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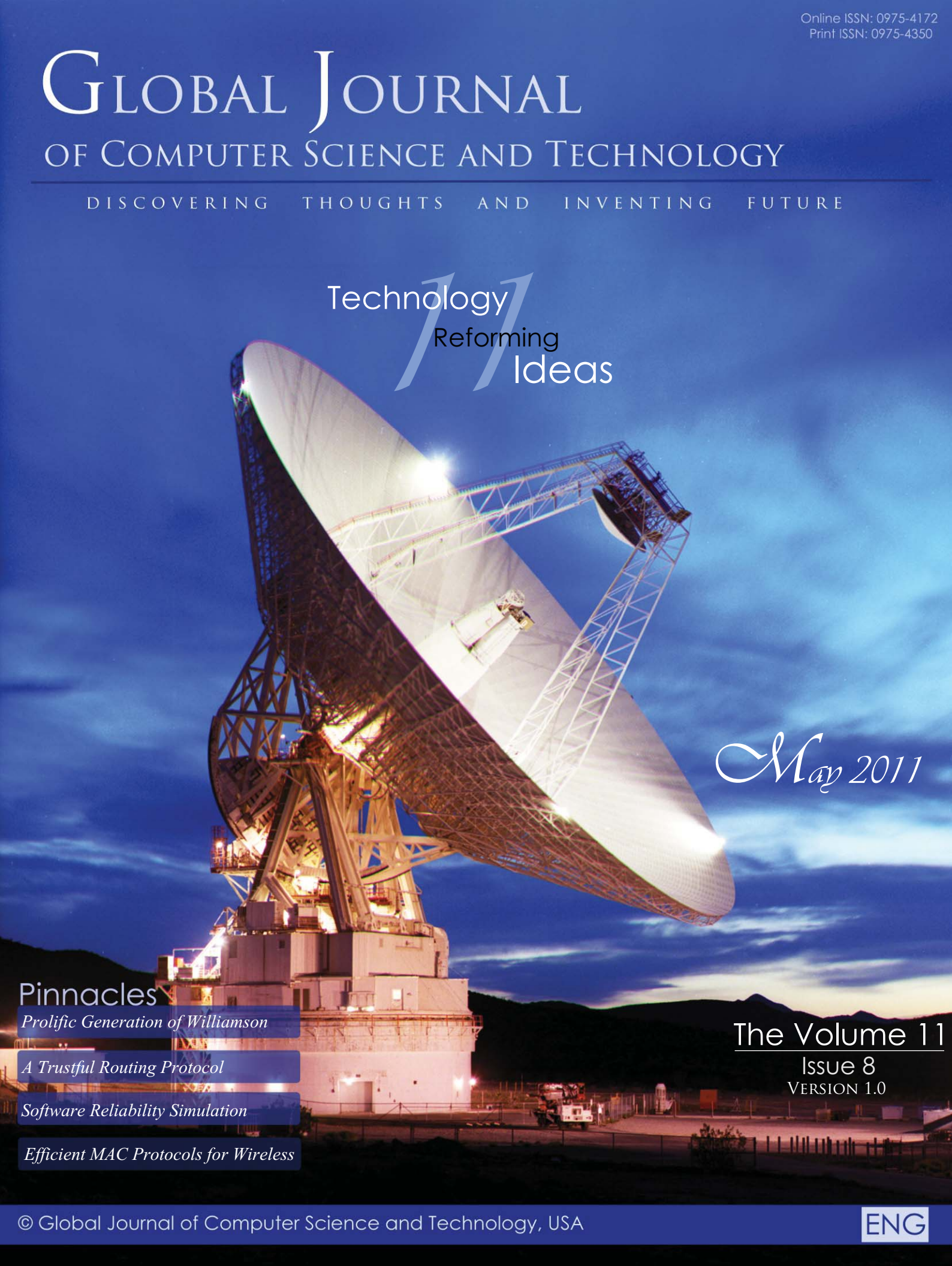

May 2011

Pinnacles

- *Prolific Generation of Williamson*
- *A Trustful Routing Protocol*
- *Software Reliability Simulation*
- *Efficient MAC Protocols for Wireless*

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Prolific Generation of Williamson Type Matrices

By M.K.Singh, Sandip Dutta, N C Mahanti

Abstract- A new method of generating Williamson type Matrices A, B, C, D is described such that
(i) A, B, C, D are symmetric.
(ii) A, B, C are circulant matrices and D is a back circulant matrix.
All such Williamsom type matrices of order n = 7, 9, 11, 13, 15, 17 are obtained by exhaustive computer search. The number of Williamson type Matrices constructed here is much greater than that of Williamson Matrices of same order. For example there are only 4 Williamson Matrices of order 17 but by our method we have obtained 504 Williamson type Matrices of order 17.

Keywords: Hadamard Matrices, Williamson & Williamson type Matrices, circulant and back circulant matrices, turnpike or partial digest problem.

GJCST Classification: *F.2.1, G.1.3*

Strictly as per the compliance and regulations of:

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Index Terms- Hadamard Matrices, Williamson & Williamson type Matrices, circulant and back circulant matrices, turnpike or partial digest problem.

I. Introduction

We recall the following definitions from Craigen and Kharaghani [1].

1.1 Hadamard Matrix [or H-Matrix] : An n x n (+1, -1) matrix H is a Hadamard matrix if $HH^T = nI_n$.
It is conjectured that an H-matrix exists for every order n = 4t where t is a positive integer.

1.2 Amicable matrices : Two matrices X and Y are called amicable, if $XY^T = YX^T$.

1.3 Circulant matrix : circ(a_1, a_2, ...a_n) is the matrix

$$\begin{bmatrix} a_1 & a_2 & .. & a_{n-1} & a_n \\ a_n & a_1 & a_2 & ... & a_{n-1} \\ a_{n-1} & a_n & a_1 & ... & a_{n-2} \\ .. & .. & .. & .. & .. \\ a_2 & a_3 & .. & .. & a_1 \end{bmatrix}$$

called circulant matrix.

1.4 Back circulant matrix : bcirc(a_1, a_2, ...a_n) is the matrix

$$\begin{bmatrix} a_1 & a_2 & .. & a_{n-1} & a_n \\ a_2 & a_3 & .. & a_n & a_1 \\ a_3 & a_4 & .. & a_1 & a_2 \\ .. & .. & .. & .. & .. \\ a_n & a_1 & .. & .. & a_{n-1} \end{bmatrix}$$

called back circulant matrix.

Back circulant bcirc (0 0 .... 0 1) is called back diagonal matrix.

1.5 Matrics used in the construction of H-Matrices : n x n (+1, -1) matrices A, B, C, D satisfying

$$AA^T + BB^T + CC^T + DD^T = 4nI_n \quad (1)$$

Are
(i) Williamson Matrices if they are symmetric and circulant.
(ii) Goethals Seidel type matrices if they are circulant but not necessarily symmetric.
(iii) Williamson type matrices if they are pairwise amicable. vide [1]

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(iii) Williamson type matrices if they are pairwise amicable.
vide [1]

1.6 Orthogonal Design OD (4t, t, t, t, t): OD (4t, t, t, t, t) is an orthogonal design of order 4t and type (t, t, t, t), t is a +ve integer, which is defined as an 4t x 4t matrix with entries ±A, ±B, ±C, ±D (A,B,C,D are commuting indeterminates) satisfying

$$XX^T = t(A^2+B^2+C^2+D^2)I_{4t}$$

For details vide Geramita and Seberry [2]

II. Previous Work

If A,B,C,D are Williamson or Williamson type Matrices then the H-matrix, H can be constructed as

$$H = \begin{bmatrix} A & -B & -C & -D \\ B & A & -D & C \\ C & D & A & -B \\ D & -C & B & A \end{bmatrix}$$

Originally Williamson[3] constructed Williamson matrices for m ≤ 21, m=25, 37, 43. Baumert, Golomb and Hall[4] constructed Williamson matrix for m = 23. Baumert and Hall[5] found all solutions for 3 ≤ m ≤ 23 and some solutions
for m =25, 27, 37, 43. For details of the solutions vide Hall[6]. Baumert[7] gave one solution for m = 29. Koukouvinos and Kounians[8] made exhaustive search for all Williamson atrices of order 33.

Williamson type martrices have been constructed by Seberry [9], [10] & Whiteman [11].

If A, B, C, D are circulant matrices satisfying equation (1) then H-matrix G can be obtained as the Goethals & Seidel array [12]

$$G = \begin{bmatrix} A & -BR & -CR & -DR \\ BR & A & -D^TR & C^TR \\ CR & DR & A & -BR \\ DR & -CR & BR & A \end{bmatrix}$$

Where R is a (0,1) –back diagonal matrix.

A Quadruple of Williamson type matrices A,B,C,D has advantage over other Quadruples used to construct H-matrices. The following lemma of Baumert and Hall [vide Colbourn & Dimtz[13] shows that from a quadruple(A,B,C,D) of Williamson type matrices. Several Hadamard matrices can be constructed.

Lemma 1: The existence of orthogonal design OD(4t; t,t,t,t) and four Williamson type matrices of order n implies the existence of H-matrices of order 4nt. Though it is generally conjectured that the above OD exists for all t, the existence is known for t ≤73 (vide Colbourn and Dinitz ([14] p295).

III. Methodology

3.1 Some basic facts: We will begin with the following (new) definitions: (we assume that n is an odd positive integer)

(i) Input Set

A set $S_k=\{n_1, n_2, ...n_k\}$ of inergers where $0 < n_i < n$, k is even, will be called an input set. The input set S_k will be called symmetric if $n_i \in S_k \rightarrow n - n_i \in S_k$

(ii) Output Vector

Let m = (n-1)/2. Let S_k be an input set defined above

Let $S_k + j = \{ n_{1+j}, n_{2+j}, ...n_{k+j}\}$, where + stands for addition mod n.

Let $r_j = |S_{k+j} - S_k|$ = the order of the set $(S_{k+j}) - S_k$ ———— (1)

and $e_j = n - 4r_j$, j = 1, 2, 3 .....m ———— (2)

Binary reprentation of S_k:

row vector $b_k = (a_1, a_2, ...a_n\text{-}1)$ will be called binary representation vector ((BR)-vector) of S_k if $a_i = -1$ if $i \in S_k$ & $a_i = +1$, otherwise

3.2 Method of Construction

Step-I Generation of size vector

First construct 4-vector $(k_1, k_2, k_3; k_4)$ which consists of feasible sizes of the four input sets as follows

Express 4n as $4n = n_1^2 + n_2^2 + n_3^2 + n_4^2$

where n_i are odd integers. [This is always possible]

let $m_i = (n - n_i)/2$ and $k_i = m_i$ or $n - m_i$ according as m_i is even or odd i = 1, 2, 3

Let $k_4 = (n - n_4)/2$ or $(n + n_4)/2$

The vector $(k_1, k_2, k_3; k_4)$ will be called size vector for an input set.

Step-II Generation of input sets

(a) Three symmetric input sets S_{k1} , S_{k2} , S_{k3} of size k_1, k_2 , k_3 respectively.

Let $k \in \{k_1, k_2, k_3\}$. Generate all (k/2) - subsets of the set {1,2,3,.....m}. From each (k/2)-subset $S_{k/2} = (n_1, n_2,.....n_{k/2})$ obtain a k-subset S_k by adjoining k/2 new elements $n - n_i$, i = 1, 2, ... k/2

(b) One input set S_{k4} of size k_4 obtain all k_4 - subsets of the set (1, 2, ... (n-1))

Step-III Generation of binary vectors and output vectors

Let $k \in \{k_1, k_2, k_3, k_4\}$

For each input set Sk obtained in Step-II form its binary vector bk and the output vector vk and record all correspondences $S_k \rightarrow b_k \rightarrow v_k$

Step-IV Sum of output vectors corresponding to three

symmetric input sets

Form the set $S = \{s=(s_1, s_2, s_3, ... s_m) : s$ is the sum of triplets of output vectors corresponding to symmetric input sets S_{k1} , S_{k2} , S_{k3} obtained in Step II (a) Omit all vectors $\in S$

for which $|si| \geq n - 2$. Let S' be the resulting set. Also record

the correspondences $(S_{k1}, S_{k2}, S_{k3}) \rightarrow s \in S'$.

Step-V Set of output vectors corresponding to S_{k4}

Form the set T of output vectors $t = (t_1, t_2, t_3, ... t_m)$ of S_{k4} obtained in Step II (b)

Let $T' = \{-t = (-t_1, -t_2, -t_3, ... -t_m)\}$

Record all correspondences $S_{k4} \rightarrow -t$

Step-VI Construction of four Williamson type matrices A, B, C, D

Corresponding to each vector $\in S' \cap T'$, there is a set of four Williamson type matrices (A, B, C, D) which can be obtained as follows:

Find $s = -t \in S \cap T'$ ..... (4)

Find the corresponding (S_{k1}, S_{k2}, S_{k3}) & S_{k4} through the correspondences in Step IV & Step V

Next find the binary vectors b_{k1} , b_{k2} , b_{k3} , b_{k4} corresponding to input sets S_{k1} , S_{k2} , S_{k3} & S_{k4} obtained in step VI by means of the correspondences in Step-III.

Form circulant matrices A, B, C whose 1st rows are b_{k1} , b_{k2} , b_{k3} respectively and back circulant one D whose 1st row is bk4 . Then A, B, C, D are required Williamson type matrics.

Step-VII Exhaustive search for A, B, C, D For exhaustive search repeat the preceding process for all possible size vector (k_1, k_2 , k_3; k_4).

Remark: We can get rid of Step II(b), Step-V and Step-VI by replacing them by the following single step to obtain S_{k4}.

Step Use of Turnpike problem Form the set T consisting of t = ($-s_1$, $-s_2$. . . $-s_m$) satisfying (s_1, s_2, ...s_m) ∈ S' (constructed in Step IV)

Record the correspondences t → s → {A, B, C} using the correspondences s → {A, B, C}

For the vector t = ($-s_1$, $-s_2$,..... $-s_m$) ∈ T

(i) Find $k_4 = (n - \sqrt{n - 2(s_1 + s_2 + ... + s_m)}) / 2$

(ii) Find fi = ($4k_4$ - n - s_i) / 4 where i = 1, 2, ... m

(iii) Form a set D_1= {d_1, d_2, ... d_k}, di ∈ {1, 2, ... m} and a multiset M of differences dj - di (mod n) of every pair of distinct elements of D_1 such that

(a) Differences are between 0 and m, (if a difference is <- m, then replace it by n - m).

(b) In the multiset M of differences obtained in (a) i appears f_i times i = 1, 2, 3, ... m, where f_i are numbers defined in (ii)

t ∈ T will be called feasible vector, if the set D_1 defined in (iii) exists. Each feasible t ∈ T will give Williamson type matrices A, B, C, D which can be obtained as follows

Circulant A, B, C can be obtained through the correspondence : feasible t →s → {A, B, C} using the correspondence in Step-IV.

The back circulant matrix D can be obtained as follows :

(iv) if D_1 = (d_1, d_2, ... d_k) is the set corresponding to t, then form a back circulant matrix D where first row contains -1 at d_1^{th}, d_2^{th}, ... d_k^{th} place and +1 elsewhere.

Remark : Step-(iii) is equivalent to turnpike or partial digest problem (vide [15], [16], [17], [18]). Using the method described above, we have obtained all Williamson type matrices of order 9,11,13,15 & 17 by exhaustive computing search.

IV. Results

Williamson type matrices of order 9

Type - I (4 x 9 = $1^2 + 1^2 + 3^2 + 5^2$) Subtype - I (Size Vector (4, 2, 6; 4))

Sl.no	Input Set		Set of Williamson type Matrices	Output Vector
1	{3,6}	A	circ (1 1 1 -1 1 1 -1 1 1)	1 1 5 1
	{1,4,5,8}	B	circ (1 -1 1 1 -1 -1 1 1 -1)	-3 -3 1 1
	{2,3,4,5,6,7}	C	circ (1 1 -1 -1 -1 -1 -1 -1 1)	5 1 -3 -3
	{3,5,7,8}	D	circ (1 1 1 -1 1 -1 1 -1 -1)	-3 1 -3 1
2	{3,6}	A	circ (1 1 1 -1 1 1 -1 1 1)	1 1 5 1
	{1,2,7,8}	B	circ (1 -1 -1 1 1 1 1 -1 -1)	1 -3 1 -3
	{1,3,4,5,6,8}	C	circ (1 -1 1 -1 -1 -1 -1 1 -1)	-3 5 -3 1
	{3,6,7,8}	D	circ (1 1 1 -1 1 1 -1 -1 -1)	1 -3 -3 1
3	{3,6}	A	circ (1 1 1 -1 1 1 -1 1 1)	1 1 5 1
	{2,4,5,7}	B	circ (1 1 -1 1 -1 -1 1 -1 1 1)	-3 1 1 -3
	{1,2,3,6,7,8}	C	circ (1 -1 -1 -1 1 1 -1 -1 -1)	1 -3 -3 5
	{4,6,7,8}	D	circ (1 1 1 1 -1 1 -1 -1 -1)	1 1 -3 -3

Subtype- II (Size Vector (2, 4, 4; 3))

Sl.no	Input Set		Set of Williamson type Matrices	Output Vector
1	{2,7}	A	circ (1 1 -1 1 1 1 1 -1 1)	1 1 1 5
	{1,4,5,8}	B	circ (1 -1 1 1 -1 -1 1 1 -1)	-3 -3 1 1
	{3,4,5,6}	C	circ (1 1 1 -1 -1 -1 -1 1 1)	5 1 -3 -7
	{3,6,8}	D	circ (1 1 1 -1 1 1 -1 1 -1)	-3 1 1 1
2	{4,5}	A	circ (1 1 1 1 -1 -1 1 1 1)	5 1 1 1
	{1,3,6,8}	B	circ (1 -1 1 -1 1 1 -1 1 -1)	-7 5 -3 1
	{1,2,7,8}	C	circ (1 -1 -1 1 1 1 1 -1 -1)	1 -3 1 -3
	{4,7,8}	D	circ (1 1 1 1 -1 1 1 -1 -1)	1 -3 1 1
3	{1,8}	A	circ (1 -1 1 1 1 1 1 1 -1)	1 5 1 1
	{2,4,5,7}	B	circ (1 1 -1 1 -1 -1 1 -1 1)	-3 1 1 -3
	{2,3,6,7}	C	circ (1 1 -1 -1 1 1 -1 -1 1)	1 -7 -3 5
	{5,7,8}	D	circ (1 1 1 1 1 -1 1 -1 1)	1 1 1 -3

Table II *WILLIMASON TYPE MATRICE OF ORDER 11*

Type - I ($4 \times 11 = 1^2 + 3^2 + 3^2 + 5^2$)
Subtype-1 (Size Vector (4, 6, 8; 4)

Sl.no	Input Set		Set of Williamson type Matrices	Output Vector
1	{3,5,6,8}	A	circ (1 1 1 -1 1 -1 -1 1 -1 1 1)	-1 3 3 -5 -1
	{1,2,3,8,9,10}	B	circ (1 -1 -1 -1 1 1 1 1 -1 -1 -1)	3 -1 -5 -1 -1
	{1,2,3,5,6,8,9,10}	C	circ (1 -1 -1 -1 1 -1 -1 1 -1 -1 -1)	-1 -1 3 7 -1
	{4,6,9,10}	D	circ (1 1 1 1 -1 1 -1 1 1 -1 -1)	-1 -1 -1 -1 3
2	{2,4,7,9}	A	circ (1 1 -1 1 -1 1 1 -1 1 -1 1)	-5 3 -1 -1 3
	{2,3,5,6,8,9}	B	circ (1 1 -1 -1 1 -1 -1 1 -1 -1 1)	-1 -5 3 -1 -1
	{2,3,4,5,6,7,8,9}	C	circ (1 1 -1 -1 -1 -1 -1 -1 -1 -1 1)	7 3 -1 -1 -1
	{3,7,9,10}	D	circ (1 1 1 -1 1 1 1 -1 1 -1 -1)	-1 -1 -1 3 -1
3	{3,4,7,8}	A	circ (1 1 1 -1 -1 1 1 -1 -1 1 1)	3 -5 -1 3 -1
	{1,4,5,6,7,10}	B	circ (1 -1 1 1 -1 -1 -1 -1 1 1 -1)	-1 -1 -1 -5 -3
	{1,3,4,5,6,7,8,10}	C	circ (1 -1 1 -1 -1 -1 -1 -1 -1 1 -1)	-1 7 -1 3 -1
	{4,7,8,10}	D	circ (1 1 1 1 -1 1 1 -1 -1 1 -1)	-1 -1 3 -1 -1
4	{1,2,9,10}	A	circ (1 -1 -1 1 1 1 1 1 1 -1 -1)	3 -1 3 -1 -5
	{1,3,4,7,8,10}	B	circ (1 -1 1 -1 -1 1 1 -1 -1 1 -1)	-5 -1 -1 3 -1
	{1,2,3,4,7,8,9,10}	C	circ (1 -1 -1 -1 -1 1 1 -1 -1 -1 -1)	3 -1 -1 -1 7
	{5,7,9,10}	D	circ (1 1 1 1 1 -1 1 -1 1 -1 -1)	-1 3 -1 -1 -1
5	{1,5,6,10}	A	circ (1 -1 1 1 1 -1 -1 1 1 1 -1)	-1 -1 -5 3 3
	{2,4,5,6,7,9}	B	circ (1 1 -1 1 -1 -1 -1 -1 1 -1 1)	-1 3 -1 -1 -5
	{1,2,4,5,6,7,9,10}	C	circ (1 -1 -1 1 -1 -1 -1 -1 1 -1 -1)	-1 -1 7 -1 3
	{5,8,9,10}	D	circ (1 1 1 1 1 -1 1 1 -1 -1 -1)	3 -1 -1 -1 -1

Table III *WILLIMASON TYPE MATRICES OF ORDER 11*

Subtype- II (Size Vector (4, 4, 8; 5))

Sl.no	Input Set		Set of Williamson type Matrices	Output Vector
1	{1,5,6,10}	A	circ (1 -1 1 1 1 -1 -1 1 1 1 -1)	-1 -1 -5 3 3
	{4,5,6,7}	B	circ (1 1 1 1 -1 -1 -1 -1 1 1 1)	7 3 -1 -5 -5
	{1,2,3,5,6,8,9,10}	C	circ (1 -1 -1 -1 1 -1 -1 1 -1 -1 -1)	-1 -1 3 7 -1
	{2,4,7,9,10}	D	circ (1 1 -1 1 -1 1 1 -1 1 -1 -1)	-5 -1 3 -5 3
2	{2,4,7,9}	A	circ (1 1 -1 1 -1 1 1 -1 1 -1 1)	-5 3 -1 -1 3
	{3,4,7,8}	B	circ (1 1 1 -1 -1 1 1 -1 -1 1 1)	3 -5 -1 3 -1
	{2,3,4,5,6,7,8,9}	C	circ (1 1 -1 -1 -1 -1 -1 -1 -1 -1 1)	7 3 -1 -1 -1
	{3,6,8,9,10}	D	circ (1 1 1 -1 1 1 -1 1 -1 -1 -1)	-5 -1 3 -1 -1
3	{2,3,8,9}	A	circ (1 1 -1 -1 1 1 1 1 -1 -1 1)	3 -5 -5 -1 7
	{1,2,9,10}	B	circ (1 -1 -1 1 1 1 1 1 1 -1 -1)	3 -1 3 -1 -5
	{1,3,4,5,6,7,8,10}	C	circ (1 -1 1 -1 -1 -1 -1 -1 -1 1 -1)	-1 7 -1 3 -1
	{3,6,8,9,10}	D	circ (1 1 1 -1 1 1 -1 1 -1 -1 -1)	-5 -1 3 -1 -1
4	{1,4,7,10}	A	circ (1 -1 1 1 -1 1 1 -1 1 1 -1)	-5 -1 7 -5 3
	{3,4,7,8}	B	circ (1 1 1 -1 -1 1 1 -1 -1 1 1)	3 -5 -1 3 -1
	{2,3,4,5,6,7,8,9}	C	circ (1 1 -1 -1 -1 -1 -1 -1 -1 -1 1)	7 3 -1 -1 -1
	{3,5,7,9,10}	D	circ (1 1 1 -1 1 -1 1 -1 1 -1 -1)	-5 3 -5 3 -1
5	{2,4,7,9}	A	circ (1 1 -1 1 -1 1 1 -1 1 -1 1)	-5 3 -1 -1 3
	{4,5,6,7}	B	circ (1 1 1 1 -1 -1 -1 -1 1 1 1)	7 3 -1 -5 -5
	{1,2,3,5,6,8,9,10}	C	circ (1 -1 -1 -1 1 1 -1 -1 1 -1 -1 -1)	-1 -1 3 7 -1
	{3,4,7,9,10}	D	circ (1 1 1 -1 -1 1 1 -1 1 1 -1 -1)	-1 -5 -1 -1 3

6	{3,5,6,8)	A	circ (1 1 1 -1 1 -1 -1 1 -1 1 1)	-1 3 3 -5 -1
	{3,4,7,8}	B	circ (1 1 1 -1 -1 1 1 -1 -1 1 1)	3 5 -1 3 -1
	{1,3,4,5,6,7,8,10}	C	circ (1 -1 1 -1 -1 -1 -1 -1 -1 1 -1)	-1 7 -1 3 -1
	{3,4,7,9,10}	D	circ (1 1 1 -1 -1 1 1 -1 1 -1 -1)	-1 -5 -1 -1 3
7	{3,5,6,8}	A	circ (1 1 1 -1 1 -1 -1 1 -1 1 1)	-1 3 3 -5 -1
	{2,3,8,9}	B	circ (1 1 -1 -1 1 1 1 1 -1 -1 1)	3 -5 -5 -1 7
	{1,3,4,5,6,7,8,10}	C	circ (1 -1 1 -1 -1 -1 -1 -1 -1 1 -1)	-1 7 -1 3 -1
	{3,6,7,9,10}	D	circ (1 1 1 -1 1 1 -1 -1 1 -1 -1)	-1 -5 3 3 -5
8	{1,4,7,10}	A	circ (1 -1 1 1 -1 1 1 -1 1 1 -1)	-5 -1 7 -5 3
	{1,5,6,10}	B	circ (1 -1 1 1 1 -1 -1 1 1 1 -1)	-1 -1 -5 3 3
	{2,3,4,5,6,7,8,9}	C	circ (1 1 -1 -1 -1 -1 -1 -1 -1 -1 1)	7 3 -1 -1 -1
	{3,6,7,8,10}	D	circ (1 1 1 -1 1 1 -1 -1 -1 1 -1)	-1 -1 -1 3 -5
9	{2,4,7,9}	A	circ (1 1 -1 1 -1 1 1 -1 1 -1 1)	-5 3 -1 -1 3
	{1,2,9,10}	B	circ (1 -1 -1 1 1 1 1 1 1 -1 -1)	3 -1 3 -1 -5
	{1,2,3,4,7,8,9,10}	C	circ (1 -1 -1 -1 -1 1 1 -1 -1 -1 -1)	3 -1 -1 -1 7
	{3,6,7,8,10}	D	circ (1 1 1 -1 1 1 -1 -1 -1 1 -1)	-1 -1 -1 3 -5
10	{2,5,6,9}	A	circ (1 1 -1 1 1 -1 -1 1 1 -1 1)	-1 -5 3 7 -5
	{3,5,6,8}	B	circ (1 1 1 -1 1 -1 -1 1 -1 1 1)	-1 3 3 -5 -1
	{1,2,3,4,7,8,9,10}	C	circ (1 -1 -1 -1 -1 1 1 -1 -1 -1 -1)	3 -1 -1 -1 7
	{4,6,8,9,10}	D	circ (1 1 1 1 -1 1 -1 1 -1 -1 -1)	-1 3 -5 -1 -1
11	{1,5,6,10}	A	circ (1 -1 1 1 1 -1 -1 1 1 1 -1)	-1 -1 -5 3 3
	{1,2,9,10}	B	circ (1 -1 -1 1 1 1 1 1 1 -1 -1)	3 -1 3 -1 -5
	{1,2,4,5,6,7,9,10}	C	circ (1 -1 -1 1 -1 -1 -1 -1 1 -1 -1)	-1 -1 7 -1 3
	{4,6,8,9,10}	D	circ (1 1 1 1 -1 1 -1 1 -1 -1 -1)	-1 3 -5 -1 -1
12	{1,3,8,10}	A	circ (1 -1 1 -1 1 1 1 1 -1 1 -1)	-5 7 -5 3 -1
	{1,2,9,10}	B	circ (1 -1 -1 1 1 1 1 1 1 1 -1 -1)	3 -1 3 -1 -5
	{1,2,4,5,6,7,9,10}	C	circ (1 -1 -1 1 -1 -1 -1 -1 1 -1 -1)	-1 -1 7 -1 3
	{4,5,8,9,10}	D	circ (1 1 1 1 -1 -1 1 1 -1 -1 -1)	3 -5 -5 -1 3
13	{1,3,8,10}	A	circ (1 -1 1 -1 1 1 1 1 -1 1 -1)	-5 7 -5 3 -1
	{3,4,7,8}	B	circ (1 1 1 -1 -1 1 1 -1 -1 1 1)	3 -5 -1 3 -1
	{1,2,4,5,6,7,9,10}	C	circ (1 -1 -1 1 -1 -1 -1 -1 1 -1 -1)	-1 -1 7 -1 3
	{4,7,8,9,10}	D	circ (1 1 1 1 -1 1 1 -1 -1 -1 -1)	3 -1 -1 -5 -1
14	{1,5,6,10}	A	circ (1 -1 1 1 1 -1 -1 1 1 1 -1)	-1 -1 -5 3 3
	{3,5,6,8}	B	circ (1 1 1 -1 1 -1 -1 1 -1 1 1)	-1 3 3 -5 -1
	{1,2,3,5,6,8,9,10}	C	circ (1 -1 -1 -1 1 -1 -1 1 -1 -1 -1)	-1 -1 3 7 -1
	{4,7,8,9,10}	D	circ (1 1 1 1 -1 1 1 -1 -1 -1 -1)	3 -1 -1 -5 -1
15	{2,4,7,9}	A	circ (1 1 -1 1 -1 1 1 -1 1 -1 1)	-5 3 -1 -1 3
	{2,5,6,9}	B	circ (1 1 -1 1 1 -1 -1 1 1 -1 1)	-1 -5 3 7 -5
	{1,2,3,4,7,8,9,10}	C	circ (1 -1 -1 -1 -1 -1 1 1 -1 -1 -1 -1)	3 -1 -1 -1 7
	{5,7,8,9,10}	D	circ (1 1 1 1 1 -1 1 -1 -1 -1 -1)	3 3 -1 -5 -5

