, verb adjective etc. To check robustness of the rules, EtranS system took samples of five hundred sentences of various types, as the sentences of simple and compound of affirmative, interrogative and imperative types in active and passive voice. We have considered sentences from all the three tenses i.e. present, past and future. It is our belief that this methodology can be adopted for translation of similar languages. The rule base can be extended to translate various types of literature in English to Sanskrit. Based on the observations above, several experiments with EtranS were conducted. For each run we considered a set of sentence type like simple, imperative etc. The results of these experiments are summarized below in the Table 8.

The sentences are divided into three categories that are small, large and extra-large to find out the accuracy of the EtranS system. The performance of translation is graded as three categories A, B and C given in the Table 7.

In the proposed approach we have obtained ninety-nine percent of correctness for the small sentences and ninety percent accuracy for the extra-large sentences. The result shows ninety percent of the sentences are correctly translated, however due to linguistic ambiguities two percent of the sentences have reported error.

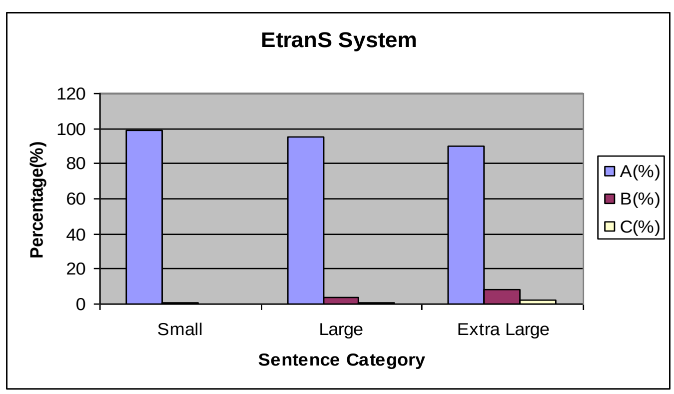

Figure 14 . Chart showing performance of the EtranS system

TABLE 6.MAPPING OF SENTENCE

Sentence	**Tokens**	**Translation**	**Semantic Information**	**Root word**	**Comments**
Ram goes to school with his friend by car	Ram goes to school with his friend by car	रामः ग्च्छति स्व विधालयम् मित्रेण् सह् कारयानेन्	प्राथमा विभक्ति , एकवचन ,पुल्लिंग शब्द प्रथम पुरुष, एकवचन (लट् लकार). अपव्य्य द्विितिया विभक्ति, एकवचन तृतीया विभक्ति, एकवचन. अपव्य्य तृतीया विभक्ति, एकवचन	राम गम् विधालय् मित्र कार	According to the root words the information is mapped with the semantic information and text would be generated
Sita dances at annual function of the school with students	Sita dances at annual function of the school with students	सीता नृत्यति वार्षिकोत्सवे विधाल्स्य सह् छात्राभि	प्राथमा विभक्ति , एकवचन , स्त्रीलिंग शब्द प्रथम पुरुष, एकवचन (लट् लकार-) सत्मी विभक्ति, एकवचन षष्ठीविभक्ति ,एकवचन अपव्य्य तृतीया विभक्ति ,बहुवचन.	सीता नृत्य विधालय् छात्रा	-do-

TABLE 7. CATEGORIES USED FOR RESULT ANALYSIS

Category	Description	Remarks
A	Sentence is correct in terms of grammar and translation.	-NIL-
B	Sentence is correct in terms of grammar but translation is not correct.	Due to the linguistic representations, few words in English may have multiple roles to play, e.g., the word became is used as a multipurpose word in English, e.g., He became king. She became sad. In Sanskrit, there are different representation for became in the above example. This is a constraint for the software but a linguist can decide where to use which word.
C	Sentence is ambiguous, i.e., it failed at the parsing level.	Few words in English may be used as both noun and verb. This generates ambiguity for the system. For example "The can can have water". A further line of work is required in this area to understand these anomalies.