Table IV WILLIAMSON TYPE MATRICES OF ORDER 13

Type - I ($4 \times 13 = 1^2 + 1^2 + 1^2 + 7^2$)
Subtype- I (Size Vector (6, 6, 10; 6))

Sl.no	Input Set		Set of Williamson type Matrices	Output Vector
1	{1,2,6,7,11,12}	A	circ (1 -1 -1 1 1 1 -1 -1 1 1 1 -1 -1)	1 -7 -3 1 5 -3
	{3,5,6,7,8,10}	B	circ (1 1 1 -1 1 -1 -1 -1 -1 1 -1 1 1)	1 5 1 -3 -3 -7
	{1,2,3,4,5,8,9,10,11,12}	C	circ (1 -1 -1 -1 -1 -1 1 1 -1 -1 -1 -1 -1)	5 1 1 1 1 9
	{2,5,7,9,11,12}	D	circ (1 1 -1 1 1 -1 1 -1 1 1 -1 1 -1 -1)	-7 1 1 1 -3 1

Type - II ($4 \times 13 = 1^2 + 1^2 + 5^2 + 5^2$)
Subtype- I (Size Vector (4, 4, 6; 6))

Sl.no	Input Set		Set of Williamson type Matrices	Output Vector
1	{1,5,8,12}	A	circ (1 -1 1 1 1 -1 1 1 -1 1 1 1 -1)	-3 1 1 5 -3 5
	{5,6,7,8}	B	circ (1 1 1 1 1 -1 -1 -1 -1 1 1 1 1)	9 5 1 -3 -3 -3
	{1,2,6,7,11,12}	C	circ (1 -1 -1 1 1 1 -1 -1 1 1 1 -1 -1)	1 -7 -3 1 5 -3
	{2,4,6,9,11,12}	D	circ (1 1 -1 1 -1 1 -1 1 1 -1 1 -1 -1)	-7 1 1 -3 1 1

Type - III ($4 \times 13 = 3^2 + 3^2 + 3^2 + 5^2$)
Subtype- I (Size Vector (8, 8, 8; 4))

Sl.no	Input Set		Set of Williamson type Matrices	Output Vector
1	{1,3,4,6,7,9,10,12}	A	circ(1 -1 1 -1 -1 1 -1 -1 1 -1 -1 1 -1)	-7 1 5 -3 1 1
	{2,3,4,6,7,9,10,11}	B	circ(1 1 -1 -1 -1 1 -1 -1 1 -1 -1 -1 1)	1 -3 -3 1 1 1
	{2,3,4,6,7,9,10,11}	C	circ(1 1 -1 -1 -1 1 -1 -1 1 -1 -1 -1 1)	1 -3 -3 1 1 1
	(8,10,11,12}	D	circ(1 1 1 1 1 1 1 1 -1 1 -1 -1 -1)	5 5 1 1 -3 -3

Table V WILLIAMSON TYPE MATRICES OF ORDER 15

Type - I ($4 \times 15 = 1^2 + 3^2 + 5^2 + 5^2$)
Subtype- I (Size Vector (6, 10, 10; 7))

Sl.no	Input Set		Set of Williamson type Matrices	Output Vector
1	{1,2,5,10,13,14}	A	circ (1 -1 -1 1 1 -1 1 1 1 1 -1 1 1 -1 -1)	-1 -5 7 3 -5 -1 -1
	{2,3,4,6,7,8,9,11,12,13}	B	circ (1 1 -1 -1 -1 1 -1 -1 -1 -1 1 -1 -1 -1 1)	1 -7 -3 1 5 -3
	{1,2,3,4,5,10,11,12,13,14}	C	circ (1 -1 -1 -1 -1 -1 1 1 1 1 -1 -1 -1 -1 -1)	7 3 -1 -5 -5 3 3
	{2,4,6,9,11,13,14}	D	circ (1 1 -1 1 -1 1 -1 1 1 -1 1 -1 1 -1 -1)	-9 3 -1 -1 3 -5 3

Type - II ($4 \times 15 = 1^2 + 1^2 + 3^2 + 7^2$)
Subtype- I (Size Vector (6, 8, 8; 4))

Sl.no	Input Set		Set of Williamson type Matrices	Output Vector
1	{2,4,7,8,11,13}	A	circ (1 1 -1 1 -1 1 1 -1 -1 1 1 -1 1 -1 1)	-5 -1 -1 3 -1 7 -5
	{1,2,6,7,8,9,13,14}	B	circ (1 -1 -1 1 1 1 -1 -1 -1 -1 1 1 1 -1 -1)	3 -5 -5 -5 -1 -1 7
	{3,4,6,7,8,9,11,12	C	circ (1 1 1 -1 -1 1 -1 -1 -1 -1 1 -1 -1 1 1)	3 -1 3 -1 -1 -5 -5
	{7,10,12,14}	D	circ (1 1 1 1 1 1 1 -1 1 1 -1 1 -1 1 -1)	-1 7 3 3 3 -1 3

Table VI WILLIAMSON TYPE MATRICES OF ORDER 17

Type - I ($4 \times 17 = 1^2 + 3^2 + 3^2 + 7^2$)
Subtype- I (Size Vector (8, 10, 10; 5))

Sl. no	Input Set		Set of Williamson type Matrices	Output Vector
1	{1,5,7,8,9,10,12,16}	A	circ(1 -1 1 1 1 -1 1 -1 -1 -1 -1 1 -1 1 1 1 -1)	-3 5 -3 1 -7 1 -3 1
	{1,2,3,6,8,9,11,14,15,16}	B	circ (1 -1 -1 -1 1 1 -1 1 -1 -1 1 -1 1 1 -1 -1 -1)	-3 -3 1 -3 5 -3 1 1
	{1,2 ,4,5,6,11,12,13,15,6}	C	circ(1 -1 -1 1 -1 -1 -1 1 1 1 1 -1 -1 -1 1 -1 -1)	1 -3 1 -3 -3 1 5 -3
	{2,6,7,8,11}	D	circ(1 1 -1 1 1 1 -1 -1 -1 1 1 -1 1 1 1 1 1)	5 1 1 5 5 1 -3 1

Type - II ($4 \times 17 = 3^2 + 3^2 + 5^2 + 5^2$)
Subtype- I (Size Vector (6, 10, 10; 11))

Sl. no	Input Set		Set of Williamson type Matrices	Output Vector

1	{2,6,8,9,11,15}	A	circ(1 1 -1 1 1 1 -1 1 -1 -1 1 -1 1 1 1 -1 1)	-3 1 1 5 -3 1 1 1
	{1,3,4,7,8,9,10,13,14,16}	B	circ (1 -1 1 -1 -1 1 1 -1 -1 -1 -1 1 1 -1 -1 1 -1)	-3 -3 -3 1 1 5 1 -3
	{1,2,3,6,8,9,11,14,15,16}	C	circ(1 -1 -1 -1 1 1 -1 1 -1 -1 1 -1 1 1 -1 -1 -1)	-3 -3 1 -3 5 -3 1 1
	{2,3,4,5,7,8,9,10,11,12,13}	D	circ(1 1 -1 -1 -1 -1 1 -1 -1 -1 -1 -1 -1 -1 1 1 1)	9 5 1 -3 -3 -3 -3 1

Subtype- II (Size Vector (6, 6, 10; 7))

Sl. no	Input Set		Set of Williamson type Matrices	Output Vector
1	{1,4,8,9,13,16}	A	circ (1 -1 1 1 -1 1 1 1 -1 -1 1 1 1 -1 1 1 -1)	-3 -3 1 1 9 -7 1 5
	{1,3,8,9,14,16}	B	circ(1 -1 1 -1 1 1 1 1 -1 -1 1 1 1 1 -1 1 -1)	-3 5 -7 1 1 5 1 1
	{1,2,3,4,5,12,13,14,15,16}	C	circ(1 -1 -1 -1 -1 -1 1 1 1 1 1 1 -1 -1 -1 -1 -1)	9 5 1 -3 -7 -3 -3 -3
	{2,6,7,10,12,13,16}	D	circ(1 1 -1 1 1 1 -1 -1 1 1 -1 1 -1 -1 1 1 -1)	-3 -7 5 1 -3 5 1 -3

Subtype- III (Size Vector (6, 10,10; 6))

Sl.no	Input Set		Set of Williamson type Matrices	Output Vector
1	{3,5,8,9,12,14}	A	circ(1 1 1 -1 1 -1 1 1 -1 -1 1 1 -1 1 -1 1 1)	-3 1 1 1 1 5 -3 1
	{1,2,3,6,8,9,11,14,15,16}	B	circ(1 -1 -1 -1 1 1 -1 1 -1 -1 1 -1 1 1 1 -1 -1 -1)	-3 -3 1 -3 5 -3 1 1
	{1,5,6,7,8,9,10,11,12,16}	C	circ(1 -1 1 1 1 -1 -1 -1 -1 -1 -1 -1 -1 1 1 1 -1)	5 5 -3 1 -3 1 -3 -7
	{2,6,7,9,15,16}	D	circ(1 1 -1 1 1 1 -1 -1 1 -1 1 1 1 1 1 -1 -1)	1 -3 1 1 -3 -3 5 5

Subtype- IV (Size Vector (10,10, 12; 8))

Sl. no	Input Set		Set of Williamson type Matrices	Output Vector
1	{1,3,4,7,8,9,10,13,14,16}	A	circ (1 -1 1 -1 -1 1 1 -1 -1 -1 -1 1 1 -1 -1 1 -1)	-3 -3 -3 1 1 5 1 -3
	{3,4,5,6,8,9,11,12,13,14}	B	circ(1 1 1 -1 -1 -1 -1 1 -1 -1 1 -1 -1 -1 -1 1 1)	5 1 1 -7 -3 -3 -3 5
	{2,3,5,6,7,8,9,10,11,12,14,15}	C	circ(1 1 -1 -1 1 -1 -1 -1 -1 -1 -1 -1 -1 1 -1 -1 1)	5 1 5 5 5 -3 -3 1
	{3,4,6,8,10,13,14,16}	D	circ(1 1 1 -1 -1 1 -1 1 -1 1 -1 1 1 -1 -1 1 -1)	-7 1 -3 1 -3 1 5 -3

Table VII WILLIAMSON TYPE MATRICES OF ORDER 19

Type - I ($4 \times 19 = 1^2 + 5^2 + 5^2 + 5^2$)
Subtype- I (Size Vector (8, 8, 8; 6))

Sl. no	Input Set		Set of Williamson type Matrices	Output Vector
1	{1,4,8,9,10,11,15,18}	A	circ (1 -1 1 1 -1 1 1 1 -1 -1 -1 -1 1 1 1 -1 1 1 -1)	-1 -1 -1 -5 3 -5 3 -1 3
	{1,6,7,9,10,12,13,18}	B	circ(1 -1 1 1 1 1 -1 -1 1 -1 -1 1 -1 -1 1 1 1 1 -1)	-1 -1 3 -5 -1 3 -1 3 -5
	{3,5,6,7,10,11,12,14}	C	circ(1 1 1 1 -1 1 -1 -1 -1 1 1 1 -1 -1 -1 1 -1 1 1 1)	3 3 -1 3 -1 -5 -1 -1 -5
	{4,5,8,12,14,18}	D	circ(1 1 1 1 -1 -1 1 1 -1 1 1 1 -1 1 -1 1 1 1 -1)	1 1 1 -7 1 -7 1 1 -7

V. Remark

Remark-1 In the above tables A, B, C are circulant matrices and D is a back circulant matrix whose 1st row is shown.

Remark-2 Table 7 shows that there exists a Williamson type matrix corresponding to the expression $4x19 = 1^2 + 5^2 + 5^2 + 5^2$, whereas there is no Williamson matrix to the above
expression. This indicates that one can find Williamson type matrices by our method, where Williamson's method fails.

The following Table 8 shows that the number of Williamson type matrices of small order obtained by our method is much greater than that of Williamson matices of the same order.

Table VIII COMPARISON WITH WILLIAMSON MATRICES

Order	Number of Williamson matrices	Number of Williamson type matrices constructed by our method
Order 9	3	6
Order 11	1	20
Order 13	4	57
Order 15	4	196
Order 17	4	504

VI. Justification

Justification for the method of construction: The following theorm justifies the construction of Williamsion type matrices.

Theorm: The matrices A, B, C, D constructed above are Williamsion type matrices

Proof : The method consists in finding four circulants matrices A, B, C & D_1 of order n (odd) such that

(i) A, B, C are symmetric

(ii) $AA^T + BB^T + CC^T + D_1D_1^T = 4nI_n$

Let A=circ (a_0, a_1, a_2 , a_3, ... $a_{(n-1))}$ = the circulant where 1st row is (a_0, a1, a2 , a3, ... a(n−1))

B=circ (b_0, b_1, b_2 , b_3, ... $b_{(n-1)}$)

C=circ (c_0, c_1, c_2 , c_3, ... $c_{(n-1)}$)

D=circ (d_0, d_1, d_2 , d_3, ... $d_{(n-1)}$)

We assume without any loss of generality that $a_0 = b_0 = c_0 = d_0 = 1$

Represent A by the input set

$S_{k1} = (m_1, m_2, \ldots\ldots m_{k1})$

where $m_i \in S_{k1}$ if and only if $a_{mi} < 0$.

Parallely represent A, B, C, D_1 by input sets S_{k2} , S_{k3} & S_{k4} respectively, since A, B, C are symmetric , k_1, k_2 , k_3 are even integers

We claim that

(i) If (e_1, e_2,..... e_{n-1}) (m=(n-1)/2) be the output vector of S_{k1} then

AA^T =circ (n,e_1, e_2,..... e_m, e_m,e_{m-1}, ---------- e_1)

& similar expression for B & C.

Also $D_1D_1^T$ = circ (n, f_1, f_2, ... f_{n-1}) if (f_1, f_2,..... f_{n-1}) is the output vector of S_{k4}

(ii) $(n - 2k_1)^2 + (n - 2k_2)^2 + (n - 2k_3)^2 + (n - 2k_4)^2 + (k_4)^2 = 4n$

where $\bar{k_4}$ = k4 if k4 is odd

Proof (i) In AA^T

e_j= scalar product of 1st row R1 of A with $(j + 1)^{th}$ row R_{j+1} of A .

Let S_{k1}be the input set corresponding to 1st row R1of A and j+S_{k1} be that corresponding to (j+1) throw R_{j+1} of A (where + stands for addition mod n). Let the order of the set (j + S_{k1}) - S_{k1} be r_j. The rows R_1 and R_{j+1} of A differ at $2r_j$ places. Hence the scalar product R_1R_2 is $(n - 2r_2) - 2r_2 = n - 4rj = e_j$ by definition. By the same argument we get expressions for BB^T, CC^T & $D_1D_1^T$. Since from (4) the sum of output vectors for A, B, C, D_1 is 0, it follows that

$\sum AA^T$ = circ (4n, 0, 0, ---------- 0)

A, B, C, $D_1 = 4nI_n$

Proof (ii)

Consider all $k_1(k_1 - 1)$ differences (mod n) of the set S_{k1} .

Suppose in the multiset of differences j appears g_j times j = 1,2 , ------- (n-1).

Then $\sum_{j=1}^{n-1} g_j = k_1(k_1 - 1)$ ---------- (5)

Also j + S_{k1} and S_{k1} has g_j common elements.

Hence $|(j + S_{k1}) - S_{k1}| = k_1 - g_j = r_j$

Also $e_j = n - 4r_j$ [from (1) & (2)] in 3.1

Therefore $e_j = n - 4(k_1 - g_j)$

$\Rightarrow \sum_{j=1}^{n-1} e_j = (n - 1)\, n - 4((n - 1)\, k_1 - \sum_{j=1}^{n-1} g_j) = (n - 2k_1)^2 - n$ [using (5)]

There are similar expressions corresponding to the sets S_{k2} , S_{k3} , & S_{k4}

Summing all the four expressions we get $\sum_{i=1}^{4}(n\text{-}2k_i)^2 - 4n = 0$ [Since the sum of output vectors for A, B, C, D_1 is zero.

This proves (ii) and justices Step I through Step VI. Replace D_1 by D, a back circulant matrix with same 1st row as that of D_1. Since a symmetric back circulant commutes with symmetric circulant matrices the Step VI is justified.

VII. Future Work

Like Williamson's method, the present method requires great computational effort. However using genetic algorithm or some other heuristic method one can find some Williamson type matrices of higer order.

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Design of Quality Model during Reengineering of Legacy System

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Abstract- The purpose of this paper is design such kind of model that will improve the quality of system during reengineering[1] of legacy system that why this model is known as Quality Model. During reengineering of object oriented system[2,3], the methodology is design in such a way that will create a link/bridge between problem detection and problem correction in the legacy system, as well as simultaneously improvement in object oriented design, that can be used during later reengineering and also reduces the complexity as compared to object oriented design[4,5,6].

The further design of legacy system in such a way to specifying, how branches can be selected, how behavior is preserved and how code transformation applied. Quality of model, depends upon two factor favor and disfavor, attach to each branches, software quality is directly proportional to maintenance cost. Quality model is used for two purpose sketch and blueprint. Sketch is used a thinking tool, which help developer communicates, some aspects of a system and alternative about, what are about to be done. Blueprint intends to be comprehensive and definitive. It is used for guiding the implementation.

Keywords: *Reengineering, object oriented design, Quality model, Problem detection, Re-factoring.*

GJCST Classification: *D.2.2*

Strictly as per the compliance and regulations of:

Design of Quality Model during Reengineering of Legacy System

Dr Ashok Kumar[α], Anil Kumar[Ω]

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I. Problem Statement

There is no doubt, that OO design [4,5,6] is one of the best choice of designer, to design any software modules, however, is universal truth, that while we restructure[7] any system it is always acceptable, it will improve its efficiency, productivity, scalability and reduces the complexity as well as reduces the resources that are required during development of development of software modules.

Therefore, restructure is part of reengineering of OO design, that help transformation of a software system, without modifying its behavior that will improve its structure of the system. A common path during reengineering of OO design is to identify fragments in the subject system's design that violet principle of good design and then try to restructure the system in such a way, that minimizes these violations. Currently there is no. of approaches that can help developer and designer to identify design flows on one side and that can perform various code transformation safely on other side. While reengineering takes place on legacy system, where OO approaches are used to build a system, developer obtain a list of design flows together with their location in the system, but the necessary transformation that remove them are left to their own judgment and experience. The mapping between a specific design flow and the code transformation to remove it, together with the consequence of choosing one set of transformation over the other, is missing. Still, there is no satisfactory approach that links between the two, guiding the developer from problem detection to code transformation, that can remove the identified problem. Therefore, improvement of OO design are required.

II. Introduction

The life of software products extends far beyond the development of first release. After being developed to the customer, a software product enter the most extended stage of its life: evolution. Software maintenance [8] is concerned with the changes, that need to be made on an existing product: defect are removed. As we know that, software evolution is a reality with various reason and consequence. As software system evolve, their structure degrades a phenomena know as software decay.

Developer who makes the changes are not same as the one who developed the initial system. For a large system it is difficult to understand the concept of initial designer had in mind, so changes are made that changes the initial concept.

Future changes are need to take into account, the new concept and execution introduced by previous changes. This leads to system very difficult to update and understand, the changes introduces more bugs and documentation became increasingly inaccurate. Maintaining these system become nightmare and the maintenance cost increase very much. Therefore, reengineering is the best choice for this purpose. During reengineering process certain phases can be identified. The one that bears restructure of OO system, where subject system is modified in order to improve its structure without affecting its functionality.

In other words, restructure process aims to improve the quality of existing system, in order to

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facilitate the later reengineering task. Restructuring is often used as a form of preventive maintenance to improve the physical state of the subject system with respect to certain standard.

The steps that will be followed by restructuring of OO system are:

- Do a survey of existing work on problem detection and re-factoring and attempts to provide a link between two.
- Select a no. of design flow that are the subject of further investigation
- Describe the way to remove such design flows from OO system
- Define methodologies for the design improvement using correction strategies

- Implement an infrastructure that allows the easy implementation of correction strategies.

The quality model is based on design pattern [9], that will improve the legacy system, during design phase, rather than code.

This model is help to determining:

- Language independence: approach should operate at design level, rather than programming language level. This way, it should be applicable to the system written in any programming language, that should support OO paradigm[10]
- Behavior preservation: any approach should give a minimum degree of confidence that the modified system will behave the same as before
- Automation: most legacy system are very large as well as very complex. Therefore, this approach should allow for large degree of automation and should minimizes human intervention during the process
- Quality estimation
- Extensibility easy to accommodate, new knowledge
- Causality: this approach should directly detect any risk at design flows.

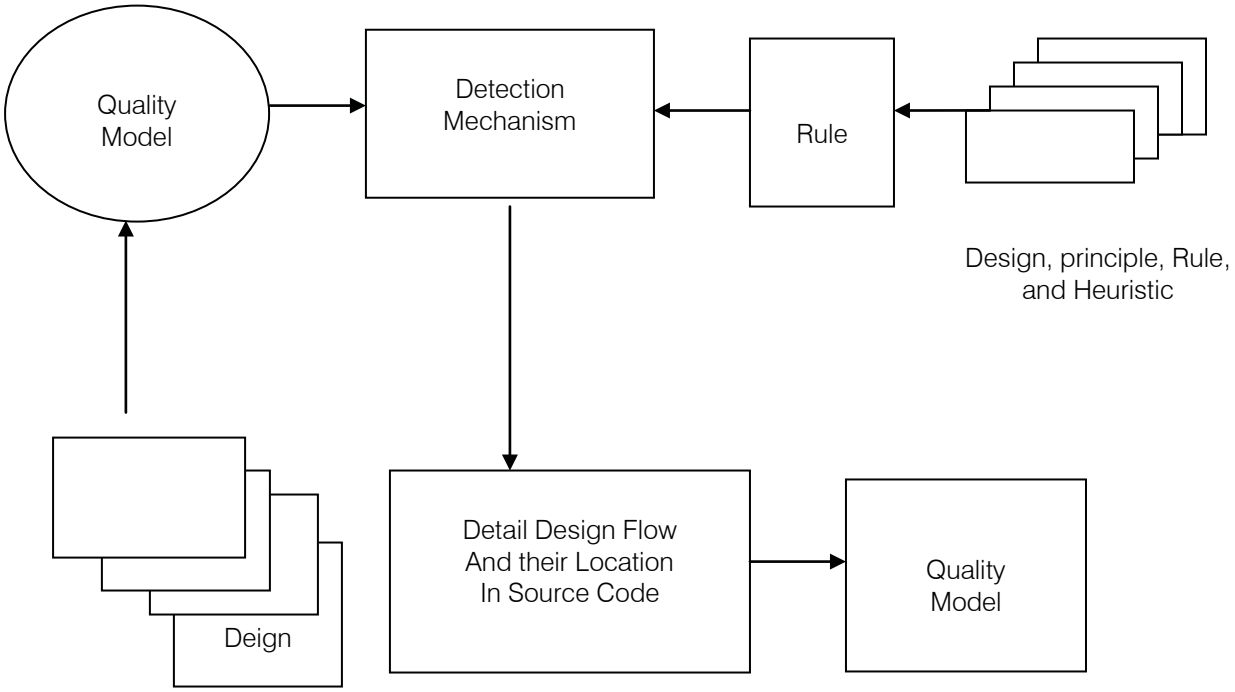
Reengineering life cycle [11,12,13] contain problem detection phase, when design flows are modified.

Each pattern describe a problem, which occurs over and over again in one environment and the describe the core of the solution to that problem, in such a way that you can use this solution a million of times over, without ever doing it, the same way twice.

Design pattern, is the description of communicating objects and classes, that are customized to solve a general design problem in a particular context. Here, we do not inspect all area of reengineering, but focus on two phases that aim to link: problem detection and re-factoring.

III. Problem Detection

Problem detection is a specific phase in the reengineering lifecycle. Its process aims to identify design flows in the analyzed system. It has a series of steps – first formalization, which takes OO design heuristics, rules, principle and turns them into precise rules and that can be used to identify design flows. The source code is parsed and a model of the system is obtained.



"Problem Detection Model During Reengineering of OO System"

It will support the assessment and improvement of the quality in OO system . the problem detection strategies on the model's entities that is packages, classes, methods, attributes, local variables, global variables and parameters.

Re-Factoring

Re-factoring[14] is the process of changing a software system, in such a way that it does not alter its external behaviors, but still improves its internal structure. The framework are reusable architecture , they are the result of many iterations and no. of way limited to OO framework [15,16,17,18] and more recent software development process, suggest, re-factoring should be part of development cycle.

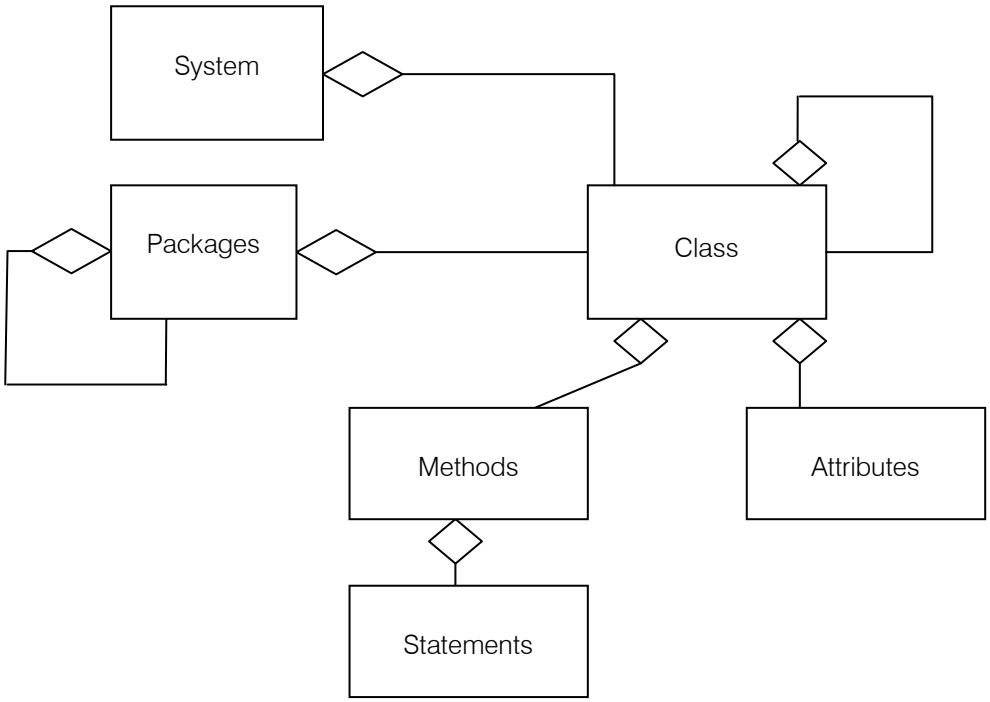
Re-factoring OO System [10]:

- Defining an abstract super class of one or more existing classes
- Specializing a class by defining sub class and using sub-classing to estimate conditionals
- Changing how the whole/part relationship is modeled (from inheritance to aggregation)
- Moving a class within or among inheritance hierarchies
- Moving member variable and function
- Replacing a code segments with a function call
- Changing name of classes, variables or functions
- Replacing unrestricted access to member variable with a more abstract interface

Re-Factoring are further classified as:

- Low level re-factoring, such as rename, move, replace, a code segment with a function call
- High level re-factoring, such as defining as abstract super class, replacing conditionals with polymorphism and changing inheritance to aggregation. These re-factoring make use of other low-level re-factoring

Re-factoring have to guarantee, that they preserve the behaviors of the system.

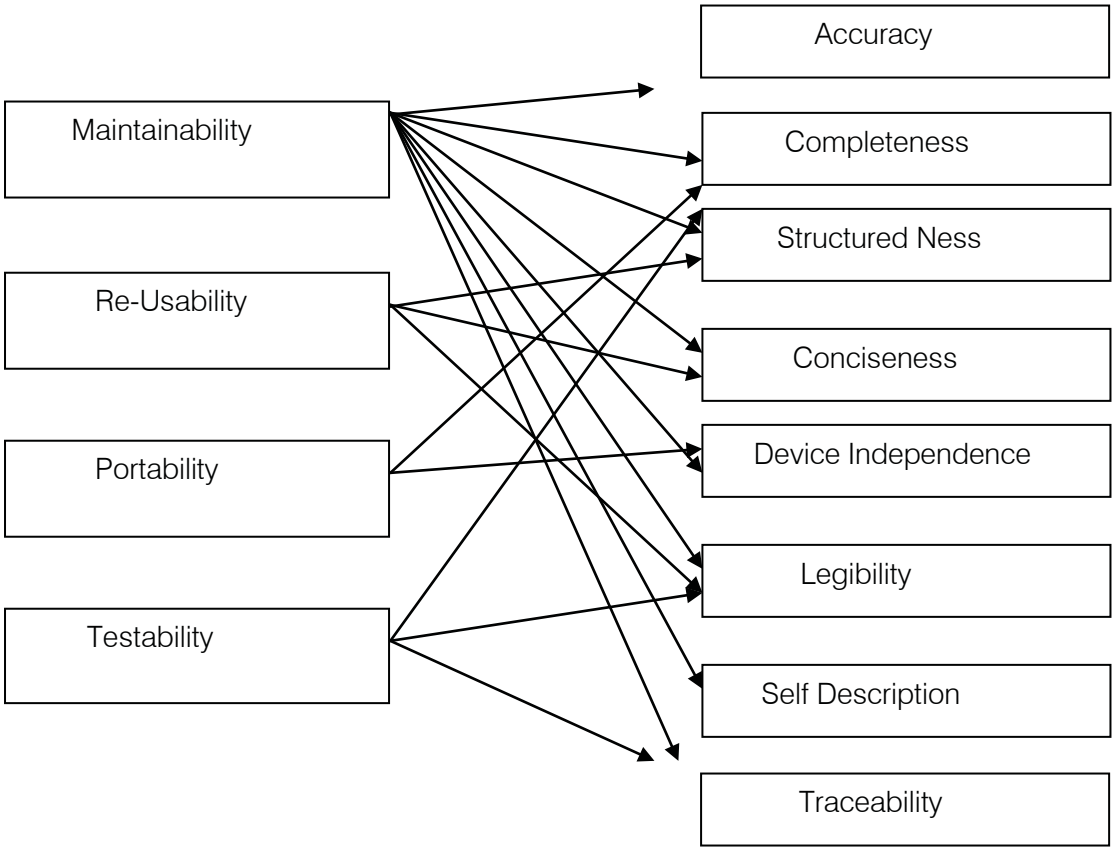


"Pattern Based Quality Model"

The further design of legacy system, in such a way to specifying, how branches can be selected, how behaviors is preserved and how code transformation applied. Here, problem detection model, are used to choose the appropriate branches in each decision node and safely applying code transformation. By applying this, finding a path through graph strategies. Depending on the system and reengineering goals, different path can be chosen for the same design flow.

Reengineering process, start with requirement analysis, which establish the overall reengineering goals. Reengineering goal provides the focus of all activities carried out, during the process of reengineering. These goal can be expressed in terms of quality factors, that need improvement: flexibility, portability, efficiency etc..

At each decision node, the available branches can be selected according to their impact on each of the considered quality factors.



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A Trustful Routing Protocol for Ad-hoc Network

By Mahendra Kumar Mishra

Abstract- Mobile Ad-hoc Network (MANET) is a wireless system that comprises mobile nodes. It is usually referred to a decentralized autonomous system. Self configurability and easy deployment feature of the MANET resulted in numerous applications in this modern era. Its routing protocol has to be able to cope with the new challenges that a MANET creates such as nodes mobility, security maintenance, and quality of service, limited bandwidth and limited power supply. These challenges set new demands on MANET routing protocols. With the increasing interest in MANETs, there has been a greater focus on the subject of securing such networks. However, the majority of these MANET secure routing protocols did not provide a complete solution for all the MANETs' attacks and assumed that any node participating in the MANET is not selfish and that it will cooperate to support different network functionalities. My thesis strategy is to choose one of the secure routing protocols According to its security-effectiveness, study it and analyze its functionality and performance. The authenticated routing for ad hoc networks (ARAN) secure routing protocol was chosen for analysis. Then, the different existing cooperation enforcement schemes were surveyed so that to come up with a reputation-based scheme to integrate with the ARAN protocol. The result of that integration is called: Trustful-ARAN. Consequently, the ARAN is capable of handling both selfish and malicious nodes' attacks. The improvement is obtained at the cost of a higher overhead percentage with minimal increase in the average number of hops. The Trustful-ARAN proves to be more efficient and more secure than normal ARAN secure routing protocol in defending against both malicious and authenticated selfish nodes.

Keywords: *MANET, ARAN, Routing Protocols.*

GJCST Classification: *C.2.1, C.2.2*

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I. Introduction

Wireless networking is an emerging technology that allows users to access information and services electronically, regardless of their geographic position.

The use of wireless communication between mobile users has become increasingly popular due to recent performance advancements in computer and wireless technologies. This has led to lower prices and higher data rates, which are the two main reasons why mobile computing is expected to see increasingly widespread use and applications. There are two distinct approaches for enabling wireless communications between mobile hosts. The first approach is to use a fixed network infrastructure that provides wireless access points. In this network, a mobile host communicates with the network through an access point within its communication radius. When it goes out of range of one access point, it connects with a new access point within its range and starts communicating through it. An example of this type of network is the cellular network infrastructure. A major problem of this approach is handoff, which tries to handle the situation when a connection should be smoothly handed over from one access point to another access point without noticeable delay or packet loss. Another issue is that networks based on a fixed infrastructure are limited to places where there exist such network infrastructures [1] and [4].

The second approach which is the focus of this thesis research is to form a wireless ad hoc network among users wanting to communicate with each other with no pre-established infrastructure. Laptops and personal digital assistants (PDAs) that communicate directly with each other are examples of nodes in an ad hoc network. Nodes in the ad-hoc network are often mobile, but can also consist of stationary nodes. Each of the nodes has a wireless interface and communicates with others over either radio or infrared channels.

Wireless ad-hoc networks can be deployed in areas where a wired network infrastructure may be undesirable due to reasons such as cost or convenience. It can be rapidly deployed to support emergency requirements, short-term needs, and coverage in undeveloped areas. So there is a plethora of applications for wireless ad-hoc networks. As a matter of fact, any day-to-day application such as electronic email and file transfer can be considered to be easily deployable within an ad hoc network environment. Also, we need not emphasize the wide range of military applications possible with ad hoc networks. Not to mention, the technology was initially developed keeping in mind the military applications, such as battlefield in an unknown territory where an infrastructure network is almost impossible to have or maintain. In such situations, the ad hoc networks having self-organizing capability can be effectively used where other technologies either fail or cannot be deployed effectively.

In the field of mobile ad hoc networks routing protocols, there are lot of problems to be tackled such as Quality of service, power awareness, routing optimization and security issues. In this thesis, the main interest is in the security issues related to routing protocols in MANETs. So, I started researching by reading about the different research directions in this

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huge field and analyzed the different existing routing protocols and their various types. I ended up interested in the AODV protocol and studied its source code. Then more interest in secure routing protocols and their different mechanism in defending against the malicious, compromised and selfish nodes in the mobile ad hoc network were developed. Existing secure routing protocols were studied such as ARAN, SAODV, SRP and others. Then, the decision to work with the ARAN protocol was taken after having read many papers about it, getting in contact with its author and doing some comparisons and analysis with other secure routing protocols. The ARAN protocol was observed to defend almost against all security attacks in MANETs. However, by doing more research in the field of MANETs, one major flaw in any of the existing secure routing protocols was discovered. This is that all of these secure routing protocols do not account for selfish nodes whether by detecting or isolating them from the network. So I decided to read about the different types of cooperation enforcement schemes in mobile ad hoc networks and then to design and integrate a reputation-based scheme with the ARAN routing protocol to end up with Reputed-ARAN that is capable of defending itself against both malicious and authenticated selfish nodes [2] and [3].

II. Background

Security in MANET is an essential component for basic network functionalities like packet forwarding and routing. Network operation can be easily jeopardized if security countermeasures are not embedded into basic network functions at the early stages of their design. In mobile ad hoc networks, network basic functions like packet forwarding, routing and network management are performed by all nodes instead of dedicated ones. In fact, the security problems specific to a mobile ad hoc network can be traced back to this very difference. Instead of using dedicated nodes for the execution of critical network functions, one has to find other ways to solve this because the nodes of a mobile ad hoc network cannot be trusted in this way. In the following section, the different types of attacks in MANETs will be presented.

- Attacks targeting Routing Protocols

There are basically two types of security threats to a routing protocol, external and internal attackers. An external attacker can be in the form of an adversary who injects erroneous information into the network and cause the routing to stop functioning properly. The internal attacker is a node that has been compromised, which might feed other nodes with incorrect information.

- Malicious and Selfish Nodes in MANETs

Malicious nodes can disrupt the correct functioning of a routing protocol by modifying routing information, by fabricating false routing information and by impersonating other nodes. On the other side, selfish nodes can severely degrade network performances and eventually partition the network by simply not participating in the network operation.

In existing ad hoc routing protocols, nodes are trusted in that they do not maliciously tamper with the content of protocol messages transferred among nodes. Malicious nodes can easily perpetrate integrity attacks by simply altering protocol fields in order to subvert traffic, deny communication to legitimate nodes (denial of service) and compromise the integrity of routing computations in general. As a result the attacker can cause network traffic to be dropped, redirected to a different destination or to take a longer route to the destination increasing communication delays [2] and [5].

A more subtle type of active attack is the creation of a tunnel (or wormhole) in the network between two colluding malicious nodes linked through a private connection bypassing the network. This exploit allows a node to short-circuit the normal flow of routing messages creating a virtual vertex cut in the network that is controlled by the two colluding attackers.

In the figure 1, M1 and M2 are malicious nodes collaborating to misrepresent available path lengths by tunneling route request packets. Solid lines denote actual paths between nodes, the thin line denotes the tunnel, and the dotted line denotes the path that M1 and M2 falsely claim is between them. Let us say that node S wishes to form a route to D and initiates route discovery.

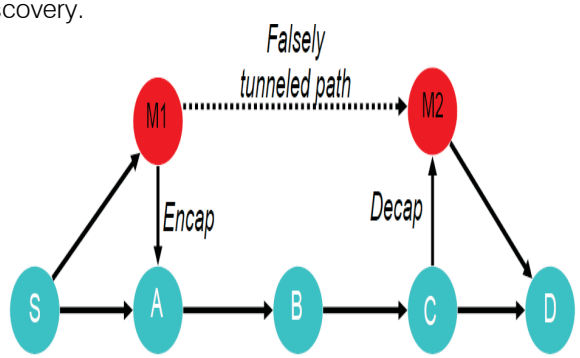

Figure 1 Wormhole Attack

When M1 receives a RDP from S, M1 encapsulates the RDP and tunnels it to M2 through an existing data route, in this case {M1→A→B→C→M2}. When M2 receives the encapsulated RDP, it forwards the RDP on to D as if it had only traveled {S→M1→M2→D}. Neither M1 nor M2 update the packet header to reflect that the RDP also traveled the path {A→B→C}. After route discovery, it appears to the destination that there are two routes from S of unequal length: {S→A→B→C→D} and {S→M1→M2→D}. If M2 tunnels the RREP back to M1, S would falsely consider the path to D via M1 a better choice (in terms of path length) than the path to D via A. Another exposure of

current ad hoc routing protocols is due to node selfishness that results in lack of cooperation among ad hoc nodes. A selfish node that wants to save battery life, CPU cycles and bandwidth for its own communication can endanger the correct network operation by simply not participating in the routing protocol or by not forwarding packets and dropping them whether control or data packets. This type of attack is called the black-hole attack. Current Ad Hoc routing protocols do not address the selfishness problem and assumes that all nodes in the MANET will cooperate to provide the required network functionalities.

Routing Protocols' Security Requirements

To solve the security issue in an ad hoc network and make it secure we have to look at a number of requirements that have to be achieved. These requirements are: availability, confidentiality, integrity, authentication and non-repudiation.

→Availability: the network must at all times be available to send and receive messages despite if it is under attack. An attack can be in the form of a denial of service or an employed jamming to interfere with the communication. Other possible threats to the availability are if an attacker disrupts the routing protocol or some other high-level service and disconnects the network. The node itself can also be the problem to availability. This is if the node is selfish and will not provide its services for the benefit of other nodes in order to save its own resources like, battery power.

→Confidentiality: provides secrecy to sensitive material being sent over the network. This is especially important in a military scenario where strategic and tactical information is sent. If this information would fall into enemy hands it could have devastating ramifications.

→ Integrity: ensures that messages being sent over the network are not corrupted. Possible attacks that would compromise the integrity are malicious attacks on the network or benign failures in the form of radio signal failures.

→Authentication: ensures the identity of the nodes in the network. If A is sending to B, A knows that it is B who is receiving the message. Also B knows that it is A who is sending the message. If the authentication is not working, it is possible for an outsider to masquerade a node and then be able to send and receive messages without anybody noticing it, thus gaining access to sensitive information.

→ Non-repudiation: makes it possible for a receiving node to identify another node as the origin of a message. The sender cannot deny having sent the message and are therefore responsible for its contents. It is particularly useful for detection of compromised nodes. However, because there are so many threats to protect from, there can not be a general solution to them all. Also different applications will have different security requirements to take into consideration. As a result of this diversity, many different approaches have been made which focus on different parts of the problems. In the coming section, a comparison of some of the existing secure mobile ad hoc routing protocols with respect to most of the fundamental performance parameters will be given [1] and [4] and [6].

Authenticated Routing for Ad Hoc Networks Protocol (ARAN)

One of the secure mobile ad hoc networks protocols, which is Authenticated routing for ad hoc networks (ARAN) is analyzed. Such protocol is classified as a secure reactive routing protocol, which is based on some type of query-reply dialog. That means ARAN does not attempt to continuously maintain the up-to-date topology of the network, but rather when there is a need, it invokes a function to find a route to the destination. In the following subsections, the details of the different phases of the ARAN secure routing protocol are presented. Furthermore, appendix B presents documentation for all the functions of ARAN secure mobile ad hoc network routing protocol.

Authenticated Routing for Ad Hoc Networks

The ARAN secure routing protocol proposed in recent and uses cryptographic certificates to prevent and detect most of the security attacks that most of the ad hoc routing protocols face. This protocol introduces authentication, message integrity and non-repudiation as part of a minimal security policy for the ad hoc environment.

ARAN consists of a preliminary certification process followed by a route instantiation process that guarantees end-to-end authentication. Thus, the routing messages are authenticated end-to-end and only authorized nodes participate at each hop between source and destination.

Route Maintenance

When no traffic has occurred on an existing route for that route's lifetime, the route is simply deactivated in the routing table. Data received on an inactive route causes nodes to generate a Route Error (RERR) message. Also, nodes use RERR messages to report links in active routes that are broken due to node movement. Of course, all RERR messages are signed.

On the other hand, it is extremely difficult to detect when RERR messages are fabricated for links that are truly active and not broken. That is why having messages signed prevents impersonation and enables non-repudiation. So a node that transmits a large number of RERR messages, whether the RERR messages are valid or fabricated should be avoided.

Key Revocation

In the event that a certificate needs to be revoked, the trusted certificate server, T, sends a broadcast message to the ad hoc network announcing the revoked node. And any node receiving this message rebroadcasts it to its neighbors. Moreover, revocation-notices need to be stored until the revoked certificate expire normally [7] and [8].

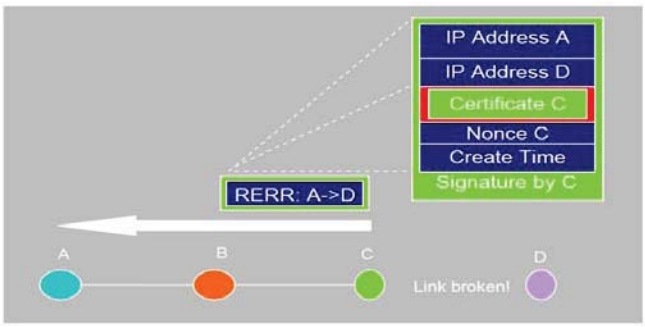

Figure 2: Route Maintenance

Malicious attacks defended by ARAN

An analysis of the robustness of the Authenticated Routing for Ad Hoc Networks in the presence of the different attacks introduced in earlier sections is given:

➔ Unauthorized participation: Since all ARAN packets must be signed, a node cannot participate in routing without authorization from the trusted certificate server. This access control therefore rests in the security of the trusted authority, the authorization mechanisms employed by the trusted authority, the strength of the issued certificates, and the revocation mechanism.

➔Spoofed Route Signaling: Route discovery packets contain the certificate of the source node and are signed with the source's private key. Similarly, reply packets include the destination node's certificate and signature, ensuring that only the destination can respond to route discovery. This prevents impersonation attacks where either the source or destination node is spoofed.

➔Fabricated Routing Messages: Since all routing messages must include the sending node's certificate and signature, ARAN ensures non-repudiation and prevents spoofing and unauthorized participation in routing.

➔ Alteration of Routing Messages: ARAN specifies that all fields of RDP and RREP packets remain unchanged between source and destination. Since both packet types are signed by the initiating node, any alterations in transit would be detected, and the altered packet would be subsequently discarded. Thus, modification attacks are prevented in ARAN.

Denial-of-Service Attacks: Denial-of-service (DoS) attacks can be conducted by nodes with or without valid ARAN certificates. In the certificate-less case, all possible attacks are limited to the attacker's immediate neighbors because unsigned route requests are dropped. However, nodes with valid certificates can conduct effective DoS attacks by sending many unnecessary route requests and they will go undetected as the current existing ARAN protocol cannot differentiate between legitimate and malicious RREQs coming from authenticated nodes.

Attack	ARAN
Remote Redirection	NO
Modification of hop counts	NO
Modification of source routs	NO
Tunneling	YES, but only to length path
Spoofing	--------
Fabrication	--------
Fabrication of error message	YES, but non-repudiable
Fabrication of source routs	NO

ARAN and Selfish node weakness

It is clear from the above mentioned security analysis of the ARAN protocol that ARAN is a secure MANET routing protocol providing authentication, message integrity, confidentiality and non-repudiation by using certificates infrastructure. As a consequence, ARAN is capable of defending itself against spoofing, fabrication, modification, DoS and disclosure attacks. However, erratic behavior can come from a malicious node, which will be defended against successfully by existing ARAN protocol, and can also come from an authenticated node. The currently existing ARAN secure routing protocol does not account for attacks that are conducted by authenticated selfish nodes as these nodes trust each other to cooperate in providing network functionalities. This results in that ARAN fails to detect and defend against an authenticated selfish node participating in the mobile ad hoc network. Thus, if an authenticated selfish node does not forward or intentionally drop control or data packets, the current specification of ARAN routing protocol cannot detect or defend against such authenticated selfish nodes. This weakness in ARAN specification will result in the disturbance of the ad hoc network and the waste of the network bandwidth. A solution is proposed to account for this type of attack [1] and [2] and [4] and [7].

Proposed Technique

Performance of Mobile Ad Hoc Networks is well known to suffer from free-riding, selfish nodes, as there is a natural incentive for nodes to only consume, but not contribute to the services of the system. The definition of selfish behavior and the newly designed reputation-based scheme, to be integrated with normal ARAN

routing protocol ending up having Reputed-ARAN, are presented.

Main Idea of the Reputation System

In the proposed reputation scheme, all the nodes in the mobile ad hoc network will be assigned an initial value of null (0) as in the Ocean reputation-based scheme. Also, the functionality of the normal ARAN routing protocol in the authenticated route setup phase will be modified so that instead of the destination unicasts a RREP to the first received RDP packet of a specific sender only, the destination will unicast a RREP for each RDP packet it receives and forward this RREP on the reverse-path. The next-hop node will relay this RREP. This process continues until the RREP reaches the sender. After that, the source node sends the data packet to the node with the highest reputation. Then the intermediate node forwards the data packet to the next hop with the highest reputation and the process is repeated till the packet reaches its destination. The destination acknowledges the data packet (DACK) to the source that updates its reputation table by giving a recommendation of (+1) to the first hop of the reverse path. All the intermediate nodes in the route give a recommendation of (+1) to their respective next hop in the route and update their local reputation tables. If there is a selfish node in the route, the data packet does not reach its destination. As a result, the source does not receive any DACK for the data packet in appropriate time. So, the source gives a recommendation of (-2) to the first hop on the route. The intermediate nodes also give a recommendation (-2) to their next hop in the route up to the node that dropped the packet. As a consequence, all the nodes between the selfish node and the sender, including the selfish node, get a recommendation of (-2). The idea of giving (-2) to selfish nodes per each data packet dropping is due to the fact that negative behavior should be given greater weight than positive behavior. In addition, this way prevents a selfish node from dropping alternate packets in order to keep

its reputation constant. This makes it more difficult for a selfish node to build up a good reputation to attack for a sustained period of time. Moreover, the selfish node will be isolated if its reputation reached a threshold of (-40) as in the Ocean reputation-based scheme.

The proposed protocol is structured into the following four main phases, which are explained in the subsequent subsections:

- Route Lookup Phase
- Data Transfer Phase
- Reputation Phase
- Timeout Phase

Route Lookup Phase

This phase mainly incorporates the authenticated route discovery and route setup phases of the normal ARAN secure routing protocol. In this phase, if a source node S has packets for the destination node D, the source node broadcasts a route discovery packet (RDP) for a route from node S to node D. Each intermediate node interested in cooperating to route this control packet broadcasts it throughout the mobile ad hoc network; in addition, each intermediate node inserts a record of the source, nonce, destination and previous-hop of this packet in its routing records. This process continues until this RDP packet reaches the destination. Then the destination unicasts a route reply packet (RREP) for each RDP packet it receives back using the reverse-path. Each intermediate node receiving this RREP updates its routing table for the next-hop of the route reply packet and then unicasts this RREP in the reverse-path using the earlier-stored previous-hop node information. This process repeats until the RREP packet reaches the source node S. Finally, the source node S inserts a record for the destination node D in its routing table for each received RREP. In the below figures, the route lookup phase is presented in details, illustrating the two phases of it, the authenticated route discovery phase and the authenticated route setup phase.

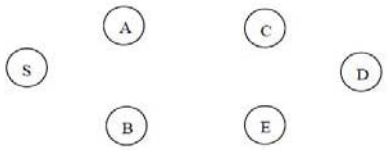

Figure 3: A MANET Environment

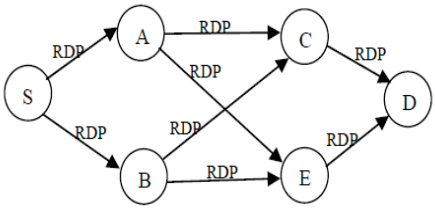

Figure 4: Broadcasting RDP

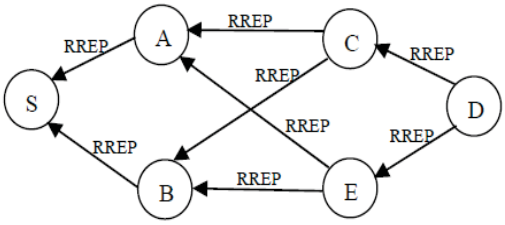

Figure 5: Replying to each RDP

Data Transfer Phase

At this time, the source node S and the other intermediate nodes have many RREPs for the same

RDP packet sent earlier. So, the source node S chooses the highly-reputed next-hop node for its data transfer. If two next-hop nodes have the same reputation, S will choose one of them randomly, stores its information in the sent-table as the path for its data transfer. Also, the source node will start a timer before it should receive a data acknowledgement (DACK) from the destination for this data packet. Afterwards, the chosen next-hop node will again choose the highly-reputed next-hop node from its routing table and will store its information in its sent-table as the path of this data transfer. Also, this chosen node will start a timer, before which it should receive the DACK from the destination for this data packet. This process continues till the data packet reaches the destination node D. And of course in this phase, if the data packet has originated from a low-reputed node, the packet is put back at the end of the queue of the current node. If the packet has originated from a high-reputed node, the current node sends the data packet to the next highly-reputed hop in the route discovered in the previous phase as soon as possible. Once the packet reaches its destination, the destination node D sends a signed data acknowledgement packet to the source S. The DACK traverses the same route as the data packet, but in the reverse direction. In the following figures, the data transfer phase is illustrated:

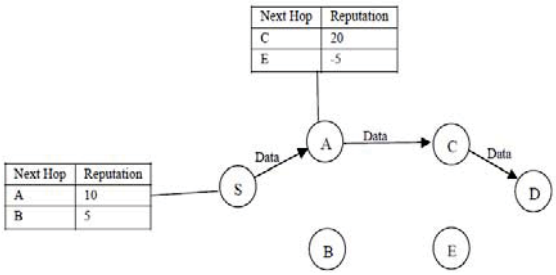

Figure 6: Choosing the highly-reputed next-hop node

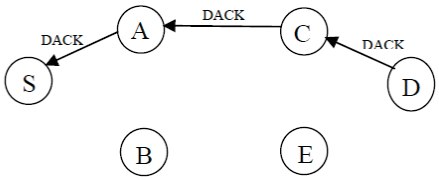

Figure 7: Sending Data Acknowledgement for each received data packet

Reputation Phase

In this phase, when an intermediate node receives a data acknowledgement packet (DACK), it retrieves the record, inserted in the data transfer phase, corresponding to this data packet then it increments the reputation of the next hop node. In addition, it deletes this data packet entry from its sent-table. Once the DACK packet reaches node S, it deletes this entry from its sent-table and gives a recommendation of (+1) to the node that delivered the acknowledgement.

Timeout Phase

In this phase, once the timer for a given data packet expires at a node; the node retrieves the entry corresponding to this data transfer operation returned by the timer from its sent-table. Then, the node gives a negative recommendation (-2) to the next-hop node and deletes the entry from the sent-table. Later on, when the intermediate nodes' timers up to the node that dropped the packet expire, they give a negative recommendation to their next hop node and delete the entry from their sent-table. As a consequence, all the nodes between the selfish node and the sender, including the selfish node, get a recommendation of (-2). Now, if the reputation of the next-hop node goes below the threshold (-40), the current node deactivates this node in its routing table and sends an error message RERR to the upstream nodes in the route. Then the original ARAN protocol handles it. Now, it is the responsibility of the sender to reinitiate the route discovery again. In addition, the node whose reputation value reached (-40) is now temporally weeded out of the MANET for five minutes and it later joins the network with a value of (0) so that to treat it as a newly joined node in the network.

Analysis of the proposed Reputed-ARAN

An analysis of the proposed reputation-based scheme is given by discussing different authenticated selfish nodes' forms of attacks and presenting ways of counteracting them by the introduced reputation-based scheme.

→ An authenticated selfish node might make a false claim of knowing the route to a destination and generate a RREP for a destination for which it does not have a route. This attack can be foiled by the proposed reputation-based scheme routing. After receiving the data packet for the corresponding destination, this authenticated selfish node will have to drop the data packet. The sender and the intermediate nodes until this selfish node will give a negative recommendation to it. Thus, once the reputation of this selfish node falls below the threshold reputation, it will be considered as selfish and will eventually be temporary ostracized.

→An authenticated selfish node might not reveal that it knows the route to the destination by not replying to or forwarding control packets so that to save its resources, such as energy and processing power; by doing this selfish behavior, it will not be able to inflict any damage to the network as it will not be able to drop the data packets routed via other paths. To face this type of selfish attack, the proposed scheme considers the reputation value of the node asking others to forward its packets. If the packet has originated from a low-reputed node, the packet is assigned lowermost priority and if the packet has originated from a high-reputed node, the current node sends the data packet to the next hop in

the route as soon as possible. Hence, these selfish nodes will see a considerable increase in network latency. So, the proposed scheme helps in encouraging the nodes to participate and cooperate in the ad hoc network effectively.

→ An authenticated selfish node might promise to route data packets, but then it starts to drop all the data packets that it receives. The presented reputation-based scheme foils this attack. In such a scenario, the upstream neighbor of the node will give it a negative recommendation and the reputation of the node will be reduced. Eventually, the node will be weeded out of the network for a period of time.

→Authenticated selfish nodes might collude by giving positive recommendations to each other so that to increase their reputations. The proposed reputation-based scheme prevents this attack by having the nodes rely on their own experience rather than the experience of their peers. Although the exchange of reputation information among the nodes will make the system more robust, it is not incorporated in my scheme. This is due to that if the nodes exchange the reputations of other nodes, the target (node soliciting reputation of another node) will have to consider the credibility of the information source (node providing reputation of another node). As a result, this will imply more work for the nodes at the routing layer and will also increase the volume of the network traffic. The downside of my scheme is that an authenticated selfish node can move around the network and selectively drop packets from different neighbors without getting caught for a long time. However, eventually this selfish node will be caught.

→An authenticated selfish node might continuously drops data packets to decrease the throughput of the mobile ad hoc network. The presented scheme can prevent such attack. Since the nodes in an ad hoc network are semi-autonomous, the proposed reputation-based scheme motivates them to allocate their resources to other nodes in the network. As the sender relays the packet only to highly reputed neighbors, it reduces the risk that its neighbors will intentionally drop the packet. The neighbors in turn forward the packets to nodes that have a high reputation with them. As a result, the number of packets intentionally dropped is reduced and the throughput of the system rises.

→ An authenticated well-behaved node might become a bottleneck since in the presented reputation-based scheme the node with the highest reputation is selected as the next hop by its neighbor. As a result, the nodes with higher reputations will become overloaded, while the other nodes become totally free. This problem is prevented in the proposed scheme as when authenticated nodes are congested and they cannot fulfill all control packets broadcasted in the MANET, they can choose not to reply to other nodes' requests in order to do their own assigned load according to their battery, performance and congestion status.

III. Results

The below figure 8 shows the results of the network throughput of both protocols: normal ARAN and Reputed-ARAN (Trustful ARAN) with different node speed and different percentages of selfish nodes. From the above graph, it is clear that the lack of cooperation has fatal effect on the efficient work in dramatic fall in normal ARAN's network throughput with increasing percentage of selfish nodes.

The different curves show a network of 20 nodes with different percentages of selfish nodes, from 0% up to 30%, and moving at different speeds. Here are some points that can be observed in this graph:

In the case that there are no selfish nodes in the mobile ad hoc network, both ARAN and Reputed-ARAN have almost identical network throughput values. This proves that the Reputed-ARAN protocol is as efficient as ARAN in delivering the packets and discovering routes to any destination. It can be noted that in both ARAN and Reputed-ARAN when the node movement speed rises, the network throughput diminishes as the network in general gets more fragile.

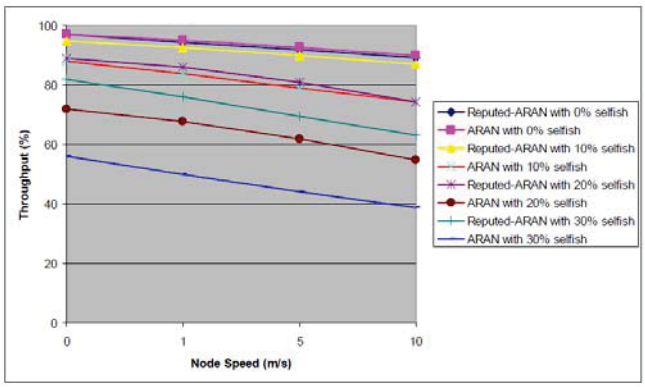

Figure 8: Effects of Selfish nodes on Network Throughput

Also, as the percentage of selfish nodes participating in the mobile ad hoc network increase, the throughput decreases because these selfish nodes tend to drop packets that they beforehand promised to forward. The outcome of dropping packets affects the normal ARAN protocol during the full life of the MANET, but in case of Reputed-ARAN, it is just affected partially as by time the selfish node will be identified and weeded out of the network. The increase of throughput of the network in the case of using Reputed-ARAN is attributed to that each node uses its local table of other nodes' reputation values in the selection of the next-hop node for establishing the data route. Thus, the throughput of the network is reduced to 38.8% with

normal ARAN, when 30% of the nodes are selfish and moving at speed of 10 m/s. However, the throughput of the network is reduced to only 63.1% with Reputed-ARAN, in the same circumstances. This proves that the Reputed g of the MANET. This graph shows the ARAN increases the network throughput by 38.5% over normal ARAN secure routing protocol.

The below figure 9 shows the results of the average route acquisition delay metric of both protocols: normal ARAN and Reputed-ARAN with different percentage of selfish nodes.