TABLE 8. ANALYSIS OF THE ETRANS SYSTEM

Sentence	Size	A (%)	B (%)	C (%)
Small	>=3 & <= 5 words	99	1	0
Large	>5 & <= 8 words	95	4	1
Extra Large	>8 & <= 11 words	90	8	2

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Exploiting Communication Framework To Increase Usage Of SMIG Model Among Users

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***Abstract*— Today is the era of parallel and distributed computing models. Recent developments in DSM, Grids and DSM based Grids focus on high end computations of parallelized applications. We have built SMIG (Shared Memory Integrated with Grid) which amalgamates DSM and Grid computing paradigms as a part of our doctoral work. Literature citations have indicated a lacuna in how technological models are communicated to potential users to increase usage. Based on this lacuna we have identified the potential users and prepared a communication framework to disseminate SMIG information in order increase its usage. Hence in this paper we have compared various communication techniques used for disseminating DSM, Grid and DSM based Grid models as surveyed from literature. We have further designed and implemented a communication framework to percolate SMIG information to users. In the communication framework we have plugged in various tools for information dissemination and feedback (apart from those found in the survey) for promoting usage of technology among volunteers and application developers. These are included in the communication framework, namely arranging overview sessions, passing written documentation like presentations, installation handbook, FAQs, and also providing an opportunity to use SMIG model. The detailed responses received from the users after implementing the communication framework are encouraging and indicates that such a communication framework can be used for disseminating other technology developments to potential users. This will prove useful in today's dynamic world where technological developments are happening on a day to day basis.**

Keywords- DSM based Grid;Shared Memory integrated Grid-SMIG;Communication Framework.

I. INTRODUCTION

With increasing advances in semiconductor integration and network technologies computer costs are decreasing and usage of computers is rapidly seeping in every day applications. Supercomputers are slowly being replaced with multiprocessor architectures which can perform similar functions at lesser costs. Two computing paradigms have emerged: parallel computing and grid computing. In the past several decades two parallel computing systems are widely used namely loosely coupled and tightly coupled systems. Both these system have their advantages and disadvantages. Distributed Shared Memory (DSM) [1, 2] exploits the advantages of both models: ease of programming of tightly coupled systems (shared memory) and scalability of loosely coupled systems (distributed memory). DSM enables each processor to have its own physical memory but all processors together display a logical abstraction of memory address space. DSM systems can be built in hardware (called Hardware DSM -HDSM) or in software (called Software DSM-SDSM) but they are dedicated completely for distributed computing applications.

Currently computers be it standalone, in LANs or in WANs may execute some high-end tasks and use 100% CPU power but not continuously. Grid computing exploits these underutilized resources for high performance computing where the high-end computations are parallelized and distributed among machines for faster execution [3,4]. It is possible to combine SDSM and grid computing paradigms and build an amalgamated model which shall have benefits of both, carry out high end computations, easy of program, scalable and exploit underutilized resources. We have built SMIG (Shared Memory Integrated with Grid) model as a part of our doctoral work. In the literature surveyed it was noticed that almost all SDSM, Grid and DSM based Grids have been developed in academic research environments. However there was a limitation in how information about these models was communicated to potential users. Hence it was felt that just building an SDSM Grid amalgamated model was not enough but it was also important to identify the potential users, design and implement a communication framework to broaden the usage of this model.

In this paper we have described the design and implementation of a Communication Framework to broaden usage of SMIG model among users. The paper is structured as follows: In section 2 we set the context with a brief idea about the background to current computing paradigms followed by an overview of SMIG model in the next section. The motivation for SMIG communication framework and the plan for communicating the same to potential users is put forth in section 4 and 5 respectively. The sections 6 and 7 give the details of the implementation methodology and discussion of the results. Finally we end the paper with conclusion and scope for further research.

II. MOTIVATION

Today there is an inherent rise in usage of computers and development of software programs, algorithms and applications. Standalone machines do not provide satisfying response to large sized programs and high end computations. Two trends cater to the need for high performance computing namely: Distributed Shared Memory –DSM and Grid

Computing. They have the advantages of optimization of memory and computing power respectively. DSM provides an abstraction of a single virtual memory although the memories are physically distributed across machines while grid computing computes through sharing of existing idle/ underutilized resources. Both these paradigms provide an efficient replacement for supercomputers. Parallel programs exhibit speed up and improve performance in a DSM environment but it uses dedicated computers, example DSM systems are Treadmarks, JUMP etc. [5,6] Grid computing optimizes existing unused computational power and is useful for parallel programs which can run independently, example EU Data Grid, NASA grid, BOINC, SLINC, SETI etc.[7,8] Both computing paradigms reduce hardware requirements and lower the installation and implementation costs. High-end computations can be easily parallelized and distributed in both DSM and grid based clustered computers to speed up execution and thus optimize the use of existing resources. There are research citations: SMG and Teamster-G which indicate that DSM based grid is a viable option to explore. SMG [9] explores the environment of OpenMP and is compatible with DSM System layered on top of Message Passing Interface (MPI) and together they can execute in a grid environment. Teamster-G is a grid enabled DSM simplifies the programming on computational grids and enriches the applications of grid computing [10]. Based on this motivation we have designed and developed SMIG model by amalgamating SDSM and Grids, namely JUMP DSM (JIAJIA Using Migrating Protocol and of working principles of SLINC (Simple Light Weight Infrastructure of Network Computing. The SMIG model is released as an open source package.