From the graph, it is clear that the newly proposed Reputed-ARAN protocol has an identical route acquisition delay as normal ARAN. This is due to that both protocols have the same steps for the discovery, setup and maintenance of the route, as no changes were done in these phases while designing the Reputed-ARAN. Also, it can be seen from the graph that in both protocols, the average route acquisition delay increases with the increase of the selfish nodes.

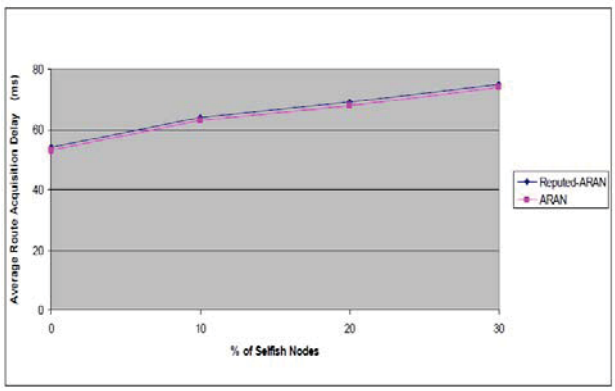

Figure 9: Average Route Acquisition Delay

This is due to the dropping of packets because of link failures and also because of the selfish behavior which results in reissuing a route discovery or taking a longer route to reach the destination.

IV. Conclusion

The field of MANETs is rapidly growing and changing. While there are still many challenges that need to be met, it is likely that such networks will see widespread use within the next few years. One of these challenges is security. Security of mobile ad hoc networks has recently gained momentum in the research community. Due to the open nature of ad hoc networks and their inherent lack of infrastructure, security exposures can be an impediment to basic network operation and countermeasures should be included in network functions from the early stages of their design. Security solutions for MANET have to cope with a challenging environment including scarce energy and computational resources and lack of persistent structure to rely on for building trust. To my knowledge, there is no previously published work on detecting and defending against malicious and authenticated selfish nodes together in the field of MANETs' routing protocols, even in the proposed secure routing protocols.

Throughout this thesis, discussion of existing mobile ad hoc networks' routing protocols' types and their advantages and disadvantages was given and a list of existing proactive, reactive and secure MANET routing protocols was compiled. Then, the different types of attacks targeting MANET routing protocols' security were explored. Also, the difference between malicious and selfish nodes and their associated attacks were discussed and a presentation of the fundamental requirements for the design of a secure routing protocol to defend against these security breaches was given. Furthermore, a comparison between some the existing secure mobile ad hoc routing protocols was presented. Then, an in-depth talk about the Authenticated Routing for Ad Hoc Networks protocol (ARAN) as one of the secure routing protocols built following the fundamental secure routing protocols design methodology was given. Afterwards, a discussion of how ARAN defends against most of the attacks that are conducted by malicious nodes such as spoofing, fabrication, modification and disclosure ones was presented. That resulted in proving that the currently existing specification of the ARAN secure routing MANET protocol does not defend against attacks performed by authenticated selfish nodes. Thus, I moved on discussing the different existing MANET cooperation enforcement schemes by stating their types: the virtual currency-based and the reputation-based schemes. Examples of each scheme and the different issues involved in the design of each were given. That resulted in proposing a new design of a reputation-based scheme to integrate it with one of the secure routing MANET protocols, ARAN, to make it detect and defend against selfish nodes and their misbehavior. In this proposal, the different phases of the proposed reputation-based scheme were explained. Then, an analysis of the various forms of selfish attacks that the proposed reputation-based scheme defends against was presented. Also, some time was invested in surveying the different simulation packages that are used in mobile ad hoc networks. Thus, the proposed design proves to be more efficient and more secure than normal ARAN secure routing protocol in defending against both malicious and authenticated selfish nodes.

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Query Based Face Retrieval From Automatic Reconstructed Images based on 3D Frontal View - Using EICA

By Y. Vijaya Lata, Dr. A. Govardhan

Abstract- Face recognition systems have been playing a vital role from several decades. Thus, various algorithms for face recognition are developed for various applications like 'person identification', 'human computer interaction', 'security systems'. A framework for face recognition with different poses through face reconstruction is being proposed in this paper. In the present work, the system is trained with only a single frontal face with normal illumination and expression. Instead of capturing the image of a person in different poses using camera or video, different views of the 3D face are reconstructed with the help of a 3D face shape model. This automatically increases the size of the training set. This approach outperforms the present 2D techniques with higher recognition rate. This paper refers to the face detection and recognition approach, which primarily focuses on Enhanced Independent Component Analysis(EICA) for the Query Based Face Retrieval and the implementation is done in Scilab. This method detects the static face(cropped photo as input) and also faces from group picture, and these faces are reconstructed using 3D face shape model. Image preprocessing is used inorder to reduce the error rate when there are illuminated images. Scilab's SIVP toolbox is used for image analysis.

Keywords: *3D face shape model, EICA, PCA, Scilab, SIVP.*

GJCST Classification: *I.4.6, I.5.1*

Strictly as per the compliance and regulations of:

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Y. Vijaya Lata[α], Dr. A. Govardhan[Ω]

Abstract-- Face recognition systems have been playing a vital role from several decades. Thus, various algorithms for face recognition are developed for various applications like 'person identification', 'human computer interaction', 'security systems'. A framework for face recognition with different poses through face reconstruction is being proposed in this paper. In the present work, the system is trained with only a single frontal face with normal illumination and expression. Instead of capturing the image of a person in different poses using camera or video, different views of the 3D face are reconstructed with the help of a 3D face shape model. This automatically increases the size of the training set. This approach outperforms the present 2D techniques with higher recognition rate. This paper refers to the face detection and recognition approach, which primarily focuses on Enhanced Independent Component Analysis(EICA) for the Query Based Face Retrieval and the implementation is done in Scilab. This method detects the static face(cropped photo as input) and also faces from group picture, and these faces are reconstructed using 3D face shape model. Image preprocessing is used inorder to reduce the error rate when there are illuminated images. Scilab's SIVP toolbox is used for image analysis.

Index Term—3D face shape model, EICA, PCA, Scilab, SIVP

I. Introduction

Face recognition systems are ubiquitous and has received substantial attention from researchers in biometrics and computer vision communities ever since security has become critically important in this commercial world. Many approaches have been proposed for face recognition systems for a captured digital photograph or a video clipping. These approaches have been prevailing since a few decades in two-dimensional space. Many algorithms are being introduced and improved then and then for the increase of the efficiencies in the recognition rates for the face recognition systems. The conventional algorithms are able to produce better results over the previous algorithms. But these conventional approaches are unable to achieve the success rates in a dramatic way due to some constraints[11]. These problems include the representation of the faces in a two-dimensional space, which is in a three-dimensional space. Thus, here a three-dimensional approach is being proposed to improve the efficiency of face recognition sy tems.

This paper aims at presenting a three-dimensional approach, a new approach, towards the face recognition systems. In this approach only a single two-dimensional face is given as an input along with the three-dimensional face shape model. Here, it is made sure that the features of the two-dimensional input face and that of the three-dimensional face model are at the same positions. Thus in this process only the essential features of a face which represent the face are been taken into consideration. The features such as hair, ears and neck parts are cropped which do not account for face recognition. Thus, even the reconstructed images also do not contain these parts to the maximum possible extent.

As the features are aligned properly, the texture of the three-dimensional face model will also be the same as on the two-dimensional input face[11][12]. Then, the face model is being rotated upon the required angle to obtain a new view of the face. In this process, some of the points are missed, overlapped and neglected, which requires the smoothing of those missing points in the face by using the concept of the nearest neighbours. Thus, the missing texture is retrieved by using this concept.

Finally, the newly obtained views of the input face are been projected onto the two-dimensional space. Thus, here a 3D(regenerated 3D face) to 2D(regenerated 2D face) projection is applied after the 2D(frontal input face) to 3D(face model) projection.

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

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(b) 3D face model after smoothing
(c) face with texture
(d) a new view with PIE

Figure1: Reconstruction of a new face with PIE[1]

The newly constructed images are being used for training the face recognition system to improve the efficiencies over the 2D approaches for face recognition. The proposed work has the following advantages: 1) Input to this proposed system is only a single frontal face with normal pose, illumination and expression(PIE). 2) Different views of a face are generated instead of capturing the images of a person in different poses using cameras or videos. 3) Automatic increase of the training set. 4) Outperforming the present 2D approaches with higher recognition rates.

Frontal Faces *Recostructed Faces*

Figure 2: Reconstructed faces for Own Database

Query based face retrieval is one of the applications of content-based image reterieval (CBIR). It requires a robust feature extraction method that is capable of deriving low-dimensional features effective for preserving class separability. Such low dimensional features are also important when one considers the computational efficiency[1] . The present paper focuses on query based face image retrieval using EICA and PCA which works on static as well as group images . In the EICA method enhanced retrieval performance is achieved by means of generalization analysis, in the reduced PCA space. EICA method has better performance than the popular face recognition methods. The present system is trained with the database shown in Figure (2), where the frontal images are taken and other images are reconstructed using 3D face shape model.The analysis have been carried out on two-dimensional face database using PCA and EICA, and also on reconstructed 3D faces.

II. Three-Dimensional Approach

In this section, the three-dimensional face reconstruction is being described in detail. Firstly, the three-dimensional face model is introduced and then the rotation of the face model is presented in a detailed manner to get the different views of the input face.

a) *Three-Dimensional Face Shape Model*

Here, the three-dimensional face shape model is represented as two-dimensional matrix which contains the height of the features of the face. The three-dimensional face model used in this paper is shown in Figure (3). This has been extracted from the GAVAB database[11][12] consisting of various face shape models. But, only one among them is selected here which was appropriate for the input images used in this paper. For the ease in computation, the height matrix of the face model is resized to 64 x 64 i.e. 64 rows and 64 columns without leading to any misinterpretation of the data.

Figure 3: 3D face shape model

Let h be the height matrix representing the face model. The original face model is been cropped till the necessary features required to represent the face and then resized. Thus, the value at h(i,j) gives the height of the feature point at the i^{th} row and j^{th} column of the face.

b) *Rotation in a Plane for Different Poses*

Rotation of the points is done by applying the rotation matrix on the points. To make them rotate in an appropriate manner without losing any data, rotation of the points is done by keeping one of the axes as fixed to minimise the burden of filling the missing areas which would be described later.

Let the rotation matrix be represented by m which is defined as follows.

$$m_x = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\alpha & -\sin\alpha \\ 0 & \sin\alpha & \cos\alpha \end{bmatrix}$$

$$H(i,j) = [i\ j\ h(i,j)] \cdot m_x$$

Thus, new points have been derived. So, the H matrix consists of the new position of the point in the 3D space. While deriving these new points, it has been observed that some points have been overlapped and so the values for some of the pixels have been missed. The following steps are taken to overcome this problem.

1) Firstly, if two or more points are intended of having the same position, then the point with the maximum height is considered and the rest of them are neglected. This is done for each pixel.

2) The missing values have been filled by the nearest neighbourhood pixels by smoothing them.

In this process no data has been misinterpreted to the possible extent.

c) *Texture Mapping*

After rotating the points, the texture is mapped according to the input face image. As each newly derived position after rotation of the points is stored in the previous position of the fontal face model, the texture of each pixel is mapped to the new position easily.

As described earlier, the missing points have been smoothened to the value of the nearest neighbour, there is a possibility of increasing and decreasing of the number of pixels for the particular texture than that of the 2D face image. For the ease in smoothening, the points are rotated in the plane by keeping one of the axes, say x-axes, as constant because determination of the value to be substituted for the missing values would be a cumbersome task.

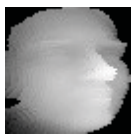


Figure 4(a): Left pose

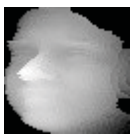


Figure 4(b): Right pose

If the angle is positive, then a left side view is generated for the face model and a right side view of the face model is generated as shown in figure (a) and (b) respectively. Thus, the left and right side views are generated by keeping the x-axis as constant.

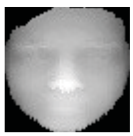


Fig 5(a) Down view

Fig 5(b) Top view

Similarly, the top and down views are generated by keeping the y-axis as the constant. The positive angle rotation gives the down view and the negative angle rotation gives the top view.

III. Face Reconition Using pca Algorithm

The recognition system consists of a training set and then the testing of the images is been carried out to recognise the testing images with those present in the training set. The training set consists of the images where the images are been trained onto the neural network. The neural network is designed with the help of the eigenvectors generated representing the training set which will be described clearly in the subsequent sections.

a) *Representation of Images*

Face images are represented by intensity values of each pixel. Let the dimensionality of each image be m x n. This means that each image consists of grid of pixels with m rows and n columns. Let I(x,y) represents intensity values for all pixels. So total number of pixels of each image will be m x n, let this value be denoted as N.

Now this image can also be considered as a vector of dimension N. So for example, say here, the images have the dimension of 64 x 64 pixels, then the dimension of the image vector will be 4096. So he--re N = 4096. Normally for all images, since dimensiona--lity of image is large, the value of N, dimension of image vector is also large.

b) *Principle Component Analysis*

Let there be n number of images used for testing. Each two-dimensional image is represented as a single dimensional data, as described in the above section, which are aligned together to form the data of the training set. Then its mean data is calculated by subtracting each image data with the average of the training set.

$$D_i = I_i - (1/n)\Sigma I_i$$

Here D forms the data set and I_i is data of i^{th} image. Then the covariance matrix, L, is obtained by the correlation of the dataset by multiplying the dataset with its transpose.

$$L = D \cdot D^T \text{ ---------- (1)}$$

$$L = D^T \cdot D \text{ ---------- (2)}$$

In equ.(1) the size of the resultant covariance matrix is N×N, which is high in dimension and is reduced to n×n in equ.(2). The eigen vectors (V) and eigen values (λ) of this covariance matrix are calculated which form the solutions to the given problem space i.e. training dataset.

$$L \cdot V = \lambda V$$

These eigen vectors are sorted in decreasing order of their corresponding eigen values. Thus, n eigen vectors are formed which are able to classify the distinct features of the images in the training set. Generally, all the eigenvectors are not necessary for the classification of the images. The eigen vectors with the negative eigen values are discarded. Further reduction of the eigen

vectors to some extent does not affect the recognition process and thus unnecessary computation is avoided. The m sorted and reduced eigen vectors (Vm) are projected on to the training set to get the eigen vectors of the training set.

$$EV = V_m \cdot D$$

Then the weights of the training set are been computed by projecting the data of each training image onto the eigen vectors of the training set which form the trained neural network.

$$O_i = EV \cdot D_i$$

Testing a new image(T) involves the steps performed on the data of individual training image by forming its one-dimensional data and subtracting the mean data of training set from it. This is then projected onto the eigen vectors to compute the weights of the testing image.

$$O_{new} = EV \cdot (T - (1/n)\sum I_i)$$
$$e_i = O_i - O_{new}$$
$$k = i \text{ , where } \min(e) = e_i$$

Then the training weights and testing weights are compared by any distance measuring criteria such as the Euclidean distance. The training image having the least difference based upon the Euclidean distance with the testing image is given as the nearest (k^{th}) matching image.

IV. Face Recognition Using EICA

This method is the enhanced form of ICA because of its enhanced retrieval performance for face recognition. Enhanced retrieval performance is achieved by means of generalization analysis and it operates in the reduced PCA space.

a) *Training Data*

Step 1: The not well illuminated images are preprocessed by using intensity normalization method, in which the lightening source increases by the factor, each RGB component of each pixel in the image is scaled by the same factor. The effect of this intensity factor is removed by dividing by the sum of the three color components. Since the pixels of the resulting image have equal intensity, summing the three color channels would result in a blank image. Therefore, to create an image with single scalar values for each pixel (as required by our Eigen face system) either consider a single color channel, or sum just the red and green components (the chromaticities).

Step 2: For the preprocessed training data calculate the image matrix X. Here the preprocessed image is resized to a 64×64 matrix will be converted to 4096×n,where n is the number of images in the data base.

Step 3: The covariance of the image matrix is to be calculated in order to find eigen values and eigen vector by applying PCA procedure.

--The covariance of image matrix is defined as

$COV=XX^T$.

--The eigen values and corresponding eigenvectors are computed for the covariance matrix.

$\Omega V = \Lambda V$

where V is the set of eigenvectors associated with the eigenvalues Λ.

Sort the eigenvectors according to their corresponding eigenvalues. Consider only the eigen vectors with non zero eigen values. This matrix of eigenvectors is the eigen space V , where each column of V is an eigenvector.

$V=[v_1|v_2....|v_p]$

Step 4: The new random vector in the reduced(50-dimensional) space is defined as

$Y= P^t X$

where P is the orthogonal eigen vector matrix of 50 dimensional.

The ICA method implemented in the appropriate reduced space is an Enhanced ICA method.

Step 5: Find the covariance of the random vector which is defined as,

$COV=YY^T$

The eigen values and corresponding eigenvectors are computed for the covariance matrix.

$\Omega V_1 = \Lambda V_1$

here V1 is the set of eigenvectors associated with the eigen values Λ.

Step 6:Calculate the basis vector which is defined as

$BV=(PV_1)^T$

Step 7:Find the basis vector for all images in training set

Z=BV x X

Train Group: Similarly the train group database is implemented using the above algorithm to calculate the basis vector for all the train group database.

e) *Testing Data*

An input image is read from the data base and it is preprocessed using intensity normalization method**.**

Step 1: Calculate the image matrix X2 for the preprocessed input image. Find the input image and is resized to 64x64 matrix which is now converted to 4096.n_1,where n_1 is number of images in test data base.

Step 2: The testing basis vector Z2 is defined as

Z2=BV x X2.

Step 3: E=((T-Z2)^{t}x(T-Z2)),where T is defined as the Basis Vector of the complete training images. In Scilab the Euclidean distance is calculated by using min method.

[Dist,Place]=min(E)

Step 4:The minimum Euclidean distance will give output image. To retrieve the details of the output image the location is to be found in database. The location can be known by using place variable which is found while calculating Euclidean distance.

After finding position, details of student are stored in result.txt and are displayed later.

V. Implementation in Scilab & Results

The above discussed methodologies have been implemented in Scilab. The algorithm has been tested for the standard image database such as Yale's database, and also on own database.

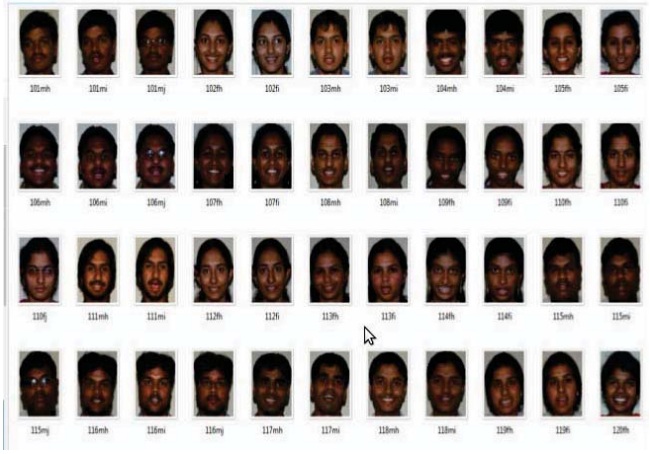
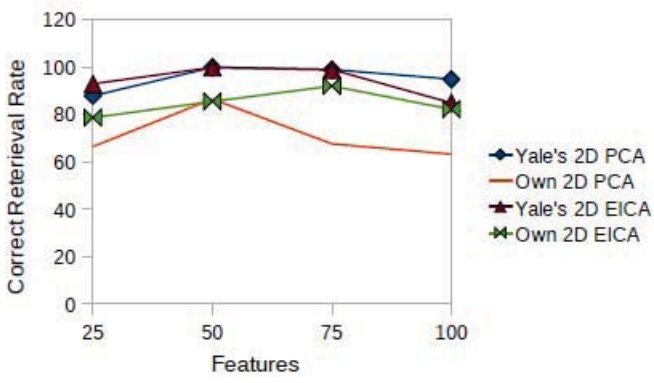


Figure 6: Own Database

PCA – Without reconstruction(2D)

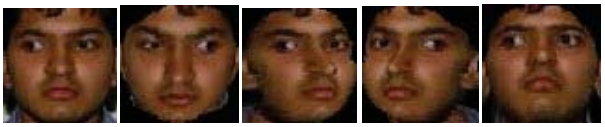
EICA - Without reconstruction(2D)



The reconstructed 2D faces based on 3D frontal view using 3D shape face model

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

Figure 7: Yale's Database – (a) original image (b)-(e) reconstructed image



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

Figure 8: Own Database – (a) original image (b)-(e) reconstructed image

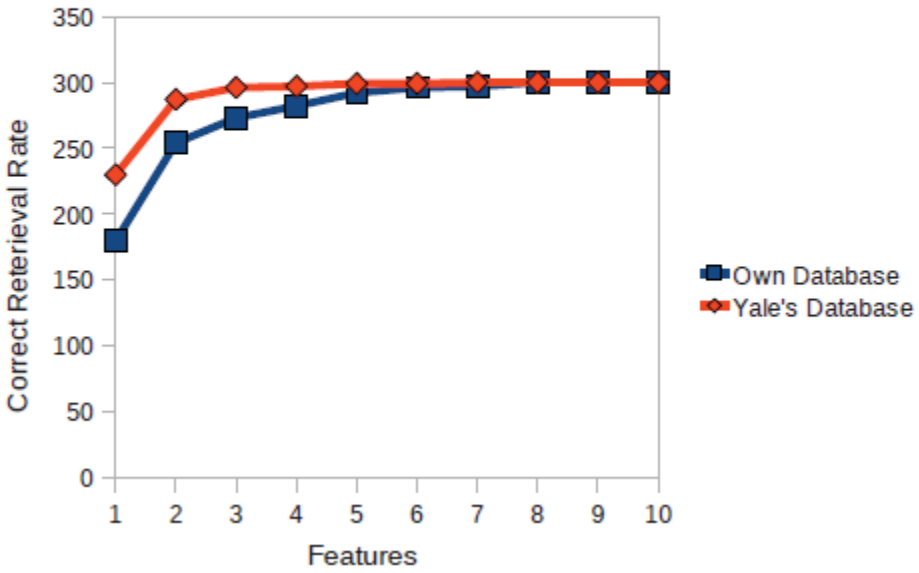
By taking single frontal image of 10 subjects each system can generate new poses of each subject in left view, right view, top view and down view. As a result 30 images per subject are generated out of which 15 images are given for training and 15 are given for testing. The images which are given for training are not included for testing.

As shown in the above figures, the faces from the single frontal face are reconstructed in different views automatically and are used for the recognition process. A testing is performed on these images by giving half of the images for the training set and the rest of the images are been tested onto the training set which are also of the normal illumination and expression as of the training images.

Here, ten subjects in each database are been selected whose features are appropriate to that of the face shape model used in this paper. Totally 300 reconstructed images (10 left view, 10 right view, 5 top view, 10 down view) have been trained along with the original frontal faces. Another 300 reconstructed images (10 left view, 10 right view, 5 top view, 5 down view) have been tested onto the training set. This is done for each of the mentioned databases. The images that are given for training are not included for testing and those given for testing are not included for training.

Database	2D approach	3D approach
Yale's Database	80 %	100 %
Own Database	65 %	99 %

Table showing the success rates of face recognition on Yale's Database and Own Database in different approaches



VI. Conclusion

The above described three-dimensional approach is outperforming the 2D approaches as higher recognition rates are been obtained. The burden of capturing the images in different views and aligning them properly in the 2D approach is not present in the 3D approach. This process is being carried out with a single frontal image as input and thus automatically increasing the training set with different poses. Using the personalised 3D face shape models will increase the clarity of the reconstructed images and thus other constraints in face recognition such as illumination and expression would be easily overcome.

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Software Reliability Simulation: Process, Approaches and Methodology

By Javaid Iqbal, Dr. S.M.K. Quadri
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Abstract- Reliability is probably the most crucial factor to put ones hand up for in any engineering process. Quantitatively, reliability gives a measure (quantity) of quality, and the quantity can be properly engineered using appropriate reliability engineering process. Software Reliability Modeling has been one of the much-attracted research domains in Software Reliability Engineering, to estimate the current state as well as predict the future state of the software system reliability.

This paper aims to raise awareness about the usefulness and importance of simulation in support of software reliability modeling and engineering. Simulation can be applied in many critical and touchy areas and enables one to address issues before they these issues become problems. This paper brings to fore some key concepts in simulation-based software reliability modeling. This paper suggests that the software engineering community could exploit simulation to much greater advantage which include cutting down on software development costs, improving reliability, narrowing down the gestation period of software development, fore-seeing the software development process and the software product itself and so on.

Keywords: *Software Reliability Engineering, Software Reliability, Modeling, Simulation, Simulation model.*

GJCST Classification: *C.4, D.2.4*

Strictly as per the compliance and regulations of:

Software Reliability Simulation: Process, Approaches and Methodology

Javaid Iqbal[α], Dr. S.M.K. Quadri[Ω]

Abstract- Reliability is probably the most crucial factor to put ones hand up for in any engineering process. Quantitatively, reliability gives a measure (quantity) of quality, and the quantity can be properly engineered using appropriate reliability engineering process. Software Reliability Modeling has been one of the much-attracted research domains in Software Reliability Engineering, to estimate the current state as well as predict the future state of the software system reliability.

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I. Introduction

Owing to the unexpectedly spiraling increase in the size and complexity of software systems during the past few decades, software reliability has become even more increasingly important for such massive systems. As a result of the compound growth rate of the order of ten times every five years in the size and complexity of software systems deployed in the key areas of telecommunications, defense, transportation industries, business etc, software system reliability is the prime factor to check out for. In such systems, a software failure can lead to serious, even fatal, consequences and repercussions in safety-critical and mission-critical systems as well as in normal business.

Software system reliability stands out as the key benchmark attribute for a software system among its various attributes. The levels of service dependability of a software system during its life-time are the indications for its reliability. In fact, the performance criterion of a software system is known by how long the software system will render faithful service. As a result of spiraling increase in the complexity of software systems, performance analysis of the software systems has gained further attention. Much focus has gone to the structural side of software systems as well. In general, the various components of a software system must remain expectedly faithful vis-à-vis their intended functions and deliverables. Software reliability has been dominating the thought-process ever since the size and hence complexities of software systems have increased. As fallout of increased size and complexity of software systems, factors contributing to the unreliability of the system become more pronounced. However, even though some level of unreliability does exist for a software system, it is worthwhile to express the quality of the software system by measuring some objective attributes such as reliability and availability. Software reliability characterizing the dynamic quality attribute of a software system can measure and predict the operational/usage profile of the software system.

II. Software Reliability and Software Reliability Engineering

Software Reliability is defined as the probability that software will provide failure-free operation in a fixed environment for a fixed interval of time [17]. In fact, software reliability is the key attribute in software reliability engineering which stands out among other attributes of software quality such as functionality, usability, capability, maintainability, and, etc., for its relevance to quantifying software failures. Software reliability quantifies software failures in a software system. By definition Reliability is probabilistic and hence hard to quantify accurately.

Software Reliability Modeling has been an active research domain for fault/failure forecasting, in software reliability engineering, for estimation as well as prediction of the current and future states, respectively, of the reliability of a software system. A software reliability model represents the behavior of software failures with respect to time as a random process. Reliability modeling as an essential element of the reliability estimation process determines whether a software system meets the specified levels of reliability and thus can be used to decide about the release time

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of a software system. Software Reliability Engineering (SRE) encompasses certain engineering techniques for the development and maintenance of software systems with an objective of measuring and predicting reliability (quality) as a quantity. The estimation as well as the prediction of reliability of a software system, involves the use of failure data represented as failure process through its reliability model. Probabilistic approach, being most common approach to developing software reliability models, represents the failure occurrences and the fault removals as probabilistic events. Probabilistic software reliability models are classified into various classes, including error seeding models, failure rate models, curve fitting models, reliability growth models, Markov structure models, and non-homogeneous Poisson process (NHPP) models .The three main reliability modeling approaches are: the error seeding and tagging approach, the data domain approach, and the time domain approach. Among these the time domain approach has gained much acceptance where techniques like curve-fitting and extrapolation are used. However, SRE techniques do have their limitations too.

Limitations of some existing SRE techniques:

1) Late collection of failure data: - SRE techniques collect the failure data during integration testing or system testing phases thereby providing for little flexibility in design re-considerations and re-structuring.

2) Non-Exhaustive failure data: - failure data collected by testing does not cover all failures under all settings (environmental, operational, usage etc). The side-effects are especially visible in software systems where we need to maintain highest levels of reliability. As a result, reliability estimation and prediction using the restricted testing data may only be approximations.

3) Non-realistic assumptions: - Assumptions underlying various SRE techniques or modeling methods for the reliability estimation may be too much unrealistic and optimistic in relation with the real scenario pertaining to the problem at hand.

Moreover, software testers test software as per laboratory settings without referring to its environmental settings. In an effort to break the software much of their attention and effort goes to designing of test cases for exceptional and boundary conditions, rather than testing for normal routine operations. Software reliability measurers, on the other hand, are much focused on testing of software as per its operational profile in order to allow for accurate reliability estimation and prediction. Against this backdrop of limitations of SR techniques and mutually exclusive focuses of testers and reliability measurers, simulation offers a luring approach to reliability modeling of a software system for it has the scope to address these important issues and bottlenecks. Furthermore, effective reliability modeling ultimately requires good data sets which are faithfully comprehensive, complete, or consistent. Such data sets are very rarely collected owing to different factors. However, simulation-based approaches do hold promise for such scenarios as well.

III. Simulation

a) *General Description*

Simulation is experimentation with models. More specifically, simulation is the technique of imitating the character of an object or process in such a way that enables us to make quantifiable inferences about the real object or process being simulated [25],[26]. When simulation is applied to software reliability, it can be used to mimic key characteristics of the various processes involved. To study a system, it is possible to experiment with the system itself or with the model of the system; experimenting with the system itself may be not be viable and feasible always, depending on the nature and type of system to be studied. Cost and risk analysis may not permit it. The objective, however, is to comprehend and predict how a system will perform before it is built. Consequently, the study of the system under consideration is generally conducted with a model of the system. A model is not only a substitute of a system but also a simplification of the system.

A model is an abstraction (simplification) of a real (existent) or conceptual (non-existent) system that is itself complex. A model embodies only those characteristics of the system under study, which are required for study, prediction, modification, or control of the system. Thus, a model includes some, but not all, aspects of the system being modeled. A model provides useful insights, predictions, and answers to the questions it is used to address. However, no single model can be used in all the situations. No model is complete; one model may work well for a set of certain software, but may be completely off track for other kinds of problems [1].

Increasing familiarization of the object-oriented systems design and modeling as well as the strikingly impressive web-based system developments have led to a substantial rise in the use of component-based software development approaches [10]. With the availability of commercial off-the-shelf software components (COTS), development of in-house, or out-sourced components, the whole application development takes place under a heterogeneous environment (multiple teams in different environments) and hence it may be inappropriate to describe the overall reliability assessment of such applications using only one of the several software reliability growth models- the black-box approach[6]. Thus, for such structured and component-based software systems, reliability prediction must start as early as its architecture phase of the life-cycle. Moreover,

assessment of reliability is made in terms of reliabilities of the components of such systems.

The existing analytical methods to predict the reliability of component-based systems are based on the Markovian assumption [2], [13]. Semi-Markov [14] relaxes this assumption in a restrictive manner. However, both Markovian and semi-Markovian methods to predict the reliability of such heterogeneous systems suffer from several limitations:

They are subject to an intractably large state-space, and They cannot account for the influence of various parameters such as reliability growth of the individual components, dependencies among the components, etc., in a single model.

Nevertheless, methods are in place to model the reliability growth of the components which cannot be accounted for by the conventional analytical methods [8], [9], [15], but they are again subject to the state-space explosion problem, and their computational complexity is also a problem. There are many other methods, however, there is no single analytical model, which takes into account all such features, and is not intractable.

A simulation model, on the other hand, offers an attractive alternative to analytical models as it describes a system being characterized in terms of its artifacts, events, interrelationships and interactions in such a way that one may perform experiments on the model, rather than on the system itself, ideally with indistinguishable results [1][26]. Thus a simulation model can capture a detailed system structure, and facilitate the study of the influence of various factors such as reliability growth, repair policies, correlations among the various versions etc. Simulation can also represent the impact of several strategies that may be employed during testing and different deployment configurations during operation. Simulation can be used to study the influence of different factors separately as well as in a combined manner on dependability measures. In addition, simulation techniques can be provided for SRE purposes. They can produce observables of interest in reliability engineering, including discrete integer-valued quantities that occur as time progresses.

b) *Simulation Model*

A simulation model is a computerized model that represents some dynamic system or phenomenon and possesses the characteristics of interest of study about that system. A simulation model or any other modeling method is an inexpensive way to gain important insights when the costs, risks, or logistics of manipulating the real system of interest are prohibitive. The most common purposes of simulation models are to provide a basis for experimentation, predict behavior, answer "what if" questions, teach about the system being modeled, etc. A simulation model used in a simulation study is basically a parametric model where the values of the parameters need not be specified. It consisting of a particular parameter set which represents the values of the parameters of the model.

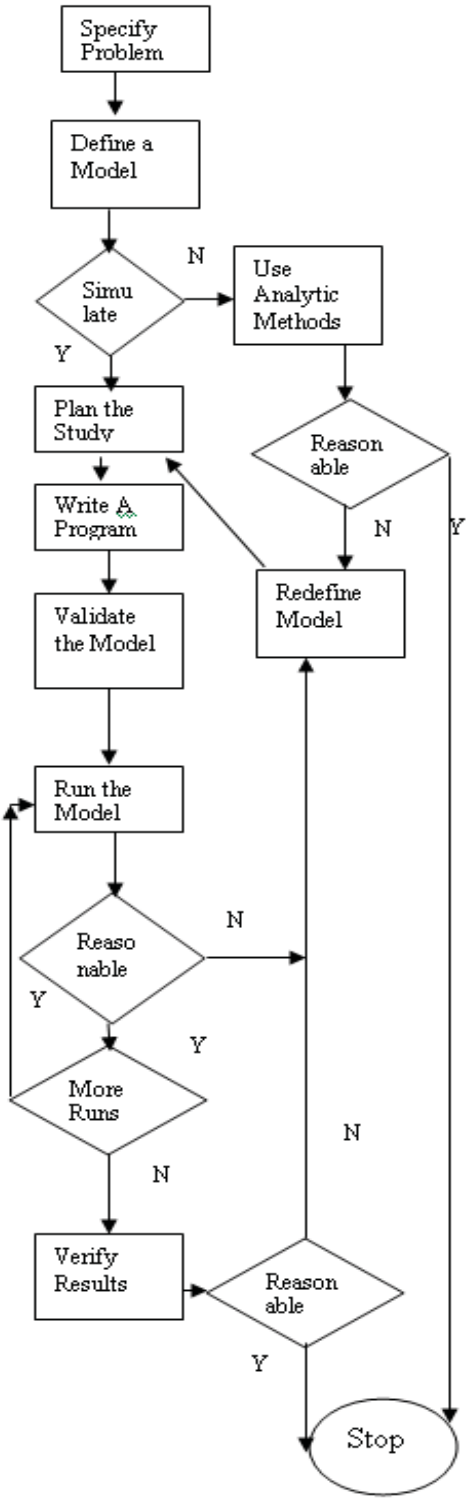
Static models or techniques may not always be the first choice for a system with high complexity levels. In such systems, simulations are generally employed to model the complexity of the system which may manifest itself in the form of system uncertainty and stochasticity, dynamic system behavior and feed-back and feed-forward mechanisms. For uncertain systems simulation provides a flexible and useful mechanism for capturing uncertainty related to complex systems. For systems with dynamic behavior, dynamic simulation models are very flexible and support modeling of a wide variety of system structures and dynamic interactions. For systems with feedback mechanisms where behavior and decisions made at one point in the process impact others in complex or indirect ways, simulation is a usable alternative.

c) *Software Reliability Simulation Model*

A software reliability simulation model focuses on some particular software reliability estimation and/or prediction process vis-à-vis a software system. It can represent reliability of a software system as currently implemented (as-is), or as desired for future (to-be). Since all models are abstractions, a model represents only some of the many aspects of a software system that potentially could be modeled. This includes the aspects believed by the model developer to be especially relevant to the issues and questions the model is used to address.

IV. Simulation Process

Data has to be considered as real system or simulated data. The fact that good data sets are exactly scarce, one purpose of simulation is to supply carefully controlled, homogeneous data or software artifacts with known characteristics for use in evaluating the various assumptions upon which existing reliability models have been built. Since actual software artifacts (e.g. faults in computer programs) and processes (e.g. failure/fault removal) often violate the assumptions of analytic software reliability models, simulation can help a better understanding of such assumptions and may even lead to a better explanation of why some analytic models work well in spite of such violations[25][26][1]. Some of the steps involved in the process of simulation study [7], [1] are illustrated by the flowchart of Figure below (process of simulating).



First up, it is required to describe the problem to be solved in a concise manner. Based on this problem definition, a model is defined. At this point of time, it can be checked out whether the model can be kept in a form that allows analytical techniques to be used. When it is decided to simulate, the experimental nature of the simulation technique makes it essential to plan the study by deciding upon the major parameters to be varied, the number of cases to be conducted and the order in which runs are to be made. Specification of experimentation has two components: experimental frame(s) and simulation run(s). An experimental frame defines a limited set of circumstances under which the system (or its model) is to be observed or subjected to experimentation. It requires specification of the observational variables, input schedules, initialization, and termination conditions and collection, compression, and display of data [20]. A simulation run is the observation of the behavior of a particular model under an experimental frame. Given that the simulation is to be on the digital computer, a program must be written. A program has both representation and execution aspects. Once the model is decided, we need to verify the model and then execute a series of runs according to the study plan. As results are obtained, it is likely that there will be many changes in the model and the study plan. The early runs may make parameter significance clear and so lead to the reassessment of the model. Verification of results is important after each run. Sometimes it is useful to repeat runs so that parts of model have different random numbers on each run. Moreover, one has to consider different groups of methodology or technique-oriented issues of modeling, experimentation, simulation, and programming. The degree of success of a simulation study is assessed in terms of the objective of the study, the structure and data of the real system, the parametric model, the model parameter set, the specification of experimentation, and the accepted norms of the modeling methodology, experimentation technique, simulation methodology, and software engineering.

V. Reliability Simulation Methodology

a) *Assumptions*

Assumptions and observed data are very important for software reliability study [3]. For the simulation (rate-based) we have the following assumptions. It may be noted that these assumptions can be seen as the most common assumptions for software reliability models [4], [22].

1. The software under testing remains essentially unchanged throughout testing, except for the removal of faults as they are found.
2. Removing a fault does not affect the chance that a different fault will be found.
3. "Time" is measured in such a way that testing effort is constant.
4. All faults are of equal importance.
5. At the time of testing, there is some finite total number of faults, which may be fixed or random; if random, their distribution may be known or of known form with unknown parameters.
6. Between failures occurrence, the failure rate follows a known functional form.

b) *Approaches To Reliability Simulation*

There are a number of modeling approaches used to investigate different aspects of the software reliability modeling process. The appropriate approach suited to the particular simulation model is best determined in terms of its purpose, questions, scope, result variables desired, etc. A variety of simulation approaches have been applied to software systems, which include: General discrete event simulation, System dynamics (or continuous simulation) and so on. However, the following are the two main approaches to reliability simulation.

i) *Rate-Based Reliability Simulation*

It is a rate-controlled event process simulation method. Here, a stochastic phenomenon is represented by a time sequence x(t), the behavior of which depends only on a rate function, R (t); R (t)*dt represents the conditional probability that a specified event occurs in infinitesimal interval (t, t+dt). Various mathematical reliability models work on Failure Rate Functions. The output of a rate-based reliability simulation approach is a time-line behavioral imitations of the activities and events involved in reliability. Reliability measures of interest in the software system are modeled parametrically over time. This approach is ba--sed on rate- based architecture, wherein phenomena occur naturally over time, controlled by their freque--ncies of occurrence. Software metrics such as number of faults so far exposed or yet remaining, failure criticality, test intensity, and software execution time govern the architecture. Rate based event simul--ation is an example of a form of modeling called system dynamics, whose distinctive feature is that the observables are discrete events randomly occurring in time. Since many software reliability growth models are based on rate (in terms of software failure/fault), the underlying processes/assumptions assumed by these models are fundamentally the same as the rate-based reliability simulation (see ASSUMPTIONS). In general, simulations enable investigations of questions too difficult to be answered analytically, and are therefore more flexible and more powerful.

ii) *Artifact-Based Reliability Simulation*

In this approach, many aspects of program construction and testing are used to investigate the effect of static features on dynamic behavior; Here, the inputs may include code structure characteristics, coding errors, test input data, test conduct, failure characteristics, debugging effectiveness, and computing environment. The output of this simulation approach is artifacts in an actual software environment according to factors and influences believed to typify these entities within a given context. The artifacts and environment are allowed to interact naturally, whereupon the flow of occurrences of activities and events is observed. This artifact-based simulation allows experiments to be set up to examine the nature of the relationships between software failures and other software metrics, such as program structure, programming error characteristics, and test strategies. It is suggested that the extent to which reliability depends merely on these factors can be measured by generating random programs having the given characteristics, and then observing their failure statistics.

A software system consists of static and dynamic structures with static structure existing in terms of component-interactions. It is evident by the inspection of the design and code of the software system and comprehendible without the need for its execution or simulation. However, it is the dynamic structure of the software system which is very important for reliability analysis. The dynamic/runtime information may include the frequency of occurrence of the interactions, the time spent in the interactions, etc. Dynamic structure is obtained by the execution or simulation of the software system. It depends on usage characteristics of the application, which is given by its operational profile [18].

VI. Implementing Reliability Simulation

With an intention to simulate the reliability measures of a software system, software system can be considered on a holistic basis in an approach called as black-box simulation or the software system can be considered as a bunch of some individual components/component combinations in another approach called as white-box simulation. Awareness of what to simulate is very important and can be helped by knowing (1) model scope, (2) result variables, (3) abstraction (represented by model), and (4) input parameters.

a) *Black-Box Reliability Simulation*

In black-box simulation approach to reliability, we treat software as a whole where only the application-level interfaces (input/out) hold significance, meaning that only the interactions with the outside world are modeled, while the internal structure and component combinations are not modeled. This is relatively a simple simulation approach. In black-box approach, only the failure data from the software systems under measurement are included in the modeling process, while the system structures are ignored. The input to the black-box simulation is a failure behavior file including the parameters of failure. The parameters can be obtained by using CASRE (Computer Aided Software Reliability Estimation) which is a tool for software reliability measurement [19]. The output of black-box

simulation is the number of cumulative failures and the failure intensity of the software.

b) *White-Box Reliability Simulation*

In the black-box simulation, the software system is treated as a whole. The internal structure and features of software (e.g. the components interactions and correlations) are not concerned. There are some shortcomings in this approach for software reliability measurements analysis. With the increasing popularity of component-based software systems design, white-box approaches to software reliability seem more fitting for simulation. As a general practice, modeling is based on availability of the whole system data, without taking into account the unit testing data which is usually available earlier for each component. Also, the simulation process can be represented by one single model; however, it may be more appropriate that different components be applied different models. For such modeling considerations, white-box simulations are the solution. Generally speaking, the white-box approach to software reliability extends the black-box approach by including structural parameters into the reliability engineering process.

VII. What Does Simulation Offer

The immediate product of simulation study is a model that is primarily visual (i.e., graphical, diagrammatic, or iconic) or textual in form. Visual models have become the de facto standard for software systems simulations for their understandability and ease of development. Understanding is further helped when the model encompasses the ability to animate; the model during simulation can be used to show the flows of objects (e.g., code units, designs, problem reports) through the process, the activities currently being performed, and so forth. Moreover, a visual model is always supplemented by textual information regarding interrelationships among components, random variables distributions, etc. Thus, a model is genuinely desirable information bank.

The nature of simulation can be deterministic, stochastic, or hybrid. In the deterministic case, input parameters are spelled out as single values or point estimates (deterministic). Stochastic modeling encompasses the inherent uncertainty in many parameters and relationships. Stochastic variables are random numbers drawn from a specified probability distribution. Hybrid modeling employs both deterministic and stochastic parameters. In a purely deterministic model, only one simulation run is needed for a given set of parameters. However, with stochastic or hybrid modeling, the result variables or observables differ from one run to another because the random numbers actually drawn differ from run to run. Thus, the result variables are best analyzed statistically e.g., in terms of mean, standard deviation, distribution form etc. across a batch of simulation runs; this is termed Monte Carlo simulation.

Finally, sensitivity analysis, a very useful capability of simulation models, is used to understand and analyze the effects and/or the significance of effects caused by varying a selected model parameter in a controlled sense on some key observable. This allows the model developer to determine the likely range of results due to uncertainties in key parameters. It also allows the model developer to identify which parameters have the most significant effects on results, suggesting that those be measured and/or controlled more carefully.

VIII. Conclusion

It is crystal clear that simulation holds a lot of promise for modeling of software systems. Simulation techniques, applicable for the assessment of fully functional systems, can evaluate the reliability and performance, as early as the architecture phase in the life-cycle of the software. Thus, help in the selection of reusable components, identification of components that should be developed in-house, and allocation of reliabilities to the individual components so that the overall reliability objective is met. It can also help in the identification of reliability and performance bottlenecks, so that remedial actions can be taken before it is too late/ too expensive. Moreover, simulation lets us fore-see the working and behavior of a revised or new process, prior to its implementation, thereby averting expensive and risky process improvements through operational experience.

However, the effectiveness of simulation is guaranteed only if both the model, and the data driving the model, accurately reflect the real world. This emphasizes collection of metric data in a consistent sense from a systems perspective - it is not simply a collection of "nice to have" data. Usually, analyst does not have clear guidelines on what is essential metric data.

As a cautionary note, simulation is not a panacea. In fact, the predictive power of simulation is governed by model validation efforts. Simulation is a simplification of the real world, and is thus inherently an approximation. As indicated in [23] it is not possible that a model is absolutely correct. Therefore, model (verification and validation) is concerned with creating enough confidence in a model for its results to be accepted. This is done by trying to prove that the model is incorrect. The more tests that are performed in which it cannot be proved that the model in incorrect, the more confidence in the model is increased.

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Performance analysis of Call Admission Control algorithm for Wireless Multimedia networks

By S.P.V.Subba Rao, Dr. S. Venkata Chalam, Dr.D.Sreenivasa Rao

Abstract- In todays wireless networks different wireless multimedia services have diverse bandwidth and QOS requirements, which need to be guaranteed by the wireless cellular networks. The decision to admit or reject the new user call is made by the call admission control algorithm.In this paper, a novel Call Admission Control algorithm for wireless cellular networks is proposed. The call admission control algorithm is based on power control. It determines the optimum number of admission users with optimum transmission power level so as to reduce the interference level and call blocking. By our simulation we show that our proposed call admission control algorithm reduces the blocking probability.

Keywords: *Call admission control, Wireless Multimedia networks,call blocking probability,*

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Performance analysis of Call Admission Control algorithm for Wireless Multimedia networks

S.P.V.Subba Rao[α], Dr. S. Venkata Chalam[Ω], Dr.D.Sreenivasa Rao[β]

Abstract- In todays wireless networks different wireless multimedia services have diverse bandwidth and QOS requirements, which need to be guaranteed by the wireless cellular networks. The decision to admit or reject the new user call is made by the call admission control algorithm.In this paper, a novel Call Admission Control algorithm for wireless cellular networks is proposed. The call admission control algorithm is based on power control. It determines the optimum number of admission users with optimum transmission power level so as to reduce the interference level and call blocking. By our simulation we show that our proposed call admission control algorithm reduces the blocking probability.

Keywords-Call admission control,Wireless Multimedia networks,call blocking probability,

I. Introduction

The upcoming wireless cellular infrastructures such as third generation (3G) and fourth generation (4G) are deemed to support new high-speed services with different Quality-of-Service (QOS) and their respective traffic profiles. The advent of the third and fourth generation of wireless multimedia services brought about a need to adapt to the existing mobile cellular networks to make them carry various classes of multimedia traffic like voice, video, image, web documents, data or a combination thereof. achieve this goal, radio resource management techniques are used. These schemes include: channel assignment, power control, call admission control, congestion control, and other traffic-and-mobility-management schemes.

Call admission control algorithm plays a central role in determining both the performance of any network, and the revenue of the network. The call admission control algorithm must decide either to accept the call or reject it, thus having an impact on both the quality of calls and the network revenues. The call admission control algorithm must deal with multiple classes of calls having different requirements, requesting different Quality of Service (QOS) and with different priorities.In our paper we are proposing novel call admission control algorithm which is based on power control . In the above algorithm priority is given for hand off request calls ,since handoffs are important then the new calls. The power of the existing users are degraded according to priorities Here non real time services are degraded first when compared with real time services which leads to reduced loss for real time services.Session III gives the detailed description of the proposed Ad-CAC algorithm along with its design approach. Session IV gives information about the simulation model and result analysis. SessionV concludes the Paper.

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II. Related Works

[1] The easiest and most simple admission control protocol is the First Come First Served (FCFS). If a request arrives and there is enough bandwidth to accommodate it, the call is admitted, otherwise rejected. FCFS produces a good utilization of the medium, but is biased against calls which require high bandwidth. Besides, it does not support prioritization because of which the hand-off calls cannot be distinguished from the new calls.

[2] In this method, the network is divided into cells. A new call is admitted only if the number of newly arriving calls is less than or equal to maximum number of calls that can be admitted in the cell .This type of threshold based algorithm does not give efficient bandwidth utilization in Multimedia Networks.

In [3-6] the well-known Guard Channel Scheme and its variations have been proposed to give higher priority to handoff connections over new connections by reserving a number of channels called guard channels for handoff call connections. All these schemes are static. Moreover, only one traffic class, i.e., voice traffic, is considered.

In [7] a Resource Reservation Estimation (RRE) methodology has been proposed. The RRE module that resides in the base station dynamically estimates the amount of bandwidth to be reserved by referencing the traffic conditions in the neighboring cells periodically or upon call request arrival depending upon the design of the system. But such a system is very complicated to design and may not assure reliability.

In [8] a Bandwidth Partitioning Scheme has been proposed. Complete Partitioning results in unfair blocking of higher bandwidth calls and leads to inefficient utilization of the bandwidth

In [9], an optimal Bandwidth Adaptation Algorithm has been obtained, but with the assumption of the continuous value of bandwidth. The practical bandwidth values of Adaptive Multimedia are more likely to be discrete than continuous.

III. Power Control and Adaptive Call Admission Control Algorithm

While describing the access system we take only one mobile cell into account in which there are M active nodes(or users) that generates messages to be transmitted to another node. In this network the base station controls all the nodes within the cell. Two kinds of links are possible in this model.

1. *Uplink: this demonstrates data transmission from mobile station MS to BS.*
2. *Downlink: this describes the data transmission from BS to MS.*

In a topological aspect, the base station is positioned for good propagation condition. The location of the portables is uncertain and varying. The wireless propagation conditions have a strong impact on a choice of a suitable multiple access protocol.

a) *Adaptive Power Control algorithm*

The transmit power can be represented as:

$$P(t+1)=P(t)+\lambda.sign(SIRtarget-SIRest)[dB] \quad (1)$$

Where P(t) represent the transmit power at time t, λ is the power control step size, SIRtarget, and SIRest are the target and estimated SIR respectively. The term sign is the sign function: sign(x) = 1, when $x \geq 0$, and sign(x) = -1, when $x < 0$.

It can be noted that sign (SIRtarget-SIRest) =-1 is equivalent to a TPC power up command which can be represented by bit 0. From Equation 1, it can be observed that the transmit power will be increased or decreased by λ on every time slot. The transmitted power will always change even when there is no change in the channel.

The transmit power is updated according to the following equation:

$$P_u(t+1)=P_u(t)+AF_u(t).PDF_u(t)\lambda.TPC_u(t) \quad (2)$$

Where AFu (t) is the Adaptive Factor of u^{th} user at time t, and TPCu (t) is the TPC command of u^{th} user at time t, corresponding to sign (SIRtarget-SIRest) in Equation 1, and PDF_u (t) is the Power Determining Factor. If the received message is High Contention Message, then it will increase the parameter and subsequently increases the power and if the message is Low Contention then the parameter will be decreased and correspondingly the power also.

b) *Adaptive call admission control algorithm*

Let P_t be the total power of the existing users in the network.

Let P_a be the total available power.

Let P_r be the power of the requested new user to get admission in the network.

1. Wait for call request arrival.
2. If a new call request arrives.
3. If it is a hand off call.
4. If $P_{t+} P_{r<} P_a$
5. Admit the request call.

else

6. If $P_{t+} P_{r>} P_a$
7. Degrade the existing users who are using Non real time services.
8. After degrading NRT services If $P_{t+} P_{r<} P_a$
9. Admit the request call.

else

10. If still $P_{t+} P_{r>} P_a$
11. Degrade the existing users who are using real time services.
12. After degrading RT services If $P_{t+} P_{r<} P_a$
13. Admit the request call.

else

14. If still $P_{t+} P_{r>} P_a$
15. Reject the requested call.
16. Else if it is new call repeat steps 4 to 15.

In the above algorithm priority is given for hand off request calls ,since handoffs are important then the new calls. The power of the existing users are degraded according to priorities . Here non real time services are degraded first when compared with real time services which leads to reduced loss for real time services. The existing users are degraded to a minimum power level till they maintain acceptable quality of service in the network.

Upgradation

If M are the out going calls in the network .The out going calls are the calls that are moved from current cell to the other neighboring cells. If N are the completed calls in the network. The total power used by the out going calls and completed calls in the network is $P_m + P_n$.

$P_{m=}$ power used by M out going calls in the network.

$P_{n.=}$ power used by N competed calls in the network.

The power levels are updated in the network .The power left by the M out going calls and N competed calls can be used by the existing users in the network.

IV. Simulation Results

a) *Simulation Setup*

In this section, We simulate the proposed adaptive call admission control (ACAC) algorithm for WCDMA cellular networks. The simulation tool used is NS2 which is a general- purpose simulation tool that provides discrete event simulation of user defined networks. In the simulation, mobile nodes move in a 600 meter x 600 meter region for 50 seco--nds simulation time. Initial locations and movements

of the nodes are obtained using the random way point (RWP) model of NS2. All nodes have the same tra --nsmission range of 250 meters.
The simulation parameters are given in table I.

Area Size	600 X 600
Number of Cells	2
Users Per Cell	20
Slot Duration	2 msec
Radio Range	250m
Frame Length	2 to 8 slots
CDMA codes	2 to 5
Simulation Time	50 sec
Routing Protocol	AODV
Traffic Source	CBR, VBR
Video Trace	JurassikH263-256k
Packet Size	512 bytes
MSDU	2132
Transmission Rate	1Mb,2Mb,…5Mb
No. of Users	2,4,6,8 and 10
SINR Threshold	5
Tx power,Rx power	0.66w,0.395w
Speed of mobile	25m/s

Table I. Simulation Parameters

b) *Performance Metric*
The performance is mainly evaluated according to the following metrics:
Throughput: It is the throughput received successfully, measured in Mb/s.
Average End-to-End Delay: The end-to-end-delay is averaged over all surviving data packets from the sources to the destinations.
Call Blocking Probability*:* It means the likelihood that a new arriving call is blocked. Actually, it depends on the CAC scheme.

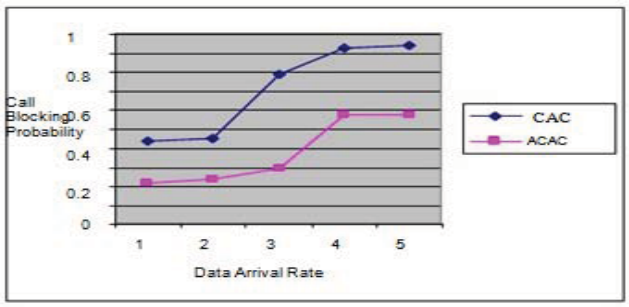

Figure1: Arrival Rate Vs Call Blocking probability

As shown in the figure 1 the call blocking probability of adaptive call admission control is less compared with non adaptive call admission control algorithm (CAC).H ere in ADCAC the users are degraded and the resource is given to the requesting users . CAC algorithm is not dynamic hence most of the resouce is wasted.

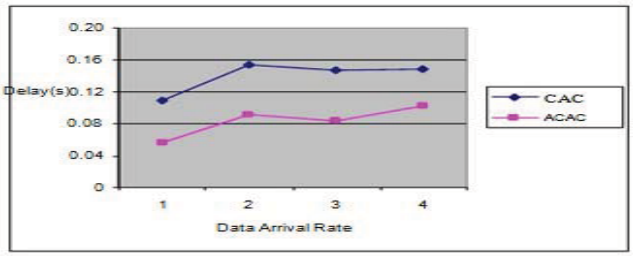

Figure2: Arrival Rate Vs delay

As shown in the figure 2 the delay of adaptive call admission control is less compared with non adaptive call admission control algorithm (CAC).Here in ADCAC more users are admitted in the network hence data can be transmitted sucessfully. where as in CAC algorithm of the resouce is not used efficiently the data is not transmitted sucessfully.

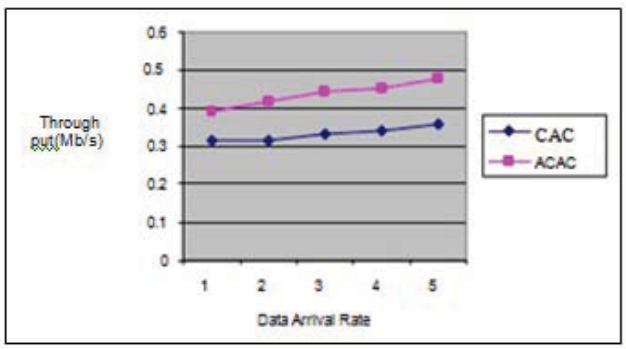

Figure3: Arrival Rate vsThroughput

As shown in the figure 3 the Throughput off adaptive call admission control is more compared with non adaptive call admission control algorithm (CAC).here in ADCAC the users as the resource is used efficiently the requesting users are admitted in the network with out delay . where as in CAC algorithm of the resouce is not used efficiently the users have to wait for getting admission in the network.

V. Conclusion

In this paper, a novel Call Admission Control algorithm for wireless cellular networks is proposed. The call admission control algorithm is based on power control. The existing users are degraded to a minimum power level till they maintain acceptable quality of service in the network and resource is utilised by the new requesting users. our proposed call admission control algorithm reduces the blocking probability increases the throughput.

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Evolutionary Computing and Second generation Wavelet Transform optimization: Current State of the Art

By S.Nagaraja Rao , Dr. M.N.Giriprasad

Abstract- The Evolutionary Computation techniques are exposed to number of domains to achieve optimization. One of those domains is second generation wavelet transformations for image compression. Various types of Lifting Schemes are being introduced in recent literature. Since the growth in Lifting Schemes is in an incremental way and new types of Lifting Schemes are appearing continually. In this context, developing flexible and adaptive optimization approaches is a severe challenge. Evolutionary Computing based lifting scheme optimization techniques are a valuable technology to achieve better results in image compression. However, despite the variety of such methods described in the literature in recent years, security tools incorporating anomaly detection functionalities are just starting to appear, and several important problems remain to be solved. In this paper, we present a review of the most well-known EC approaches for optimizing Secondary level Wavelet transformations.

Keywords: Evolutionary Computation (EC), Genetic Algorithms (GA), Image Compression, Lifting Scheme (LS), Evolutionary Algorithms (A), Evolutionary Programming (P), Interactive Evolutionary Computing (IEC) Interactive Genetic Algorithm (IGA).

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Evolutionary Computing and Second generation Wavelet Transform optimization: Current State of the Art

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Abstract- The Evolutionary Computation techniques are exposed to number of domains to achieve optimization. One of those domains is second generation wavelet transformations for image compression. Various types of Lifting Schemes are being introduced in recent literature. Since the growth in Lifting Schemes is in an incremental way and new types of Lifting Schemes are appearing continually. In this context, developing flexible and adaptive optimization approaches is a severe challenge. Evolutionary Computing based lifting scheme optimization techniques are a valuable technology to achieve better results in image compression. However, despite the variety of such methods described in the literature in recent years, security tools incorporating anomaly detection functionalities are just starting to appear, and several important problems remain to be solved. In this paper, we present a review of the most well-known EC approaches for optimizing Secondary level Wavelet transformations.

Keywords: Evolutionary Computation (EC), Genetic Algorithms (GA), Image Compression, Lifting Scheme (LS), Evolutionary Algorithms (EA), Evolutionary Programming (EP), Interactive Evolutionary Computing (IEC), Interactive Genetic Algorithm (IGA).