III. DETAILS OF SMIG MODEL

SMIG comprises of a interconnected homogeneous machines with the configuration of one Master and other Hosts. SMIG uses special calls for initialization/ finalization, memory allocation and synchronization (JUMP code) which are handled by SMIG Master. The hosts are volunteers who have donated their machines for application execution which will execute in the background. SMIG Master initiates various DSM calls: initializes the DSM abstraction, configures hosts and allocates memory on all hosts. It then initiates application processes to be executed on all the hosts. Java script is executed on hosts to call this application processes and execute them in low priority. The application process is initiated. On every local machine host OS (Operating System) schedules jobs. The application is run on low priority giving preference to the volunteer's tasks. Based on the amount of computing power available on the hosts the application processes complete execution and the results are returned to the Master. SMIG execution is illustrated in figure 1.

Once SMIG was installed, the applications (Matrix Multiplication/ Merge Sort/ Bucket Sort) for 2/4/8 hosts and a specific data size were executed. The applications were run on SMIG. It was observed that SMIG model is feasible and that all applications completed execution. However the time required for application execution on SMIG(N) was more than that on SMIG(0) with volunteers also using the hosts for their own application execution survey was carried out to understand the communication techniques used by DSM, grid and DSM based grid researchers for information dissemination to users.

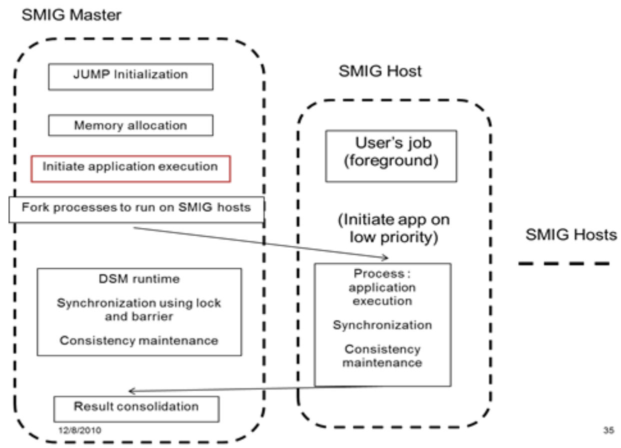

Figure 1: SMIG execution

Researchers have communicated DSM and Grid models to computer users in different ways (through web by published papers, by distributing source code, help manuals, tutorials etc.) and to different types and number of users. Many of the efforts spent in communication have not helped to boost usage of these models, or encourage research in improving performance or modifying existing systems barring a few.

IV. NEED FOR SMIG COMMUNICATION FRAMEWORK

Literature citations have highlighted various tools used for disseminating information [11, 12, 13]. Communication of information increases usage of a technical model, and leads to further research and enhancements in that area. This in turn results in evolution of new models. Extensive survey was carried out to understand the communication techniques used by DSM, grid and DSM based grid researchers for information dissemination to users. Researchers have communicated DSM and Grid models to computer users in different ways (through web by published papers, by distributing source code, help manuals, tutorials etc.) and to different types and number of users.

Many of the efforts spent in communication have not helped to boost usage of these models, or encourage research in improving performance or modifying existing systems barring a few.

This comparison of techniques used by DSM, is listed in table 1, used by grids is listed in table 2 and that used by DSM based grids is listed in table 3.