I. Introduction

Wavelets are used by several image processing applications, including JPEG2000 [14] and fingerprint compression, [15]. Discrete wavelet transforms (DWTs) can enormously reduce the number of bits required for representation by reproducing an image's energy into a set of several lower-resolution trend sub-images. Techniques like "Quantization (approximating a signal with a smaller number of bits)" and "Thresholding (setting all but the largest transform values to zero)" may bring about an extra compression. But the drawback with both these techniques is that they cause irrevocable information loss, since the mean squared error (MSE) of restored images increases proportionately. The only solution to this problem would be implementing "Evolutionary computation (EC)".EC is the technique which uses fitness-based selection and genetics-inspired operators to evolve remedies to a combinatorial optimization mission.

But the observed thing is that very few researchers have applied this technique to the wavelet domain. Grasemann and Mikkulainen[16] proposed a methodology for synthesizing new ideal reconstruction wavelets from an existing wavelet filter by combining a genetic algorithm (GA) with a lifting scheme. This method has improved presentation for certain classes of images.3 But neverthless, this genetic algorithm inflicts none of the mathematical properties required of wavelets, such as conservation of energy.

II. Evolutionary Computation (EC)

A representation plan of action is chosen by the researcher to define the set of solutions that form the explored space for the algorithm. To form an initial population a number of individual solutions have been designed. Until a remarkable solution is found this satisfies a predefined conclusion criterion these following steps have been repeated iteratively. Each individual is estimates by a fitness function which is specific to the problem being solved; a number of individuals are picked to be parents based on their fitness values. New individuals, or offspring, are produced from those parents using reproduction operators and the fitness values of those offspring are regulated. Finally, the survivors are selected from the old population and the offspring to form the new population of the later generation.

A selection method is concerned for determining which and how many parents are to be selected, how many offspring are to be generated, and which individuals will have to sustain into the later generation. Many different selection methods have been suggested in the literature but differ in complexity. The thing to be noted is that most selection methods make certain that the population of each generation is the identical size.

a) *Genetic algorithms and programming*

Genetic algorithm has become the most approved technique in evolutionary computation research. Fixed-length bit string is the representation

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used in the traditional genetic algorithm. Each position in the string is assumed to represent a particular feature of an individual, and the value stored in that location represents how that characteristic is expressed in the result. Usually, the string is "evaluated as a collection of structural features of a solution that have tiny or no interactions" [1]. The analogy may be drawn directly to genes in biological organisms. Each gene indicates an entity that is structurally independent of other genes.

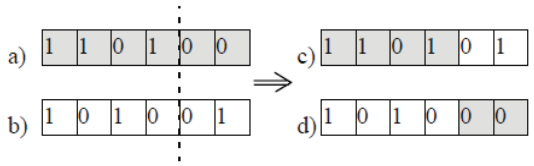

Fig 1: Bit-String Crossover of Parents a & b to form Offspring c & d

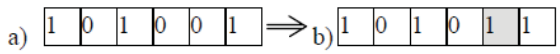

Fig 2: Bit-Flipping Mutation of Parent a to form Offspring b

Bit-string crossover is the main reproduction operator used in which two strings are used as parents and in between these two strings new individuals are formed by swapping a sub-sequence (see Figure 1). Bit-flipping mutation is an additional favoured operator in which a single bit in the string is flipped to create a new offspring string (see Figure 2). Several such variety of operators have also been evolved, but are used less frequently (e.g., inversion, in which a subsequence in the bit string is reversed). A chief difference may be made between the various operators is that they may or may not introduce any new information into the population. Crossover, for example, does not while mutation does. All operators are also prevailed to handle the string in a manner stable with the structural explication of genes. For example, two genes at the same location on two strings may be swapped between parents, but they are not merged based on their values. Traditionally, individuals are chosen to be parents probably supported on their fitness values, and the offspring that are produced replace the parents. For example, if N parents are chosen, then N offspring are generated, which replace the parents in the later generation.

"Genetic programming" is a popular technique that has been swiftly increasing. A variable-Sized tree of functions and values is the representation that is used in standard genetic program. Each leaf in the tree is a label from an available set of value labels and an each internal node in the tree is label from an available set of function labels.

The entire tree corresponds to a single function that may be evaluated. Typically, the tree is accessed in a leftmost depth-first manner and the leaf is accessed as the proportional value. A function is evaluated using as arguments for the consequence of the evaluation of its children. Genetic algorithms and genetic programming are indistinguishable in most except that the reproduction operators are outfitted to a tree representation. Sub-tree crossover is the most frequently used operator, in which an entire sub-tree is swapped between two parents as shown in figure 3. In a standard genetic program, all values and functions are assumed to return the same type despite the fact that the functions may vary in the number of arguments they take. This closure principle [2] allows any sub-tree to be considered structurally on par with any other sub-tree, and ensures that operators such as sub-tree crossover will always produce legal offspring.

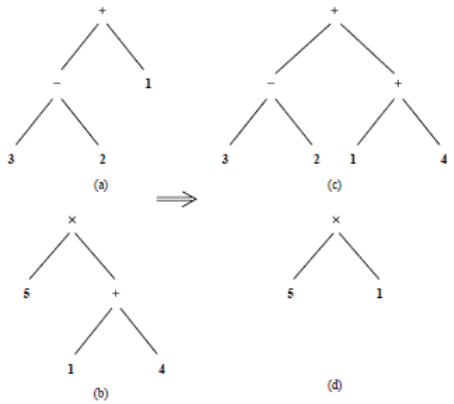

Fig 3: Subtree Crossover of Parents a & b to form Offspring c & d

b) *Strategic Evolutionary Programming*

Strategies

In evolutionary strategies, the representation used is a fixed-length real-valued vector. As with the bit strings of genetic algorithms, each position in the vector corresponds to a feature of the individual.

However, the features are considered to be behavioral rather than structural. "Consequently, arbitrary non-linear interactions between features during evaluation are expected which forces a more holistic approach to evolving solutions" [1].

To create a new offspring the main reproduction operator used in evolutionary strategies is that the "Gaussian mutation", in which a random value from a Gaussian distribution is joined to each element of an individual's vector [Fig 4]. Another operator that is used is intermediate recombination, in which the vectors of two parents are averaged together, element by element, to form a new offspring [Fig 5]. The effects of these operators have bounced the behavioral as opposed to structural interpretation of the representation since knowledge of the values of vector elements is used to derive new vector elements.

Fig 4: Gaussian Mutation of Parent a to form Offspring b

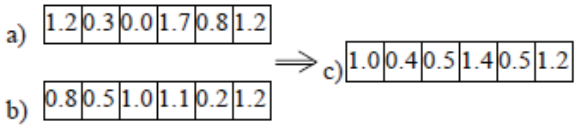

Fig 5: Intermediate Recombination of Parents a & b to form Offspring c

The selection of parents to form offspring is less constrained than it is in genetic algorithms and genetic programming. For instance, it is easy to average vectors from many individuals to form a single offspring due to the nature of the representation. In a typical evolutionary strategy, N parents are chosen uniformly randomly (i.e., not based upon fitness), more than N offspring are generated through the use of recombination, and then N survivors are chosen deterministically. The survivors are chosen either from the best N offspring (i.e., no parents survive) or produce the best N parents and offspring [3].

c) *Evolutionary Programming*

The representations used in evolutionary programming are typically tailored to the problem domain [3]. Fixed-length real-valued vector is one of the representation that is commonly used. The major difference between evolutionary programming and the preceding approaches is that there will be no exchange of material between individuals in the population made. Thus, only mutation operators are used. For real-valued vector representations, evolutionary programming is very similar to evolutionary strategies without recombination. The intension of a typical selection method is to select all the individuals in the population to be the N parents, to mutate each parent to form N offspring, and to probabilistically select, based upon fitness, N survivors from the total 2N individuals to produce the next generation.

d) *Evolutionary Algorithms*

Evolutionary algorithms (EA) are adaptive methods, which are used to solve, search and optimization problems, basing on the genetic processes of biological organisms. Charles Darwin in The Origin of Species first clearly stated that "over many generations, natural populations evolve according to the principles of natural selection and survival of the fittest". By mimicking this process, evolutionary algorithms are capable of evolving solutions to real world problems, if they have been suitably encoded [4].These are generally grouped under the term Evolutionary Algorithms or Evolutionary Computation, we also spot the domains of genetic algorithms [5,6], evolution strategies [7], evolutionary programming [8], genetic programming [2] and learning classifier systems. They all share a common conceptual base of pretending the evolution of individual structures via processes of selection, mutation, and reproduction. The processes depend on the recognized performance of the individual structures.

EA's deal with parameters of finite length, which are coded using a finite alphabet, rather than directly manipulating the parameters themselves. This means that the search is unconstrained neither by the continuity of the function under examination, nor the existence of a derivative function. Figure 6 represents the functional block diagram of a Genetic Algorithm (GA) and the various aspects are conversed below. It is assumed that a potential solution to a problem may be represented as a set of parameters. These parameters (known as genes) are joined together to create a string of values (known as a chromosome). A gene (also referred to a attribute, nature or detector) refers to a specific attribute that is encoded in the chromosome. The particular values that the genes can take are called its alleles. The position of the gene in the chromosome is its locus. Encoding issues deal with representing a solution in a chromosome and unfortunately, not atleast one technique works good for all troubles.

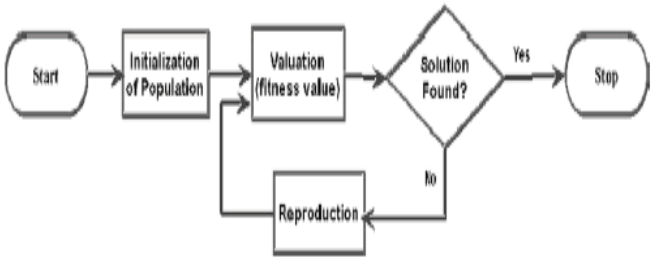

Fig 6: The functional block diagram of a genetic algorithm

There is a requirement for a fitness function that need to be devised for each problem to be solved. Given a particular chromosome, the fitness function returns a single numerical fitness or figure of merit, which determines the ability of the individual, which that chromosome indicates. Reproduction is the next critical attribute of GA's where two individuals selected from the population are allowed to mate to produce offspring, which will comprise the later generation. Having selected two parents, their chromosomes are recombined, typically using the mechanisms of crossover and mutation.

There are different ways in which crossover can be implemented. In a single point crossover two chromosome strings are cut at some randomly selected position, to produce two 'head' and two 'tail' segments. The tail segments are then swapped over to produce two new full-length chromosomes. Crossover is not generally applied to all pairs of individuals selected for mating. Another genetic operation is "Mutation", which

is an asexual operation that only operates on one individual. It randomly alters each gene with a small probability. The traditional view is that crossover is most desirable of the two techniques for rapidly exploring a search space. Mutation supplies a small amount of random search, and helps to ensure that no point in the search space has a zero probability of being examined. If the GA has been correctly implemented, the population will evolve over successive generations so that the fitness of the best and the average individual in each generation increases towards the global optimum. Selection is the survival of the fittest within GA's. It determines which individuals are to be survived to the later generation. Now coming to the selection phase it consists of three parts. The first part deals with the determination of the individual's fitness by the fitness function. A fitness function must be devised for each problem; given a particular chromosome, the fitness function returns a single numerical fitness value, which is proportional to the ability, or utility, of the individual represented by that chromosome. For many problems, deciding upon the fitness function is very straightforward. For example, for a function optimization search; the fitness is simply the value of the function. Ideally, the fitness function should be smooth and regular so that chromosomes with reasonable fitness are close in the search space, to chromosomes with slightly better fitness but it is not always possible to construct such ideal fitness functions. The second part involves converting the fitness function into an expected value followed by the last part where the expected value is then converted to a discrete number of offspring. Some of the commonly used selection techniques are 'Roulette wheel" and "Stochastic universal sampling". Genetic programming applies the GA concept to the generation of computer programs also. Evolution programming uses mutations to evolve populations. Evolution strategies incorporate many features of the GA but uses only real-valued parameters in place of binary-valued parameters. Learning classifier systems use GAs in machine learning to evolve populations of condition/action rules.

III. Evolution for Optimization

Evolutionary Computation (EC) [12] is a subfield of Artificial Intelligence (AI) which comprises of a sequence of biologically inspired search and optimization algorithms that progress iteratively better and better solutions. It involves methods inspired by biological evolution mechanisms such as reproduction, mutation, recombination, natural selection, and sustaining of the fittest. An Evolution Strategy (ES) [13] is one of the basic algorithms among Evolutionary Algorithms (EAs) that make use of a population of candidate solutions and bio-inspired operators to explore for a aimed solution. ES's are basically used for optimization of real-valued vectors. The algorithm operators are iteratively applied within a loop, where each run is said to be a generation (g), until a termination criterion is met. Variation is skilled by the so-called mutation operator. For real-valued search spaces, mutation is ordinarily performed by adding a normally (Gaussian) distributed random value to every component that is under variation. Algorithm 1 shows pseudo code description of a typical ES. One of the particular characteristics of ESs is that the individual step sizes of the variation operator for each coordinate (or correlations between coordinates) is presided by self adaptation (or by covariance matrix adaptation (CMAES) [14]). This self-adaptation of the step size σ, also known as mutation strength (i.e., standard deviation of the normal distribution), implies that σ is also included in the chromosomes, undergoing variation and selection itself (coevolving along with the solutions). The recognized versions of the ES are denoted by (μ/ρ, λ)-ES and ($\mu/\rho + \lambda$)-ES, where μ indicates the number of parents (parent population, Pμ), $\rho \leq \mu$ the mixing number (i.e., the number of parents involved in the procreation of an offspring), and λ the number of offspring (offspring population, Pλ). The parents are deterministically chosen from the set of either the offspring, referred to as comma selection ($\mu < \lambda$), or both the parents and offspring, referred to as plus selection. This selection is based on the ranking of the individuals' fitness (F) choosing the μ best individuals out of the whole pool of candidates. Once selected, ρ out of the μ parents (R) are recombined to produce an offspring individual (rl) using intermediate recombination, where the parameters of the selected parents are averaged or randomly chosen if distinct recombination is used. Each ES individual a := (y, s) consists of the object parameter vector y to be optimized and a set of strategy parameters s which evolve along with the solution (and are therefore being adapted themselves). This is a particular characteristic of ES called "self adaptation". For a general description of the ($\mu/\rho +$, λ)-ES, see [13].

(1) $g \leftarrow 0$
(2) Initialize $P_\mu^{(g)} \leftarrow \{(\mathbf{y}_m, \mathbf{s}_m),\ m = 1, \ldots, \mu\}$
(3) Evaluate $P_\mu^{(g)}$
(4) **while** not_termination_condition **do**
(5) **for all** $l \in \lambda$ **do**
(6) $\mathcal{R} \leftarrow$ Draw ρ parents from $P_\mu^{(g)}$
(7) $\mathbf{r}_l \leftarrow$ recombine $(\mathcal{R})$
(8) $(\tilde{\mathbf{y}}_l, \tilde{\mathbf{s}}_l) \leftarrow$ mutate $(\mathbf{r}_l)$
(9) $\mathcal{F}_l \leftarrow$ evaluate $(\tilde{\mathbf{y}}_l)$
(10) **end for**
(11) $P_\lambda^{(g)} \leftarrow \{(\mathbf{y}_l, \mathbf{s}_l),\ l = 1, \ldots, \lambda\}$
(12) $P_\mu^{(g+1)} \leftarrow$ selection $(P_\lambda^{(g)}, P_\mu^{(g)}, \mu, \ddagger)$
(13) $g \leftarrow g + 1$
(14) **end while**

Algorithm 1: $(\mu/\rho + , \lambda)$-ES.

IV. Adapting Wavelets Based on EC

Research on adaptive wavelets has been taking place during the last two decades. At first, dictionary-based approaches were used for the task. Coifman and Wickerhauser [9] select the best source from a set of predefined functions, modulated waveforms known as atoms, such as wavelet packets. Mallat and Zhang Matching Pursuit algorithm [10] uses a dictionary of Gabor functions by consecutive scalings, translations, and modulations of a Gaussian window function. It performs a search in the dictionary in order to find the best alike element (maximum inner product of the atom element with the signal). Later, the signal is decayed with this atom which leaves a residual vector of the signal. This algorithm is iteratively utilized over the residual up to n elements. The Matching Pursuit algorithm is capable to decompose a signal into a fixed, predefined number of atoms with arbitrary time-frequency windows. This gives a chance for a better level of adaptation than wavelet packets. These dictionary-based technologies do not generate new wavelets but just select the best blend of atoms to decompose the signal. In some cases, these methods were connected with EA for adaptive dictionary methods [11].

When the LS was put forward, new methods of building adaptive wavelets arose. One significant result is the one by Claypoole et al. [12] which used LS to adapt the prediction stage to lessen a data-based error criterion, so that this stage gets adapted to the signal formation. The revised stage is not adapted, so it is still used to protect wanted characteristics of the wavelet transform. The other area that is concentrated to bring the best reconstruction achievable without any overhead cost was suggested by Piella and Heijmans [13] that makes the update filter utilize local gradient data to adjust itself to the signal. In this research, a very remarkable analysis of the state of the art on the topic is covered. These succinct remarks on the present literature proposals explain the tendency in the research community which has importantly involved the adaptation of the transform to the local properties of the signal on the fly. This suggests an extra computational work to find out the singularities of the signal and, later, use the suggested transform. In addition, a lot of work has been brought to light on adaptive threshold techniques for data compression.

The work being reported on in this paper discusses about finding a complete new set of filters adapted to a given signal type which is equal to changing the whole wavelet transform itself. so, the general lifting framework still applies. This has the benefit of keeping the computational difficulty of the transform at a minimum (as defined by the LS) not being overloaded with additional filtering features to adapt to these local changes in the signal (as the transform is being performed).

Therefore, the review of the state of the art discussed in this section will concentrate on bio-inspired methodologies for the automatic design of new wavelets (or even the optimization of existing ones). This means that the classical meaning of adaptive lifting (as mentioned above) does not apply in this work. Adaptive, within the possibility of this work, refers to the adaptability of the system as a whole. As a result, this system does not adapt at run time to the signal being analyzed, but, in contrast, it is optimized before to the system operation (i.e., during a calibration routine or in a post fabrication adjustment phase).

V. Current State of the art in The Use of EC for Designing Image Transforms

Britny Herzog et al[17] proposed a satellite image compression technique in "Bio-Inspired Intelligent Satellite Image Compression". This paper demonstrates the technical feasibility of using evolutionary and bio-inspired optimization, for transmission of image data among unmanned aerial vehicles (UAVs) across band-width limited channels and to identify new coding and transform algorithms for optimized satellite data(e.g., image) communication (SATCOM). This research will optimize sets of transform defining filter coefficients optimized for satellite image processing. It seeks to develop new image compression algorithms that outperform the current state-of-the-art techniques for satellite image compression. The traditional wavelet algorithm currently employed in state-of-the-art signal processing systems replaces the optimized image compression algorithms.

Optimized transformers are compared with traditional wavelet-based transforms to determine the reduction in the number of bits required for robust transmission of satellite-captured images across narrow band width channels. Higher SATCOM capacity can be obtained without incurring costly hardware modifications by simply replacing the existing wavelet filter coefficients with optimized compression algorithms without altering the underlying transform algorithm. The project aims at identifying and evaluating two independent sets of satellite images which are used to develop and evaluate image compression algorithms. Next, these image sets are used to evaluate the performance of wavelet-based and optimized compression algorithms which can be the basis of comparison. Finally, a new methodology for optimizing image compression algorithms is to be devised, by exploiting the mathematical structure of wavelet-based compression techniques while leveraging the flexibility of bio-inspired optimization algorithms which enables the development of increasingly powerful satellite-based image algorithms that outperform the current state-of-the-art compression techniques. Modern signals and image processing applications often require the transmission of copious amounts of data over narrow band width channels and these require significant compression of data. Shannon's information entropy model places a theoretical limit on the possible rate of lossless compression for a given signal. Wavelets provide the basis of signal transformation in a wide range of signal processing tasks, such as image compression. Wavelets transform continuous or discrete time domain signals into a time frequency domain and they provide desirable properties for signal compression tasks. Wavelets conserve energy and redistribute the bulk of that energy to the "first trend" sub-signal. Quantization is the most common source of distortion in lossy image compression systems and it refers to the process of mapping each of the possible values of a given sampled signal y onto a smaller range of values Q(y). For many applications, quantization is the most significant source of distortion in digital images. The drawback is that, in critical applications of wavelets of military, security or medical imaging tasks, there is degradation in amount of quantization error which results in loss of information. This research aims at minimizing the loss of information at a given quantization level with the goal of improving image quality at a stated level of lossy compression required by a given signal processing application. The methodology includes collection of two independent sets of satellite images from a diverse range of subjects. Having obtained two robust image sets, the performance of various image compression techniques over each image at various levels of quantization noise is established. The quality of performance of the image compression algorithms over the entire image sets will be compared to one another using appropriate statistical hypothesis tests.

Observation: The use of bio-inspired optimization algorithms such as genetic algorithms to optimize a single set of coefficients defining either the forward or the inverse transform. Filters obtained under the proposed approach will more closely adhere to the properties of wavelets. The anticipated results include development of two robust satellite image sets, demonstration of evolutionary and bio-inspired techniques, robust methodology for image compression optimization and a novel approach for filters optimization.

In [18], the authors Yohei Katsuyama and Kaoru Arakawa discussed a new type of digital filter for removing impulsive noise from color images using interactive evolutionary computing. This new technique overcomes the drawback of median-type filters, which apart from reducing noise makes the image blurred. The method adopted by authors first detect image pixels on which impulsive noise is added on each RGB channel and interpolates the noisy signal component with some sort of weighted sum of the noiseless signal values around the pixels. Previously, the methods proposed by Taguchi et al. & Kerre et al. Used to cause less blur to image provided the noisy signals are correctly detected or else the performance gets highly degraded. The new filter discussed in this paper uses the interpolation technique proposed by Taguchi et al. In filtering phase, but the detection of noisy pixels is judged by a rule concerning the degree of peculiarity of the signals value and the relations among RGB colour components.

The phase of interpolation and then detection of noisy impulsive signal detection is described by the author in four phases as:-

Interpolation technique using colour correlation:

The interpolation technique expresses every image with colour component red(R), green (G), blue (B). Various variables are utilised by the author to use this technique on every pixel denoted by the matrix variables (i,j). The concepts of probability and mean distribution are applied over the contaminated component defined as x (i, j) by the relation:

X(i,j) = S(i,j) ; probability 1-p & h(i,j); probability p.

Where $h_c(i,j)$ denotes the noisy signal value on the channel *c.*

Rule to Detect Noisy RGB Components: For detecting the noisy signals precisely, authors employed two techniques, which are (1) analysis of the difference between the input pixel value and median of its nearby value, if the modulus of difference is large image is considered as noisy and (2) analysis of the dependency of image signals among RGB components, the degree

of correlation among RGB components of each signal is expressed with spatially adaptive neighbourhoods (SANs).

Noise detection using spatial adaptive neighbourhood (SAN):

For the noise detection using this technique firstly, the noisy pixels containing impulsive noise on at least one of the RGB channels is detected and then for a particular colour 'c' for a set of pixels (i,j) in the neighbourhood of (i_0,j_0)on a window sized *WSAN* x *WSAN* is checked for two conditions, which are (i)

$| x (i ,j) - x(i_0,j_0) | \leq \delta$ ---------(1)

where δ is a certain threshold.

(ii) any two pixels in SAN are spatially connected.

This particular set is operated under the union and intersection transformation and the number of elements in these sets are denoted by some variable say &J and |J. The value ΔJ is calculated as

$\Delta J = (|J-\&J) / \&J$ ---------(2)

The noisy signals are detected by the fact that when impulsive noise is added to each colour component randomly, the correlation becomes small and the SANs for RGB components become less overlapped.

A rule comes from this detection is quoted as:

Rule 1: If $(|J-\&J) \leq P\&$ or $\Delta J \geq P\Delta$, noise is added to the pixel.

Noise detection using Peculiarity of Signal Value: This method of detection is adopted as Rule 1 suffers from two drawbacks, as:-

It is effective on the basis of assumption that the RGB color components are always correlated.

It can judge the noisiness of the pixel (i, j), but it cannot determine which channel is noisy.

Hence, based on the peculiarity a second rule is defined which is opted if the rule 1 fails to overcome its drawbacks.

Rule 2:- If $|x_c(i j)- m_c(i j)| \geq Q$, noise is added to the pixel (*i,j*), otherwise not.

Optimization of Colour Image Noise reduction with IEC:

The interpolation technique seems for removing the impulsive noise, but the parameters P&, PΔ and Q is difficult to set such multiple parameters efficiently. The author apart from using quantitative criterions of some known training image data implies human subjective criteria which are significant for output image quality. In the application of IEC, each parameter are coded as a binary number and concatenated to make one sequence. The sequence is encoded as binary digit which hypothetically is correlated to the genetic algorithm. In this strategy first a set of M individuals are picked up to make a population and then image processing is done M times using M set of parameters P&, PΔ and Q corresponding to M individuals. Lastly, the user observes the M output images and select S satisfactory ones according to his/her taste and subjective criteria.

Observations: Hence, the techniques of interpolation described in the paper in combination of the IEC finds an optimized blend for the reduction of noise as well as maintaining the quality of output image.

The research paper "The Best Fingerprint Compression Standard Yet" proposed by Brendan Babb et al [19] describes how a genetic algorithm can outperform the 9/7 wavelet for fingerprint compression and reconstruction subject to quantization error. Genetic algorithm is used to evolve wavelet and scaling numbers for each level of a multi-resolution analysis (MRA) transform. It was demonstrated that four-level MRA transforms evolved at one quantization level actually perform across a range of quantization levels. This unexpected result provides users with a range of options: they may choose to use the evolved transforms at higher levels of quantization, without sacrificing the quality of reconstructed fingerprint images; or they may select the particular quantization level that results in the highest fidelity fingerprint images. This flexibility establishes evolved transforms as the best fingerprint compression standard yet. Modern fingerprint compression and reconstruction standards, such as those used by the US Federal Bureau of investigation (FBI), are based upon the 9/7 discrete wavelet transform. The evolved transforms also improve upon wavelets optimized by a genetic algorithm via the lifting scheme, and thus establish a new state-of-the-art in this important application area.

The discrete wavelet transforms are described by four sets of floating-point coefficients out of which h_1(Lo_D) and g_1(Hi_D) are the wavelet and scaling numbers for the forward discrete wavelet (decomposing) transform (DWT) while the other two i.e. h_2(Lo_R) dimensional DWT of a discrete input image **f** with M rows and N columns is computed by first applying the one-dimensional (1D) sub-band transform defined by the coefficients from sets h_1 and g_1 to the columns of **f**, and then applying the same transform to the rows of the resulting signal. A 2D DWT-1 is performed by applying the 1D DWT-1 defined by sets h_2 and g_2 first to the rows and then to the columns of a previously compressed signal.

Using the multi-resolution analysis (MRA) scheme, a one level DWT may be repeated as many as $k \leq \log_2 \{\min(M,N)\}$ times. The trend sub-image will typically be much larger than any of the fluctuation sub-images. A one-level DWT-1 is applied k times to reconstruct an approximation of the original M-by-N signal **f**. Quantization i.e., the process of approximating a given signal using a relatively small number of bits, allows digital images to be more easily compressed.

Quantization is essential for rapid transmission, processing and effective storage of massive data sets.

De-quantization step **Q-1(q)** produces an image **γ'** that differs from the original image **γ** according to a distortion measure **ρ.** Quantization is the most significant source of distortion in digital images in many applications. The drawback is that the performance of wavelets degrades in proportion to the amount of quantization error; for critical applications of wavelets to military, security, or medical imaging tasks, such error may be unacceptable. A total of four universities have investigated the possibility of using genetic algorithms (GAs). This paper summarizes state-of-the-art advances in fingerprint compression and re-constructive via evolved MRA transforms. The GAs used for this research was characterized by certain features like each GA run utilized a specific quantization level, the initial population consisted of M candidate solutions, test population consisted of a set of 80 fingerprint images, to name a few.

Observations: Under the improved error reduction, the primary goal of this project was to demonstrate that a GA could evolve a different set of coefficients for each level of an MRA transform that outperformed the 9/7 wavelet used by the FBI fingerprint compression standard. An equally significant result is that MRA transforms optimized for a selected quantization level performed even better than the 9/7 wavelet when both were subsequently tested at higher quantization levels. The evolved transforms are capable of greater compression than the 9/7 wavelet, without sacrificing the quality of the reconstructed image.

Tae-min Jung et al[20] proposed a research paper "Mobile Interface for Adaptive Image Refinement using Interactive Evolutionary Computing" on a new image refinement interface in mobile devices, since we cannot use the interfaces like Photoshop and Gimp, due to low computing power and small memory of mobiles phones. The proposed interface is based on IEC (interactive evolutionary computing).

We will conduct two experiments to show the feasibility of our new interface among which the first one will show how we will refine different images, and second will show how easy and convenient is to use new interface.

IEC helps us to generate user filters dynamically. This type of system provides an interface of twelve candidate images from which user can choose the most appropriate image. This system can also make same functions without pre knowledge of user about the system. The filters which are used in IEC are of three types which are algebraic filter, parametric filter and structured filters.

Algebraic filter uses input pixels information to generate an arbitrary mathematical function relation between input and output. A parametric filter uses parametric function to optimize their parameter. Structured filters uses algebraic or parametric filter to generate output.

Image filters actually uses mathematical functions to signals for refining an image. The IEC combines many predefined filters to refine an image.

We can also use brightness filter and contrast filter for image processing and by using them wecan also process analog image along with digital image. And also by the use of gamma curve and color operation filter we can change the moods of image.

Evolutionary image filter can be done by genetic algorithm which is used for performing some of the natural evaluation mechanism like mutation, crossover and survival of the fittest to optimization and machine learning.

Except fitness evaluation the IEC works on the same principle as of EC (evolutionary computing), as in IEC user has to evaluate fitness of each individual. Therefore, IEC can also be used to solve problems like graphic design, music composition and vision.

To optimize the parameters the use of IGA (interactive genetic algorithm) which is a kind of IEC takes place. So firstly, selection of k random individual takes place. By decoding process, the selected individuals are matched to a pre-defined image filter. First candidate images are generated through these filters. The next generation population is determined by the best candidate selected by user. Optimal solution is generated by GA through manufacture of chromosomes. This chromosomes use 64 bits to encode parameter of filters for brightness, contrast, gamma and color as each parameter need 8 bits for encoding. Parameters in chromosome are matched to pre-defined filters. The initial filters are combined with pre-defined filters such as brightness, color, gamma curve and contrast operation. The combined filters are faster than four different filters because of only one time retouching. It covers the low performance of mobile devices.

Next, user has to evaluate an image refined by filters; results of evaluation must be applied to the fitness of evaluation. Here two problems can occurs which can be first, human fatigue and next is, interface in mobile devices. These problems can be sorted out by using relative fitness evaluation which requires selection of the best refined pictures only one at the time of regeneration.

Relative fitness value is distance between filters, which is used to calculate similarity between a best refined image and other image, by this way the best image will survive during the process. It also offer simple inter face that require just one click on the best image.

Last thing is about settings of genetic algorithm for that we can use one point crossover and mutation. For that firstly, two individuals are selected as parents

and they generate their children through crossover and finally apply mutation. We can also apply elitism to find optimal solution fast. And filters for image refinement are generated. This process is repeated until we get the best retouched image.

The interface will display nine images from which one is parent image and others are the candidate image. We will consider the display size and ratio of image. Each one of them will represent the different moods from other image. User can compare different images with the original one. Instead of providing the external buttons for image evaluation we can provide eight clickable candidate images around the original image. The user can click the best image preference from the eight parent images. The system will retain the previous selected image to provide backup for the worst image than the previous one.

Observations: The proposed method is a novel which is proved by the subjective test. It has performed better than the other methods in SUS test. This method can be expanded in many ways i.e. by using other filter such as blur, sharpen and distort, thus the user can get high quality image in mobile devices.

Kaoru Arakawa and Kohei Nomoto[21] proposed model for removing random noise in images, a combination of several non-linear digital filters. A powerful tool for noise reduction of images contains multiple filter parameters which are difficult to be optimized. Image signals are non-stationary. Various kinds of non-linear filters have been proposed to reduce the noise reduction. A non-linear filter in which the parameters are optimized by interactive evolutionary computing (IEC) is proposed in this paper. A cascade nonlinear filter system and a conditional median filter is proposed, in which the parameters are determined by IEC. This thesis provides us with a method to optimize the nonlinear filter not quantitatively is proposed using IEC. When the noise is not small enough, a cascade of multiple ε−filters is effective for reducing the noise while keeping the abruptness of the signal. When the noise is larger, the cascade ε−filters is not powerful enough. The conditional medium filter puts out the median value in the filter window, if the input signal is contaminated with noise. This filter is especially effective for removing large-amplitude impulsive noise without degrading signal component. Moreover, image quality is evaluated not only by quantity, but also by subjective assessment by human. Thus, such subjective optimization is considered to be a powerful tool for image denoising. Moreover, the statistical characteristics of image signal and noise are usually not known. Computer simulations in image processing show the high performance of this system. Here the parameters are set at random in the initial stage, but in order to get the satisfactory result faster, a method to set initial values at appropriate ones can be considered.

Observations: A simple crossover and mutation are adopted in this paper, but the methods for generation change can be improved.

In [22] Michael R. Peterson, Gary B. Lamont, Frank Moore, and Brendan Babb employed genetic algorithms (GAs) to evolve image transforms that reduce quantization error in reconstructed signals and images. Defense research deals with image and signal processing. Wavelets form a standard methodology for signal compression algorithms. The discreet wavelet transform (DWT) redistributes energy in a signal by transforming a time signal into time-frequency domain. In a multi-resolution analysis (MRA), the DWT may be recursively applied a number of times to maximize the energy redistribution of the original image. The GA successfully improves image reconstruction both when evolving a single filter for all MRA levels and when evolving unique filters for each level of MRA wavelet decomposition. The resulting filters, evolved with one or more training images are no longer wavelets because they violate mathematical constraints. This paper focuses on evolving reconstruction filters to improve image quality in the presence of quantization error. The experiments in this paper are performed in two iterations. The GA employs an image quality measure as a fitness function to assess the performance of potential image transform filters. Wang's Universal Image Quality Index (UQI) and mean squared error (MSE) are the two image quality measures. Mean squared error (MSE) provides a simple statistical measure to estimate the error of one image as an approximation of another. Experiments evaluating recombination operators employ MSE during fitness evaluation. Authors employ the GA described using Marlab's Genetis Algorithm and Direct Search Toolbox. The initial GA population is created using a random initialization of each gene value in the range $-[1, 1]$ at each filter coefficient position. GA always uses the original db4 wavelet decomposition filter. These experiments compared the well- known non-uniform, Gaussian, and Cauchy mutation operators, as well as a local operator designed specifically for the evolution of image transform filters. The non-uniform mutation operator was described by Michalewicz. Gaussian mutation will be employed as the mutation operator in the present experiments comparing and evaluating various recombination operators. Experiments compare the performance of real-coded GAs (RCGAs) using recombination operators. The blend crossover (BLX), which provides an acceptable performance, creates a child within a hypercube connecting two parents. The simulated binary crossover (SBX) provides self-adaptive search for RCGAs. FR and SBX operators provide the best performance under the global search conditions. The parent normal crossover (PNX) operator creates new genes from parent genes using a Gaussian distribution scale but fails to identify acceptable

reconstruction filters. Experiments assess the GA performance using only Gaussian mutation, with no crossover. The uniform crossover operator provides better performance though it fails to match the performance of the SBX, BLX, and operators.

Observations: The next step in this research will be to evaluate additional advanced crossover operators for real-valued recombination, such as the "unimodal normal distribution crossover" (UNDX) or the parent-centric crossover (PCX). GA is aid in the development of defense system algorithms.

The other considerable proposals are, Jones et. al [23] use genetic programming to define and evolve a lifting-based wavelet scheme and classifier for one-dimensional signal classification. Grasemann and Miikkulainen [24] use a GA to control the design of a lifting-based wavelet for signal compression. Moore [25] describes a real-coded GA to replace DWT filter coefficients for the reconstruction. Voight et. al [26] presented the fuzzy recombination (FR) operator which provide a tradeoffs between exploitation and exploration in the search space. Bruckmann et. al [27] employ a binary GA to evolve subband structures for wavelet packet based image compression. Rani and Renganathan [28] configure a self organizing map (SOM) with a GA that, taken with a wavelet-based filter, provides robust image texture classification.

VI. Conclusions

In this paper, we emphasized the utilities of Evo-lutionary Computation techniques in various domains to achieve optimization. The optimization of second genera-tion wavelet transformations used for image compressi-on has been explored and various types of Lifting Schemes were introduced in recent literature. It is conclu-ded that Evolutionary Computing based lifting scheme optimization techniques are a valuable technology to achieve better results in image compression. In this pa-per, we presented a review of the most well-known EC approaches for optimizing Secondary level Wavelet transformations.

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FMEA and Fault Tree based Software Safety Analysis of a Railroad Crossing Critical System

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Abstract- Software for safety-critical systems must deal with the hazards identified by safety analysis in order to make the system safe, risk-free and fail-safe. Certain faults in critical systems can result in catastrophic consequences such as death, injury or environmental harm. The focus of this paper is an approach to software safety analysis based on a combination of two existing fault removal techniques. A comprehensive software safety analysis involving a combination of Failure Modes and Effects Analysis (FMEA) and Fault Tree Analysis (FTA) is conducted on the software functions of the critical system to identify potentially hazardous software faults. A prototype safety-critical system - Railroad Crossing Control System (RCCS), incorporating a microcontroller and software to operate the train on a track circuit is described.

Keywords: *Software safety, safety-critical systems, software faults, software safety analysis.*

GJCST Classification: *K.4.1, J.7*

Strictly as per the compliance and regulations of:

FMEA and Fault Tree based Software Safety Analysis of a Railroad Crossing Critical System

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Abstract- Software for safety-critical systems must deal with the hazards identified by safety analysis in order to make the system safe, risk-free and fail-safe. Certain faults in critical systems can result in catastrophic consequences such as death, injury or environmental harm. The focus of this paper is an approach to software safety analysis based on a combination of two existing fault removal techniques. A comprehensive software safety analysis involving a combination of Failure Modes and Effects Analysis (FMEA) and Fault Tree Analysis (FTA) is conducted on the software functions of the critical system to identify potentially hazardous software faults. A prototype safety-critical system - Railroad Crossing Control System (RCCS), incorporating a microcontroller and software to operate the train on a track circuit is described.

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I. Introduction

A safety-critical system is one that has the potential to cause accidents. Software is hazardous if it can cause a hazard i.e. cause other components to become hazardous or if it is used to control a hazard. Software is deemed safe if it is impossible or at least highly unlikely that the software could ever produce an output that would cause a catastrophic event for the system that the software controls. Examples of catastrophic events include loss of physical property, physical harm, and loss-of-life. Software engineering of a safety-critical system requires a clear understanding of the software's role in, and interactions with, the system [1,2].

a) *Software-induced failures in real-life*

Computers are increasingly being introduced into safety-critical systems and, as a consequence, have been involved in accidents. Some well known incidents are the massive overdoses given by the computer-controlled radiation therapy machine Therac-25 [3] with resultant death and serious injuries, during the mid-eighties; European Space Agency's Ariane 5 rocket explosion [4] during lift-off in June 1996, and SeaLaunch rocket failure [5] during lift off in March 2000. Recent examples include the following: on 7 October 2008, Qantas Flight 72 from Singapore to Perth made an emergency landing following an inflight accident featuring a pair of sudden uncommanded pitch-down manoeuvres that resulted in serious injuries to many of the occupants. The Australian Transport Safety Bureau (ATSB) said that incorrect information from the faulty computer triggered a series of alarms and then prompted the Airbus A330's flight control computers to put the jet into a 197-metre nosedive [6].

All these examples indicate that accidents still take place despite all the measures taken to prevent them. Since complete elimination of unforeseen hazards is not always possible, what we need is a fail-safe design which, in the event of a failure, allows the system to fail in a safe way, causing no harm or at least the minimum level of danger. To meet the fail-safe requirements, rigorous safety analysis is required to identify potential hazards and take corrective measures during the entire system development life cycle.

There are many software fault removal techniques in literature. The most frequent classification is by differentiating between static and dynamic techniques [8]. Different authors focus on probabilistic based approaches (like the Markov modeling method), or statistical, approaches like statistical testing, software reliability models [9]. However most of the fault removal techniques are non-probabilistic. In some standards, static techniques require formal methods and proofs based on mathematical demonstrations. Other standards and literature classify these techniques in functional and logical terms [10] or by just mentioning functional testing like in [11] or structural testing, like in [12].

None of the fault removal techniques like algorithm analysis, control flow analysis, Petri-Net analysis, reliability block diagrams, sneak circuit analysis, event tree analysis, FMEA and FTA can be considered apt and complete in all respects, when used in isolation. A way out of this is to analyse how to combine individual techniques so that the fault removal process is significantly improved. One of the most effective combinations is FMEA+FTA. The literature [9,10] already mentions that FTA technique can be associated effectively with other practices like FMEA. Their greatest advantage is in combination with each other. FMEA concentrates in identifying the severity and criticality of failures and FTA in identifying the causes of faults. FMEA technique is a fully bottom-up approach

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and FTA has a fully complementary top-down approach. Moreover, these two techniques are directly compatible with system level techniques.

In this paper, we propose a system-level approach to software safety analysis for critical systems that combines two existing fault removal techniques – FMEA and FTA to identify and eventually remove software faults at successive software development phases. We have applied our safety approach to a model railroad crossing control system to validate its effectiveness. We also compare how the safety-specific software development of a critical system is distinct from the traditional non-safety-specific software development.

The rest of this paper is organized as follows: section 2 describes the Railroad Crossing Control System (RCCS). Section 3 applies the safety analysis using SFMEA and SFTA techniques to RCCS. Section 4 addresses the hardware and software development issues of RCCS. Section 5 presents an analysis of the experimental results and section 6 concludes the discussion.

II. Railroad Crossing Control System (RCCS)

Crossing gates on a full-size railroad are controlled by a complex control system that causes the gates to be lowered to prevent access to the crossing shortly before a train arrives and to be raised to allow access to resume after the train has departed. RCCS is a prototype, real-time, safety-critical railroad crossing control system composed of several software-controlled hardware components.

a) *RCCS Interfaces*

The main interfaces of the microcontroller, which hosts and runs the embedded software, are shown below in Figure 1. The main inputs to the microcontroller are signals from the 7 sensors on the track, the 2 gates at the railroad intersection, the track-change lever, and the 3 signal lights. The main outputs of the micro-controller are control signals for the train, Gate1 Gate 2, track change lever, signal lights, LCD display. The values of these output signals are determined using different algorithms combining the input signals that are constantly updated and read by the software.

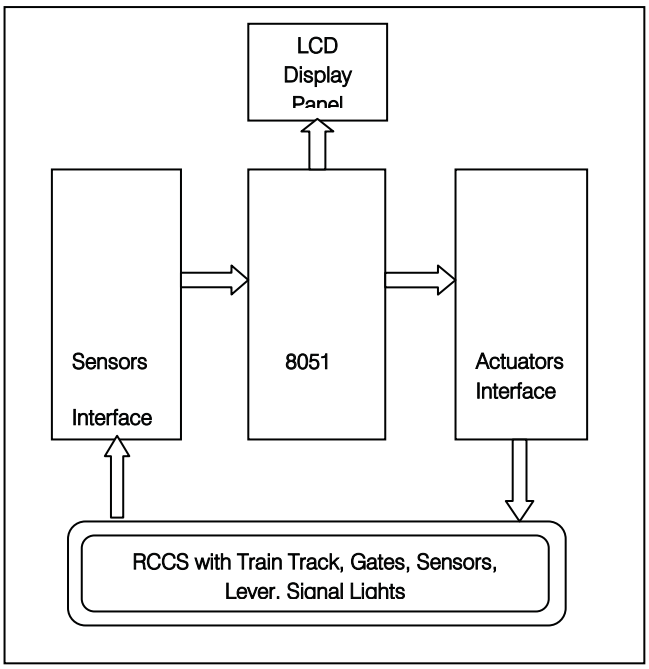

Figure 1. External interfaces of RCCS microcontroller

The main functionality of RCCS is listed in Table 1.

Table 1. RCCS System Functions – Key Areas

RCCS System Functions
• Control the overall operation of train on the track circuit
• Control the opening and closing of Gate 1 and 2 at the railroad intersections
• Control the track lever to change the track route from the outer to the inner loop
• Check the internal health of all the subsystems
• Control the train operation at the Signal Lights
• Monitor all the sensors on the track circuit

III. Safety Analysis of RCCS

The safety analysis of RCCS software functions takes place in three sequential steps.

- **Software Failure Mode and Effects Analysis (SFMEA)**

This analysis is performed in order to determine the top events for lower level analysis. SFMEA analysis will be performed following the list of failure types. SFMEA will be used to identify critical functions based on the applicable software specification. The severity consequences of a failure , as well as the observability requirements and the effects of the failure will be used to define the criticality level of the function and thus whether this function will be considered in further deeper criticality analysis. The formulation of recommendations of fault related techniques that may help reduce failure criticality is included as part of this analysis step.

- **Software Fault Tree Analysis (SFTA)**

After determining the top-level failure events, a complete Software Fault Tree Analysis shall be performed to analyse the faults that can cause those failures. This is a top down technique that determines the origin of the critical failure. The top-down technique is applied following the information provided at the design level, descending to the code modules . SFTA will be used to confirm the criticality of the functions (as output from SFMEA) when analyzing the design and code (from the software requirements phase, through the design and implementation phases) and to help:

- Reduce the criticality level of the functions due to software design and / or coding fault-related techniques used (or recommended to be used)
- Detail the test-case definition for the set of validation test cases to be executed.

- **Evaluation of Results**

The evaluation of the results will be performed after the above two steps in order to highlight the potential discrepancies and prepare the recommended corrective measures.

a) *SFMEA Analysis of RCCS*

The SFMEA, a sample of which is shown in the Table 2 below presents some software failure modes defined for RCCS. The origin and effects of each failure mode are analyzed identifying the top level events for further refinement, when the consequence of this failure could be catastrophic for this system. Three top events were singled out for further analysis of failure mode Gate not closed as train is passing through railroad intersection.

b) *SFTA Analysis of RCCS*

The fault tree is a graphical representation of the conditions or other factors causing or contributing to the occurrence of the so-called top event, which normally is identified as an undesirable event. A systematic construction of the fault tree consists in defining the immediate cause of the top event. These immediate cause events are the immediate cause or immediate mechanism for the top event to occur. From here, the immediate events should be considered as sub-top events and the same process should be applied to them. All applicable fault types should be considered for applicability as the cause of a higher level fault. This process proceeds down the tree until the limit of resolution of tree is reached, thereby reaching the basic events, which are the terminal nodes of the tree. Figure 2 shows the sample fault tree for the top event Gate Not Closed at the railroad intersection.

Table 2. Example of SFMEA table for RCCS

Failure Mode	Possible Causes	Effect	Severity of risk	Prevention And Compensation
Gate not closed as train is passing through	a) sensor not detected by s/w b) gate motor mechanism is defective c) s/w gives wrong command d) s/w gives right command at wrong time	Train collision with passing road traffic leading to accidents	Critical	Software first checks the working status of gates each time the train is about to cross the gates
Track change lever is not activated to change train route	a) sensor is not detected by s/w b) track lever motor mechanism is defective c) s/w gives wrong command to lever d) s/w gives right command at wrong time e) s/w fails to give a command to activate lever	Train fails to change its path from the outer track circuit to the inner track circuit leading to accident	Critical	Software first checks the working status of the track lever each time the train is about to enter the inner track loop
Control program software is corrupted	a) logic fault b) interface fault c) data fault d)calculation fault e) memory fault	Unpredictable sequence of operations leading to accident	Critical or Catastrophic	algorithm logic is verified for accuracy. Data Structures and Memory overflow is checked.

c) *Recommendations to Design and Coding*

From the safety analysis we have conducted, the major critical events that might occur and the corresponding safety properties the RCCS software has to implement, and which are controlled by the embedded software in the microcontroller are listed below.

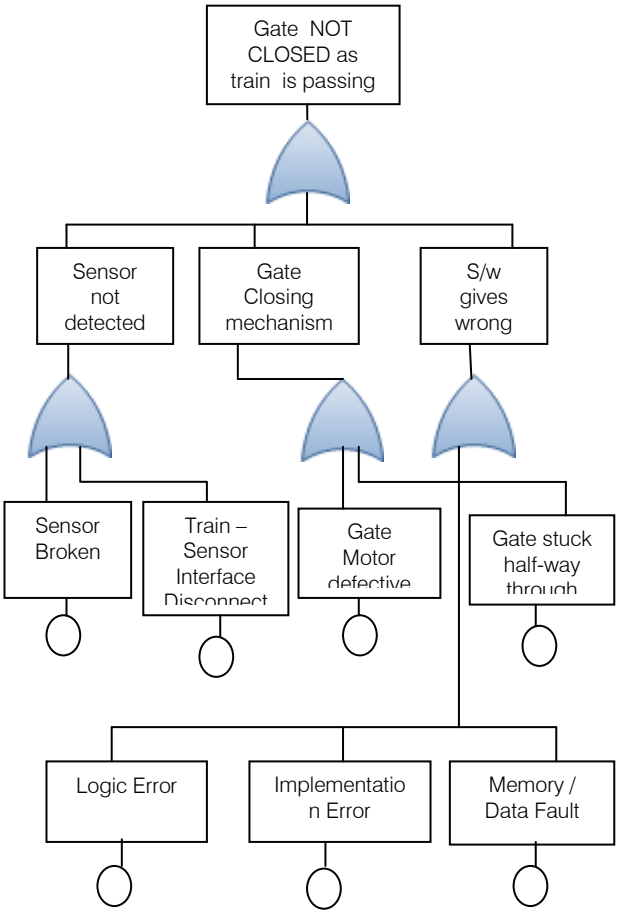

Figure 2. Software Fault Tree sample for top event Gate Not Closed at the railroad intersection

- The software shall make sure that the 2 gates on either side of the railroad intersection operate correctly – ie. opening and closing the gates, at the proper time. The consequences of failure to do so are very severe, since it can result in the train and road traffic collision, leading to death.
- The software shall make sure that the train changes its path from the outer track circuit to the inner track circuit by correctly operating the track change lever at the right time. Failure to do so can have severe consequences leading to collision with another train that may be stationary on the outer track.
- The software shall prevent the running operation of the train if it detects that the gates at the intersection have not been fully closed.
- The software shall prevent the running operation of the train, if the train engine detects any physical obstacle just ahead of it, either at the mid-section of the railroad intersection or at any point on the track path, just ahead of the engine. Failure to do so can lead to collisions.
- The software shall prevent the running operation of the train if a Red signal is displayed in the Signal Light alongside the track. Failure to do so can lead to accidents.
- The software shall prevent the running operation of the train if the train engine is not able to confirm that a green signal has been given to it, to resume running after a previous red signal to stop running.
- The software shall bring the running train to a halt at the location designated as railway station platform, on the track, after every cycle of operation around the track. Failure to do so can cause collision with another train that is passing just ahead on the same track.
- The software shall receive accurate data input values from the various sensors. If even slightly inaccurate data values are provided, it may have dire consequences
- The software shall monitor the internal health of all the subsystems – gate operation motors, track lever operation motor, signal lamps, sensor connectivity etc. before the start of train operation.

IV. RCCS Development

RCCS hardware and software development is described in this section.

a) *RCCS Hardware Components*

RCCS model, shown in Figure 3, consists of the following main components: train, railway track, sensors, gates, microcontroller, signal lights, and a track-change lever. A brief description of each component is given below.

Train: The train is powered by a power supply relay. When the power is initially switched on, the train begins movement along the track when the metallic wheels of the train receive power. The train comes to a halt at the position where the power to the tracks is switched off.

Sensors: These are used to detect the location of the train on the tracks. Altogether RCCS employs seven sensors. Two pairs of sensors detect the train position before and after the gates. A set of two sensors relate to track change where the track splits into two directions. One sensor gives the train position with reference to the platform, which is the starting point of the train movement. Information from each of the sensors is passed to controller.

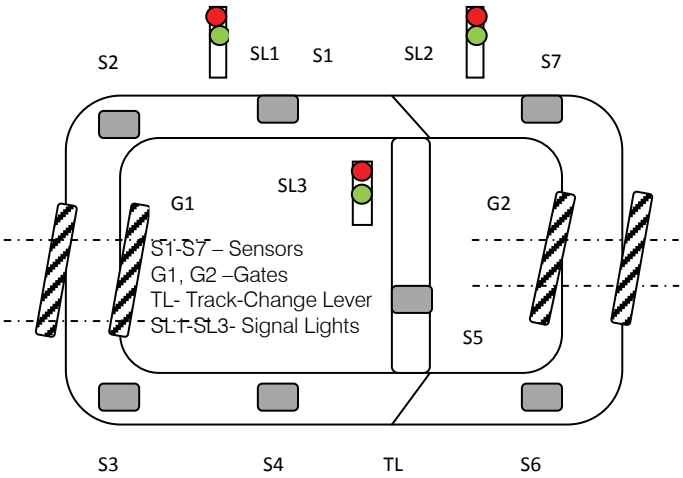

Figure 3. RCCS Track Layout with sensors, gates, track-change lever and signal lights

Controller: An 8051 is used as a controller for RCCS. RCCS software that controls the overall operation of the system is stored in the memory of the controller. The controller continuously monitors the sensors and controls the gate actuators, track change lever, and the signal lights.

Gates: RCCS has two sets of gates on either side of the track layout. The gate receives signals from the controller. When it receives *lower* command, arms of the gate moves down and close the gate, preventing the road traffic at the intersection. When the gate receives *raise*, it moves up allowing the traffic to pass through. The gates are operated by means of a motor-based mechanism.

Signal Lights: RCCS contains three train signals, erected beside the track. One signal is at the platform to signal a halt at the platform. The other two signals are placed just before the point of convergence of the inner track and outer track, which lead to the platform.

b) *RCCS Software Development*

The safety-specific version of RCCS controller program used the same techniques as the non-safety version with the addition of the following safety-specific analysis: preliminary hazard analysis, and design-level hazard analysis, FMEA and FTA analyses. These techniques target the specification and designs. The goal here is to determine if the inclusion of these methods reduces the number of latent safety-critical faults relative to non-safety specific methods.

The software safety-based development involves preliminary software hazard analysis, which among other things identifies software hazards, ie. the states in the software that can lead to an accident. Without identifying the hazards, we have little assurance that the hazards will not occur. Therefore, preliminary software hazard analysis is an important first step in verifying safety-critical software systems. Once the hazard list exists, the verification process can continue by applying several static and dynamic verification techniques. Static techniques include failure modes and effects analysis (FMEA), and fault-tree analysis (FTA).

After static verification, software engineers must dynamically verify the software's safety (ie. safety testing). Safety-critical testing of RCCS can be done by separating the code into two risk groups. Group one includes hazards that are catastrophic or critical. Group two includes hazards that are marginal or negligible. More testing effort should be spent on those code sections dealing with hazards related to group one.

V. Experimental Results & Analysis

In view of the comprehensive safety analysis, and specification and implementation the safety properties during RCCS design and development, the expected result was that safety-specific RCCS development would produce a software system with fewer latent safety-critical faults than traditional non-safety specific techniques alone. This is due to the belief that the safety-specific techniques will prevent safety-critical faults in the specifications and designs that the traditional techniques have a tendency to miss. Figure 4 shows the RCCS laboratory prototype developed in the lab.

During the operation of RCCS, the safety-specific development version of RCCS clearly demonstrated the fulfillment of the safety properties. For example, if the gate at the railroad intersection is not closed at all, or partially closed, as the train is about to pass through the intersection, the controller software makes the train come to a halt. Only after confirming that the gate is fully closed does the software allow the train to pass through the railroad intersection. On the other hand, in the non-safety version of RCCS, the controller software allows the train to pass through the intersection without confirming whether the gate is actually closed or not, assuming that the gate function will operate without failure, leading to a major accident.

Likewise, in the safety-version of RCCS, when the train is changing its track route from the outer loop to the inner loop, the software first confirms whether the track change lever is fully activated and operational. If the track lever is stuck halfway through and the rails connection to the inner loop is incomplete, the software makes the train come to a halt. In the case of the non-safety version, the software allows the train to change route without confirming the health status of the track lever, leading to an accident. The safety version also demonstrated a preliminary check of the internal health of all the RCCS subsystems – the gates mechanism, track lever operation, sensors, signal light LEDs, displaying the health status on the LCD display panel.

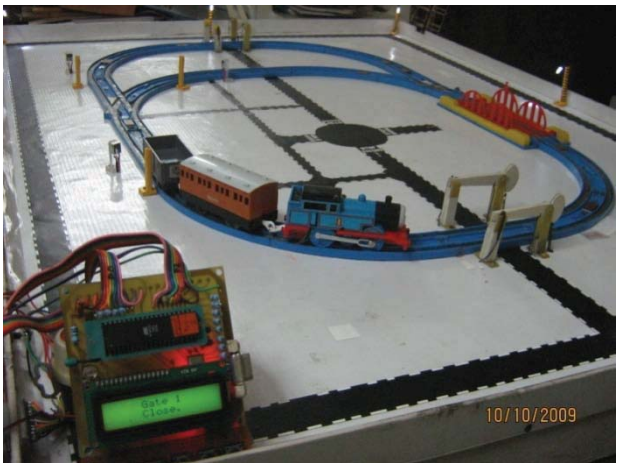

Figure 4. Laboratory prototype of RCCS

VI. Conclusion

This paper discussed a FMEA and Fault Tree based approach to software safety analysis for critical systems. A comprehensive software safety analysis involving a combination of FMEA and FTA techniques was conducted on the software functions of the critical system to identify potentially hazardous software faults. The safety properties of the prototype railroad crossing control system were identified as part of the safety-critical requirements. These safety requirements were incorporated in the design and development of a railroad crossing control system (RCCS). We also briefly compared safety-specific and non-safety specific techniques at developing RCCS. The non-safety version of RCCS broadly focused on achieving the functional behavior of the system. The safety-specific version clearly demonstrated that the software safety properties identified in RCCS specification were fully met in the working system.

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Agents as Tools for Solving Complex Control Problems

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Abstract- Modern control systems must cope with significant degrees of uncertainty, as well as with more dynamic environments, and to provide greater flexibility. This complexity requires to employ the efficacy of the agent-oriented software engineering approach. Agents and multi-agent systems are becoming a new way to analyze, design and implement complex software systems, since the focus of an agent-based approach is on goals, tasks, communication and coordination. The aim of this paper is to present agents as tools that enhance the design for solving complex control problems. In this paper, we will argue that analyzing, designing, and implementing control complex software systems as a collection of interacting, autonomous, flexible components (i.e., as agents) affords software engineers several significant advantages over contemporary methods. A case study in the domain of control process is treated where the experiences of using an agent-based approach is assessed. A case study will be given to demonstrate this design method. Our purpose is to design a power intelligent management system that is able to fulfill the user comfort and minimize the consumption of the fuel of the generator. It is based on the concepts of an agent and a multi-agent systemhere.

Keywords: *Control agent, multi-controller systems, control agency, coordination obect.*

GJCST Classification: *I.2.11*

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Agents as Tools for Solving Complex Control Problems

Alketa Hyso[α], Betim Çiço[Ω]

Abstract- Modern control systems must cope with significant degrees of uncertainty, as well as with more dynamic environments, and to provide greater flexibility. This complexity requires to employ the efficacy of the agent-oriented software engineering approach. Agents and multi-agent systems are becoming a new way to analyze, design and implement complex software systems, since the focus of an agent-based approach is on goals, tasks, communication and coordination. The aim of this paper is to present agents as tools that enhance the design for solving complex control problems. In this paper, we will argue that analyzing, designing, and implementing control complex software systems as a collection of interacting, autonomous, flexible components (i.e., as agents) affords software engineers several significant advantages over contemporary methods. A case study in the domain of control process is treated where the experiences of using an agent-based approach is assessed. A case study will be given to demonstrate this design method. Our purpose is to design a power intelligent management system that is able to fulfill the user comfort and minimize the consumption of the fuel of the generator. It is based on the concepts of an agent and a multi-agent systemhere.