TABLE I. COMPARISON OF MODES OF COMMUNICATION OF DSM

Title	**System type**	**Research papers**	**Technical information availability on the web**			
			Source code	**Documentation**	**Promotion techniques**	**Others**
JUMP DSM	Model	Yes	Yes	Yes	Nil	Nil
Teamster	Model	Yes	Nil	Nil	Nil	Nil

TABLE II. COMPARISON OF MODES OF COMMUNICATION OF GRIDS

Title	**System type**	**Research papers**	**Technical information availability on the web**			
			Source code	**Documentation**	**Promotion techniques**	**Others**
OptorSim	Simulator	Yes	Yes	Yes	Posters	Nil
GridSim	Simulator	Yes	Yes	Yes	Nil	Nil
Globus toolkit [10]	Grid building toolkit	Yes	Yes	Yes	Nil	Online support, newer versions.
BOINC	Model	Yes	Yes	Yes	Nil	Tutorials , online community
SLINC	Model	Yes	Yes	Yes	Nil	Peer review for usability
EU Data Grid (European Union)	Consortium of academic institutes	Yes	Yes	Yes	Posters, handouts, demonstrations	Online forum, community

TABLE III. COMPARISON OF MODES OF COMMUNICATION OF DSM BASED GRIDS

Title	**System type**	**Research papers**	**Technical information availability on the web**			
			Source code	**Documentation**	**Promotion techniques**	**Others**
SMG (Shared Memory Grid)	Model	Yes	Nil	Nil	Nil	Nil
Teamster-G	Model	Yes	Nil	Nil	Nil	Nil

As an example JUMP DSM source code and documentation are made available on the web. The JUMP documentation was sufficient to install and execute applications and no additional help was required during this activity.

The user manual also provided steps for writing our own application program. JUMP installation guide includes pre requisites, installation steps, executing application programs, how to write applications for JUMP and the application programming interface.

Few communication tools have been used for DSM and Grids. However no details were available for communication of DSM based Grid on the web apart from one or two published papers. Building a model is not enough, concrete steps need to be taken to communicate the model.

V. SMIG COMMUNICATION PLAN

We have proposed a communication framework to propagate the technology related information to potential users. The users were classified as volunteers who donate resources to SMIG for application execution, and developers who can use SMIG for running high end computations. The objective for volunteers was to create awareness of SMIG among users and enable them to recommend volunteering on SMIG to others.

The goal of communicating to application developers was to create awareness of technical information and how high end computations can be executed on SMIG and enable them to promote SMIG for high end computations. Various information dissemination and feedback tools have been identified as listed in table 4 and table 5 for information dissemination and feedback respectively. The above tools form the basic building blocks of SMIG communication framework.

TABLE IV. TOOLS FOR INFORMATION DISSEMINATION

Tool	**Mode**	**Comment**
Presentation	Lecture	Was different for volunteers and Application developer
Interactive discussion	Oral	Audience participation to clarify doubts
FAQ	Written	Create more awareness of SMIG
Installation handbook	Written	Only for application developer Gives overview of the installation procedure Gives overview of application development
Experiment SMIG usage	Hands on practice on SMIG	For volunteers: to understand how SMIG works and how SMIG does not slow down user's tasks For application developers to understand how SMIG is used for high end computations

TABLE V. FEEDBACK TECHNIQUES

Techniques	**Mode**	**Comment**
Pre SMIG questionnaire	Written through email	For both Volunteers and Application developers
Post CF (Communication Framework) questionnaire	Written through email	Different for Volunteers and Application developers

Observation Report	Non verbal, written in observation report	Different for Volunteers and Application developers

VI. IMPLEMENTATION PLAN

The communication framework was built using the above information dissemination and feedback tools. The documents were prepared and later specific information was disseminated to users: volunteers and application developers.

TABLE VI. CRITERIA FOR SELECTING V AND AD

No.	Criteria	Volunteer		Application developer	
		EG(V)	**CG(V)**	**EG(AD)**	**CG(AD)**
1	Experience	0-1.5 years	0-1.5 years	1.5-3 years	1.5-3 years
2	Competency	Computer users/ Basic programming	Computer users/ Basic programming	Computer programmers	Computer programmers
3	Working hours	General / morning shift	Any shift	General / morning shift	Any shift
4	Project phase	Design/ coding	Any except Go Live	Design/ Coding / Testing	Any except Go Live
5	Location	Mumbai / getting transferred to Mumbai	Any location	Mumbai / getting transferred to Mumbai	Any location

Pre SMIG Survey Questionnaire was given to the entire study group to get information about the computer usage in terms of time for which used, platform of working and were they aware of their average CPU power and memory usage. The other information gathered from the survey was whether they were aware of the concept of volunteering, background processing, and of SETI and UD (United Devices, here onwards called as UD) on the Internet. \Lastly two additional questions were included in the survey to find out whether they have volunteered earlier and would they be willing to donate their CPU cycles. The Post CF survey was conducted after SMIG information dissemination (Lecture, distribution of FAQ, and SMIG usage) to volunteers.

The post CF survey was conducted after SMIG information (Lecture, distribution of FAQ, and installation handbook and SMIG usage) to application developers. This survey was designed with the objective of gauging the feedback of the treatment of the communication framework components on Volunteers and Application developer's experimental groups. The questions related to the presentation are listed in table 7. The interactive discussion and SMIG usage was closely observed for both volunteers and application developers and the implementation details have been summarized in table 8.

TABLE VII. POST CF INFORMATION

Question related to	Details from Volunteer regarding	Details from Application developer regarding
Presentation	Quality, message of volunteering and SMIG overview, provided inspiration for volunteering	Quality, message of volunteering and SMIG technical overview, resource optimization and parallelization of high end applications, provided inspiration for volunteering, using SMIG for application execution and promote to others
FAQ	Quality	Quality
Installation handbook	Not applicable	Quality, installation understood
SMIG usage	Types of tasks were executed on SMIG as volunteers, whether the responder realized that SMIG was running in the background.	Types of tasks were executed on SMIG as volunteers, whether the responder realized that SMIG was running in the background.
Post communication framework	Inspired for volunteering and recommending to others for volunteering	Inspired for volunteering and recommending to others for volunteering, using for high end applications and promoting to others
Communication framework component	Which was responsible to inspiring and recommending volunteering (presentation, FAQ, SMIG usage)	Which was responsible to inspiring and recommending to others (presentation, FAQ, installation handbook,SMIG use)

TABLE VIII. INSTRUMENT: INTERACTIVE DISCUSSION / SMIG USAGE

Atmosphere	Communication details	Monitoring	Observation comments	Summary
Environment , site, group constitution, body language	Event, objective, mode, procedure of the event	How was the event monitored	Comments regarding the response of the attendees to the conduct event and their participation	Impact of the event on the participants, relate to dependent variables

The communication framework implementation for experimental group of both volunteers-EG(V) and application developers-EG(AD) are illustrated in figure 5.

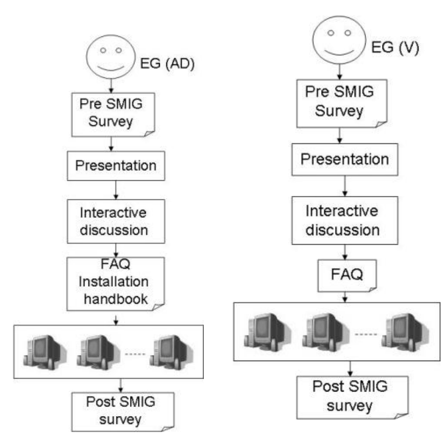

Figure 2: Communication Framework

The communication framework (figure 5) was implemented for volunteers and application developers separately.

VII. Analysis of Results

The communication framework (figure 5) was implemented for volunteers and application developers separately. For volunteers the details of responses received from volunteers for presentation are detailed in table 9. Overall the responses were encouraging and volunteers were inspired to recommend the concept of volunteering to others.

TABLE IX. POST CF RESPONSES FOR PRESENTATION

Sr. No.	Survey questions	Yes	No	Not sure
1	Concept of volunteering	46	2	2
2	Overview of SMIG	42	5	3
3	Has the presentation encouraged you to donate your desktop power for any such high end application execution?	15	14	21
4	Has the presentation inspired you to recommend volunteering to others?	9	15	26
5	Were you satisfied with the overall quality of the presentation?	38	12	NA

After the presentation FAQ (Frequently Asked Questions) was distributed to the volunteering group through mail. The overall response of the group to FAQ was positive. The questions and related responses are listed in table 10.

TABLE X. POST CF (V) RESPONSES FOR FAQ

Sr. No.	Survey questions	Yes	No
1	Has the FAQ explained all the questions clearly?	43	7
2	Has the FAQ enabled you to develop a better understanding of SMIG?	39	12

After attending SMIG presentation and going through the FAQ the volunteer group was asked to use SMIG as volunteers to do their own work. They were asked questions to find out whether SMIG application execution running in the background hampered their work or not. The responses to these questions are tabulated in table 11. The volunteers could do their own work along with SMIG program running in the background.

TABLE XI. POST CF (V) SMIG USAGE FEEDBACK

Sr. No.	For each of these programs or applications (1-3) did your program take longer time to execute?	Yes	No	Not sure
1	Word processing	1	36	13
2	Playing recorded sessions	3	28	19
3	C/ Java programs or anti virus scan	2	32	16
4	Did you realize that SMIG was running on your machine?	8	37	5

The comments were summarized as follows: "Hands on usage of SMIG led to increase in confidence level of study group for volunteering and for recommending volunteering to others". The application developer group used the CF components of information dissemination – presentation, FAQ, Installation handbook and SMIG usage. The group was closely observed during the interactive discussion and SMIG usage. After this the EG(AD) group was given a Post CF survey questionnaire. The survey data was collected from the group of application developers through the Post CF survey form. The results are consolidated and discussed in the table 12. Overall the group understood the concept of volunteering, SMIG architecture, using SMIG for high end computations.

TABLE XII. POST CF EG(AD) PRESENTATION RESPONSE

No.	Survey Question	Yes	No	Not sure
1	Concept of volunteering	19	5	1
2	SMIG architecture and working	14	9	2
3	Concept of resource optimization	15	9	1
4	Overview of application development	21	3	1
5	Has the presentation encouraged you to donate your desktop power for SETI / UD or any such application?	8	14	3
6	Were you satisfied with the overall quality of the presentation?	14	11	
7	Has the presentation inspired you to recommend volunteering to others?	5	18	2
8	Has the presentation encouraged you to execute high application programs on SMIG?	3	20	2
9	Do you feel that the presentation inspired you to promote SMIG for high end computations to others?	3	19	3

After the presentation, FAQ was distributed to the group through mail and the responses collected from the group are listed in table 13. The group got a better understanding of SMIG after going through the FAQ.

TABLE XIII. POST CF EG(AD) FAQ RESPONSE

No.	Survey Question	Yes	No
1	Has the FAQ explained all the questions clearly?	21	4
2	Has the FAQ enabled you to develop a better understanding of SMIG?	19	6

Since the application developers had technical expertise, they were also circulated the Installation Handbook through mail. Responses were collected from the application developer group and are listed in table 14. The group got a clear idea of installation process from the handbook.

TABLE XIV. POST CF EG(AD) INSTALLATION HANDBOOK RESPONSE

No.	Survey Question	Yes	No
1	Has the installation handbook explained the installation procedure clearly?	23	2
2	Will installation handbook be enough to start installing SMIG?	18	7

The group members were asked to use SMIG as volunteers to do their work. Feedback was collected from the group and responses are detailed in table 15. They were asked questions to find out whether SMIG application execution running in the background hampered their work or not. Overall the group member's work was not hampered by SMIG job running in the background.

Using Communication Framework SMIG information was thus disseminated to population of volunteers and application developers.

TABLE XV. POST CF EG(AD) SMIG USAGE FEEDBACK

No.	For each of these programs or applications did your program take longer time to execute?	Yes	No	Not sure
1	Word processing :	3	18	4
2	Playing recorded sessions	5	16	4
3	C/ Java programs or anti virus scan	7	15	3
4	Did you realize that SMIG was running on your machine?	12	9	4

VIII. CONCLUSION

DSM and Grids focus on parallelizing applications and reduce hardware requirements and thus lower the installation and implementation costs. As a part of the doctoral work we have built SMIG (Shared Memory Integrated with Grid), a model which combines DSM and Grid computing paradigms. Literature citations indicate that some DSMs, Grids have hosted their home pages on the Internet, where they have given the source code and help documentation. Several research works in the area DSM based Grid have been published, but none of these research initiatives have been successful in reaching out to users beyond the campus.

Based on this survey a communication framework was designed and implemented to percolate SMIG information among potential users. The major advantages of designing the communication framework was to create awareness and enable users to promote the concept of volunteering, optimizing resources and use existing resources of SMIG for high end application execution. The communication framework included various tools like arranging overview sessions through presentations, handing written documentation circulate to users and also providing an opportunity to use the model. Feedback was collected after using each component of the communication framework. To summarize: the SMIG information and volunteering concept was transmitted to the group of volunteers and application developers. It was concluded that the motivational level of users to volunteer or donate resources was increased. The volunteer group members found it comfortable to use SMIG and the confidence level of group members to recommend SMIG to others also increased. The implementation of the communication framework among application developers has additionally enabled to promote SMIG for application development apart from volunteering their machines for SMIG execution.

Based on the implementation results it is evident that such a communication framework can be used for disseminating other technology developments to potential users. This is critically important in today's fast moving dynamic world where technological developments are happening on a day to day basis. Also there is a need to know what research is happening today and how researchers can contribute in enhancing it rather than doing working on it in the near future.

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