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I. Introduction

Nowadays multi-agent system (MAS) technology is being used for a wide range of control applications including scheduling and planning [1], diagnostics [2], condition monitoring [3], distributed control [4], hybrid control [5], congestion control [6], system restoration, market simulation [7], network control [8], and automation. MAS is exploited in two ways [9]: as an approach for building flexible and extensible hardware/software systems, and as a modeling approach. We note an interesting link between the desirable properties of intelligent control systems for complex autonomous systems and the behaviour of agent-based systems. Many benefits are derived from the characteristics of the agents reactivity, proactiveness, and social ability. An interesting issue of solving practical control problems is that they are generally not solved by using one technique. So, in general, they are solved by using multiple, heterogeneous models and multiple heterogeneous design techniques, while taking into account multiple control objectives. Agents have been proposed as enhanced controllers with features useful for fulfilling the new flexibility, availability and changeability requirements [10, 11, 12]. Agents have been considered as goal-oriented, semi-autonomous controllers in a distributed control system. They are expected to coordinate control operations both in normal and abnormal situations. In control functions the overall role of agents has usually been proposed to be decision making concerning actions in one controller and coordination of these decisions with other controllers.

This paper begins by describing essential concepts of multi-agent systems that are related to the control systems and presents why multi-agent systems are being used for a number of control engineering applications. Section 3 discusses the essence of a controller agent and section 4 - the application. Finally, the paper presents some conclusions. We represent a qualitative analysis to provide why agent-based systems are well suited for solving complex control problems. It proceeds from the standpoint of using agents as tools for designing multi-controller systems.

II. Agents in Control Engineering Applications

Multi-agent system is investigated as a new approach for control systems modeling and implementation. Why agents technology is supposed appropriate for control engineering application?

There are many control engineering applications that flexible and extensible solutions are useful for them. Agents can provide a way for building such systems. Wooldridge [13] extends the definitions of an agent to an intelligent agent by extending the definition of autonomy to flexible autonomy. This is the ability to respond to dynamic situations (environment) correctly, to select the most proper actions from a set of actions. Extensibility implies the ability to easily add new functionality to a system, or upgrading any existing functionality [9]. The agent framework provides the functionality for messaging and service location, it means that new agent integration and communications are handled without effort from the system designer

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[14]. This creates extensible systems: extra functionality can be added by deploying new agents in system, and some parts of systems can be upgraded by deploying a replacement agent and removing the old one.

Across many applications in control engineering there is also a requirement for the distribution of the controller elements throughout the system; so each component is controlled by one or more controllers. The agent platform is adequate for distributed systems. Agents own the properties to produce this quality. An agent is separate from its environment, it means that it can be placed in different environments and still has the same goals and abilities. This means that the same set of agents can be deployed on one computer, and alternatively on multiple networked computers, without modifying or changing the agent code [14].

Fault tolerance is another requirement in many applications in control engineering. The flexibility offered by an open architecture of agents with social ability will provide a tolerance to physical faults. Agents use their own localized knowledge for decision-making, supplementing this with information gained by communication with other agents. Remaining independent of any kind of centralized control at while taking a local view of decisions gives rise to a tendency for robust behavior.

Adopting an agent-oriented approach to software engineering means decomposing the problem into multiple autonomous components that can act and interact in flexible ways to achieve their set objectives [15]; from a control perspective, this view of software systems has several similarities to work on hierarchical systems in distributed control.

Practical control systems generally are systems that consist of multiple control algorithms. Each control algorithm is designed to fulfill a particular task. In general, each control subproblem is different in nature and requires a particular design method for its solution. Also, each subset of controller modules requires a different combining technique. The agent-based framework is suitable and can be used to design and implement hierarchical structured multi-controller systems that consist of a set of heterogeneous control algorithms that are combined by heterogeneous techniques [16].

It is for these reasons that we consider an agent-based system to be a suitable model on which to base an intelligent control system for complex systems.

III. The Essence of a Controller Agent

A special role in the theory and tools for solving complex control problems is attributed to the concept of an agent [17, 18, 19]. An agent represents an abstract entity that is able to solve a particular (partial) problem. Conflict between agents, which naturally arise in such systems due to the dependencies between the partial problems the agents solve, are handled by properly coordinating the agents' activities. Agents can be combined into a multi-agent system, such that the overall multi-agent system is able to solve a more complex problem. Combining the concepts of a local controller and an agent has resulted in a so called controller-agent. 'A controller-agent is a local controller that is responsible for the initialization and finalization of its state variables, has knowledge about its operating regime and has an interface to coordinate its behavior with other controller-agents' [20].

Two different ways can be imagined to combine controllers and agents. The first way is to design a controller for the sense-think-act mapping of a particular agent. The controller becomes the architecture of the agent. Another way is to use agents for execution of control algorithms. A controller would consist of several agents, each becoming active and producing control signals under particular operating conditions of the controlled plant.

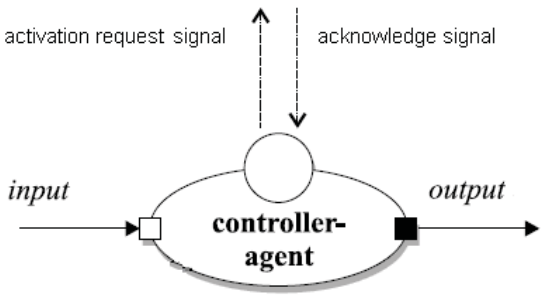

Fig 1. The architecture of a controller – agent

When constructing a multi-controller an important organizational design issue is to determine the entity or functional unit that will be responsible for each of these functions - the local control algorithm to calculate the control signals, the local operating regime of the local control algorithm in order to decide when to (de)activate the local controller, and initialization and finalization functions to initialize and finalize state variables of the local control algorithm.

Agent theory, however, suggests a different organization, [16] i.e., to include all functions into an autonomous entity. The interface of a controller-agent is made up of its inputs and outputs, and its activation request and acknowledges signals. A controller-agent behaves either as being "active" or "inactive". Whether a controller agent is active or inactive depends on its intentions, and on the intentions of the remaining controller-agents. These intentions are expressed by the activation request signal. To coordinate several controller-agents, a mechanism - coordination object is needed that (in) activates them based on their intentions

(i.e., activation request signal). It calculates acknowledge signals by using a so called decide function. So, a coordination object must take the decision and hence still must solve conflicts, deadlock, bumpless transfer and shattering.

IV. The Application

We shall take into consideration an agent-based design for multi-controller systems, such that individual local controllers can be added, modified or removed from the overall multi-controller without redesigning the remaining system. We'll use agents for execution of control algorithms. A controller would consist of several agents, each becoming active and producing control signals under particular operating conditions of the controlled plant. We shall analyze the design of a power intelligent management system in a vessel.

This system allows having acclimatization, some light bulbs, and a hot water heater. A generator furnishes power for the vessel. All the equipments are independent and distributed. This system is open and the number of equipments in it is changeable. We can add or remove equipment in this system. The generator will supply with power to all these equipments. Our purpose is to design a power management system that is able to fulfill the user comfort and minimize the consumption of the oil of the generator.

First of all, we identify global control strategies which optimally run the process. In a second step, control strategies are decomposed into single control tasks which can be executed locally. These control tasks are then grouped and assigned to the agent. After that, we are faced with the task of coordinating their operations. The partial control problems should be defined. We need to control the generator consumption so as to control this equipment let's embed an agent (or control agency) in it.

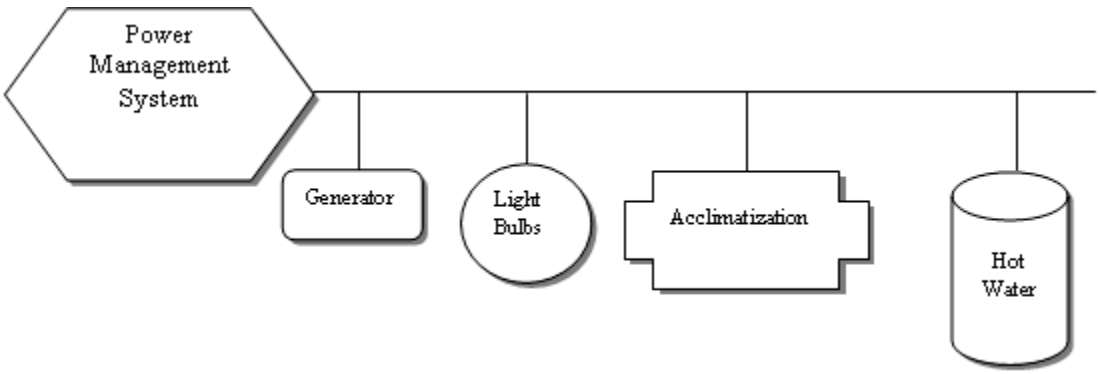

Fig 2. The Power Management System, generator, and consumption equipments

The generator is supplied with a flow of fuel and can generate electrical energy. The controller agent regulates the electrical power generated by the generator by controlling the rate of rotation and the injection of fuel in the internal combustion engine.

Also we have to control the light bulbs, (their light intensity must be variable according the time of the day). We need an agent (control agency) which is able to control the light bulbs. This lighting control system has to minimize energy consumption and therefore minimize the cost of energy required. The light agent controls some fluorescent light fixtures. The light agent can provide direct control of the power level of the fixture.

Also the acclimatization needs to adjust the room temperature according to the user requirements. We need a controller agency to control the acclimatization equipments. This controller agent is able to choose through the heat generator or coolant compressor depending on the temperature of the rooms. Energy demand signals are calculated from the agent which defines the duration of and spacing between the closing of the thermostat switches. The agent uses this timing information to control switching signals in accordance with the duration of energy demand.

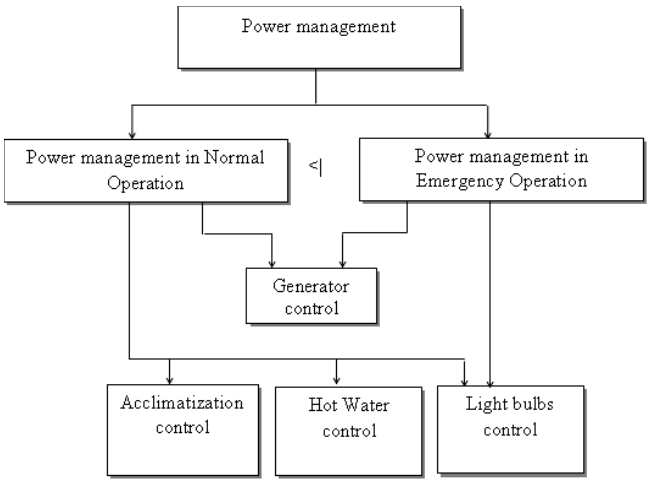

Fig 3. The structure diagram of power management system control problem

Another control problem is to control the temperature of the hot water. So a control agency is needed for this purpose. Suppose we have a tankless water heater for heating water passing there through. The controller agent communicates with the temperature sensors positioned to detect water temperature proximate the inlet and outlet portion. Agent also communicates with a flow meter positioned proximate the inlet portion which detect fluid volume. The agent receives the signals from the sensors and flow meter and decides for a proportional amount of electric current to the heating elements distributed on the tube.

The control algorithm is decomposed into two complementary mechanisms:an emergency mechanism and a normal-Operation mechanism. Emergency mechanism, which is a real time one, will be triggered when the level of fuel in the generator's deposit is lower than a reference level. During the emergency process only the request of the light bulbs control agency will be accepted. If the level of the fuel is higher than the reference level, the normal-Operation mechanism will be operated. During this phase, all the requests that come from all the control agencies will be taken in consideration. The priority of the emergency mechanism is higher than the normalOperation mechanism one. Also the priority level of the light bulbs control agency is higher than the priority of any other consumption equipment. Fig.3. shows this decomposition of the control algorithm into two complementary mechanisms. These embedded control agencies need to communicate and coordinate their operations. Every control agency has a coordinated mechanism, which analyze the request signal to be active or inactive that comes from the agents of the control agency. It takes into consideration the priority level of the agents of this agency, and then it transmits this request signal to the central coordination mechanism. This mechanism sends an acknowledge signal to the control agency with higher priority level.

The main coordinator mechanism initializes the negotiation by asking the coordination mechanisms of the control agencies of the consumption equipments to send to it their power needs, with the purpose to reach a satisfactory function provided by this agent. It coordinates the operations of all the agents in the hierarchy, also makes decisions as accept or refuse the request signals that the other agents send. The coordination object acts like a supervisor and decides which controller-agent to (in) activate based on measured information and the controller-agent's intentions. Fig.4. shows the communication of the coordination object with all other agents. All the information about the current status of the controlled equipments is coming back to their embedded agents. So the agents can consider this information in their future plan.

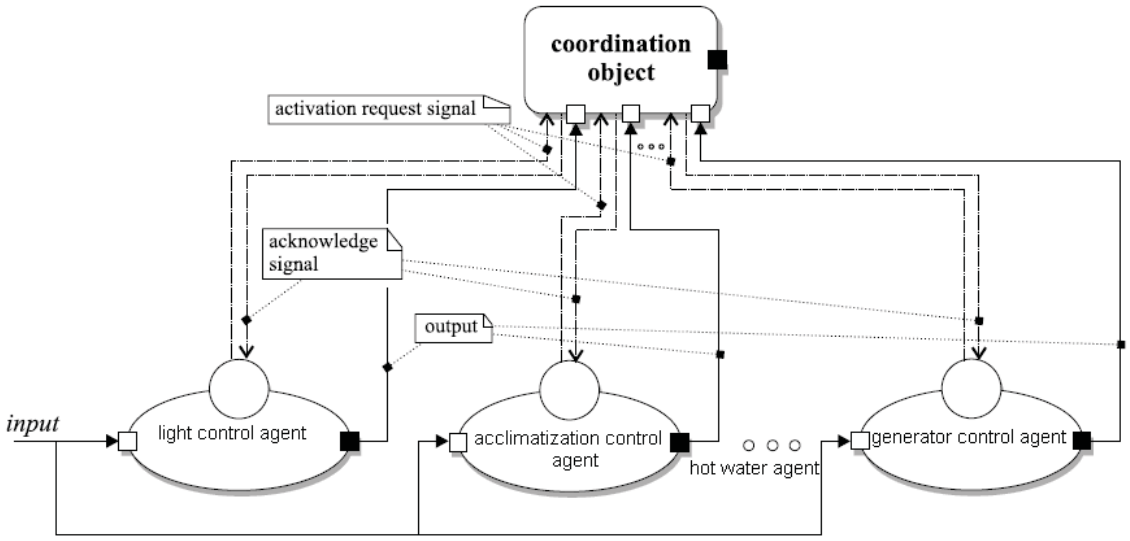

Fig. 4. The coordination object and the agents in the hierarchy

A thermostat device will be part of the acclimatization control agency. It could be considered as an agent. It is situated in its environment. It reacts to temperature changes of environment. It also exhibits a degree of autonomy. The structure diagram of the thermostat problem is presented in Fig. 5. Let's present here the design and the architecture of one of the agents of the acclimatization control agency - that component (agent) of the thermostat which provides the feature of programming the time instances by which a particular room temperature must be reached. Whenever a setpoint change is going to occur at an upcoming time instance and the new setpoint is higher than the current room temperature, the heater should be turned on.

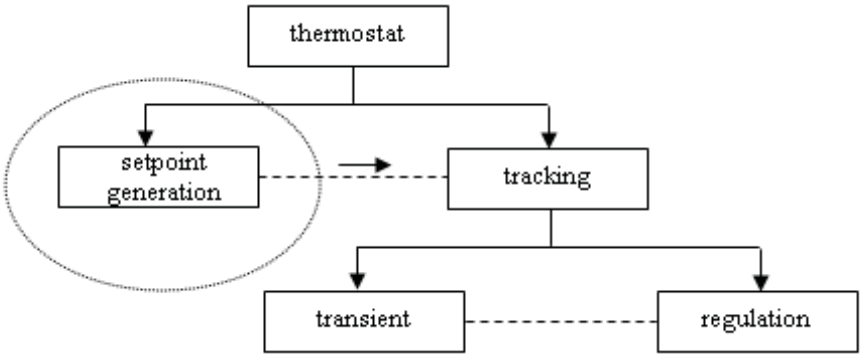

Fig. 5. The structure diagram of the thermostat problem

Our agent is responsible for the initialization and finalization of its state variables, has knowledge about its operating regime and has an interface to coordinate its behavior with other agents that solve elementary control problems of the thermostat. The agent contains an activation request signal. An object will coordinate the activity of the agents of the system. The activation signal is sent from our agent to the coordination object of the acclimatization agency at the moment when the current time reaches the time at which recovery to the new setpoint temperature occurs.

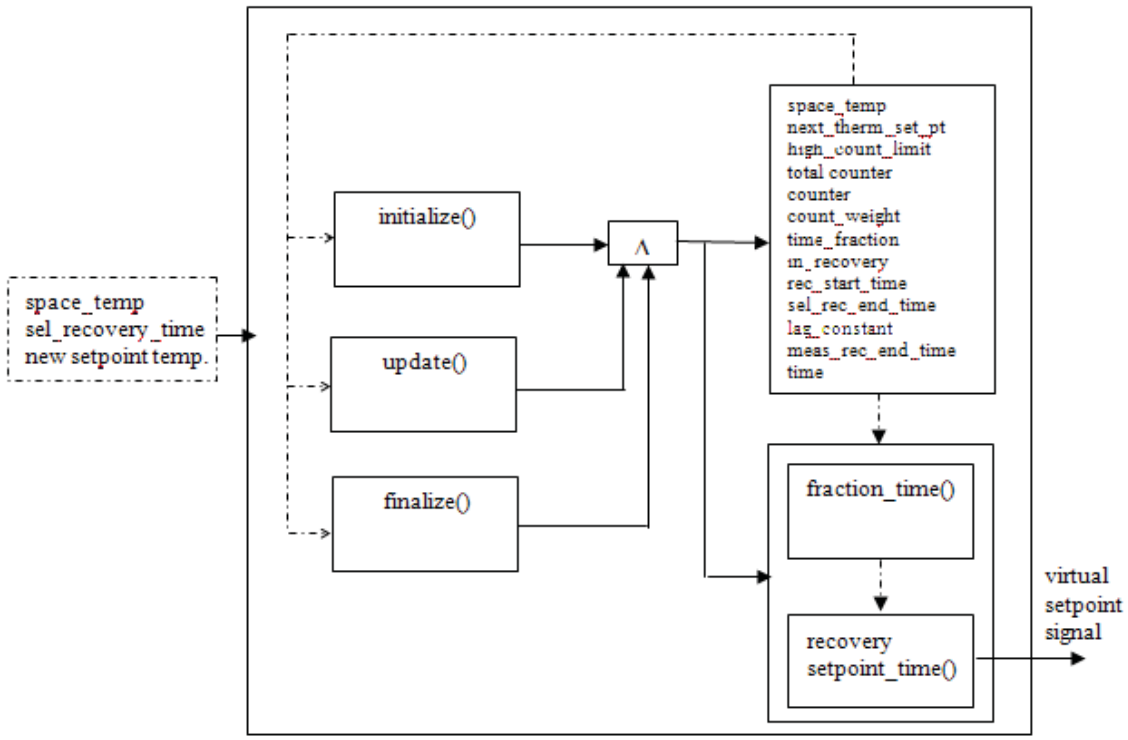

Fig. 7. The architecture of the agent

After that, an acknowledge signal, is sent from the coordination object to the agent. The agent goes to the operating regime and sends a recovery signal that provides a virtual setpoint temperature. The architecture of our agent is presented in Fig.7. Following we will see it in detail. When the agent switches from 'inactive' to 'active', it carries out some initialization or finalization functions to initialize, respectively finalize internal state variables of the agent The agent contains also, a calculate function that is being executed when the agent is active. It produces the recovery signal at the programming time.

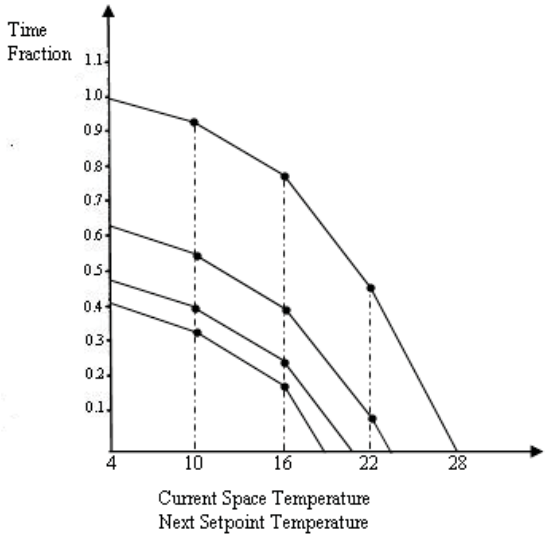

Fig. 8. The time fraction value as a function dependant on the current space temperature and the preselectable comfort temperature setpoint range

Inputs, outputs, parameters, state variables
inputs: spaceTemp,nextThermSetPt, selRecEndTime;
outputs: virtualSetPt;
parameters: tempTolerance, timeTolerance; and other state variables: time, inRecovery, thermSetPt, reStartTime, req, ack, lagConstant;

Initialize function
```
public void initialize (){
req = false; ack = false; inRecovery = true;
}
```

Calculate function
A new setpoint temperature changes the state of inRecovery variable. If it is "not true" we calculate the time at which recovery should start to allow the space temperature to reach the next thermostat setpoint at the associated recovery end time.

```
public void recoveryTime (){
if (not inRecovery){
timeFraction = calculateFractionValue (spaceTemp, nextThermSetPt);
recStartTime =selRecEndTime – (lagConstant * timeFraction);
}
}
```

The agent goes in operating regime when the current time reaches recStartTime and provides a virtual setpoint temperature signal.

```
public void activate (double nextThermSetPt){
if (abs(time-recStartTime) < timeTolerance){
//a request signal is sent to the coordinator object
req =true;
//agent is waiting for an acknowledge signal
//if an acknowledge signal is received from coordinator
If(ack){
//agent send a recovery virtual setpoint signal
inRecovery = true;
thermSetPt = nextThermSetPt; virtualSetPt=true;
}
}
}
```

Update function
The statements following have the purpose of determining how closely to the desired recovery end time (sel_rec_end_time) the actual recovery end time (meas_rec_end_time) occurred. This is embodied in the lag_constant value. The lag_constant value is the current best estimate of the time required to change the enclosure temperature from 4°C to 28°C The value of the lag constant variable is recalculated each time recovery ends to reflect changes in the thermal load on the enclosure.

```
private void updateLagConstant () {
if (abs(thermSetPt – spaceTemp) < tempTolerance){
double measRecEndTime = time; inRecovery = false;
lagConstant+=(measRecEndTime–
selRecEndTime)/timeFraction;
}
}
```

This agent can be modified or replaced and this doesn't effect the other parts of the system. Our agent will use the same interface to communicate with the system.

V. Conclusion

The agent-based design method presented in this paper helps the designer to solve complex control

problems. The design method encourages to develop local solutions and to reason about their dependencies. It offers the coordination mechanisms to deal with these dependencies.

This paper has outlined that using the agent-based design method, allows that individual controllers can be designed, implemented and tested separately. We demonstrate the use of an agent-based design technique for multi-controller systems. It is our future intent to continue the work and to implement step by step one of the control agencies.

Multi-controller system in general reflects the decomposition of the complex control problem. Agents offer us as tools for solving control problems and organizing individual solutions. The agents are responsible for the initialization and finalization of their state variables, have knowledge about their operating regime and have an interface to coordinate its behavior with other agents of the system. They can be added, modified or removed from the overall multi-controller without redesigning the remaining system.

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Performance Issues of Heterogeneous Hadoop Clusters in Cloud Computing

By B.Thirumala Rao, N.V.Sridevi, V.Krishna Reddy, L.S.S.Reddy

Abstract- Nowadays most of the cloud applications process large amount of data to provide the desired results. Data volumes to be processed by cloud applications are growing much faster than computing power. This growth demands new strategies for processing and analyzing information. Dealing with large data volumes requires two things: 1) Inexpensive, reliable storagee 2) New tools for analyzing unstructured and structured data. Hadoop is a powerful open source software platform that addresses both of these problems. The current Hadoop implementation assumes that computing nodes in a cluster are homogeneous in nature. Hadoop lacks performance in heterogeneous clusters where the nodes have different computing capacity. In this paper we address the issues that affect the performance of hadoop in eterogeneous clusters and also provided some guidelines on how to overcome these bottlenecks.

Keywords: *Cloud Computing, Hadoop, HDFS, Maperduce.*

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I. Introduction

Cloud computing[1] is a relatively new way of referring to the use of shared computing resources, and it is an alternative to having local servers handle applications. Cloud computing groups together large numbers of compute servers and other resources and typically offers their combined capacity on an on-demand, pay-percycle basis. The end users of a cloud computing network usually have no idea where the servers are physically located–they just spin up their application and start working.

This flexibility is the key advantage to cloud computing, and what distinguishes it from other forms of grid or utility computing and software as a service (SaaS). The ability to launch new instances of an application with minimal labor and expense allows application providers to scale up and down rapidly, recover from a failure, bring up development or test instances, roll out new versions to the customer base.

The primary concept behind Cloud Computing isn't a brand new one. John McCarthy within the sixties imagined that processing amenities is going to be supplied to everyone just like a utility. The word "cloud" has already been utilized in numerous contexts such as explaining big ATM systems within the 1990s. Nevertheless, it had been following Google's BOSS Eric Schmidt utilized the term to explain the company type of supplying providers over the Web within 2006. Since then, the term cloud computing has been used mainly as a marketing term in a variety of contexts to represent many different ideas. Certainly, the lack of a standard definition of cloud computing has generated not only market hypes, but also a fair amount of skepticism and confusion. For this reason, recently there has been work on standardizing the definition of cloud computing. As an example, the work in compared over 20 different definitions from a variety of sources to confirm a standard definition. In this paper, we adopt the definition of cloud computing provided by The National Institute of Standards and Technology (NIST), as it covers, in our opinion, all the essential aspects of cloud computing:

NIST definition of cloud computing[2] Cloud computing is a model for enabling convenient, ondemand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. The main reason for the existence of different perceptions of cloud computing is that cloud computing, unlike other technical terms, is not a new technology, but rather a new operations model that brings together a set of existing technologies to run business in a differentway. Indeed, most of the technologies used by cloudcomputing, such as virtualization and utility-based pricing, are not new. Instead, cloud computing leverages these existing technologies to meet the technological and economic requirements of today's demand for information technology.

II. Related Technologies

Cloud computing is often compared to the following technologies[3], each of which shares certain aspects with cloud computing:

Grid Computing: Grid computing is a distributed computing paradigm that coordinates networked resources to achieve a common computational objective. The development of Grid computing was originally driven by scientific applications which are

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usually computation-intensive. Cloud computing is similar to Grid computing in that it also employs distributed resources to achieve application-level objectives. However, cloud computing takes one step further by leveraging virtualization technologies at multiple levels (hardware and application platform) to realize resource sharing and dynamic resource provisioning.

Utility Computing: Utility computing represents the model of providing resources on-demand and charging customers based on usage rather than a flat rate. Cloud computing can be perceived as a realization of utility computing. It adopts a utility-based pricing scheme entirely for economic reasons. With on-demand resource provisioning and utility based pricing, service providers can truly maximize resource utilization and minimize their operating costs.

Virtualization: Virtualization is a technology that abstracts away the details of physical hardware and provides virtualized resources for high-level applications. A virtualized server is commonly called a virtual machine (VM). Virtualization forms the foundation of cloud computing, as it provides the capability of pooling computing resources from clusters of servers and dynamically assigning or reassigning virtual resources to applications on-demand.

Autonomic Computing: Originally coined by IBM in 2001, autonomic computing aims at building computing systems capable of self-management, i.e. reacting to internal and external observations without human intervention. The goal of autonomic computing is to overcome the management complexity of todays computer systems. Although cloud computing exhibits certain autonomic features such as automatic resource provisioning, its objective is to lower the resource cost rather than to reduce system complexity. In summary, cloud computing leverages virtualization technology to achieve the goal of providing computing resources as a utility. It shares certain aspects with grid computing and autonomic computing but differs from them in other aspects. Therefore, it offers unique benefits and imposes distinctive challenges to meet its requirements.

III. Hadoop

Hadoop[9] is an open source implementation of the MapReduce parallel processing framework. Hadoop hides the details of parallel processing, including distributing data to processing nodes, restarting subtasks after a failure, and collecting the results of the computation. This framework allows developers to write relatively simple programs that focus on their computation problem, rather than on the nuts and bolts of parallelization.

Hadoop Components

- Distributed file system (HDFS)
  - Single namespace for entire cluster
  - Replicates data 3x for fault-tolerance
- MapReduce framework
  - Executes user jobs specified as "map" and "reduce" functions
  - Manages work distribution & fault tolerance

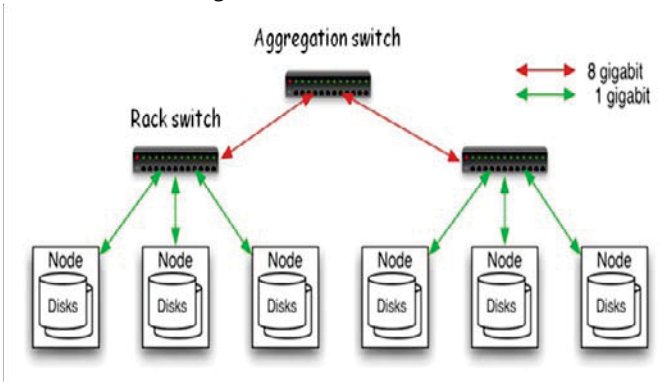

Fig 1: Typical Hadoop Cluster

A hadoop Cluster may contain:

- 40 nodes/rack, 1000-4000 nodes in cluster
- 1 Gbps bandwidth within rack, 8 Gbps out of rack
- Node specs (Yahoo terasort): 8 x 2 GHz cores, 8 GB RAM, 4 disks (= 4 TB?)
- Files split into 128MB blocks
- Blocks replicated across several datanodes (usually 3)
- Single namenode stores metadata (file names, block locations, etc)
- Optimized for large files, sequential reads

a) *HDFS- Distributed file system over clouds*

Google File System (GFS) [6] is a proprietary distributed file system developed by Google and specially designed to provide efficient, reliable access to data using large clusters of commodity servers. Files are divided into chunks of 64 megabytes, and are usually appended to or read and only extremely rarely overwritten or shrunk. Compared with traditional file systems, GFS is designed and optimized to run on data centers to provide extremely high data throughputs, low latency and survive individual server failures. Inspired by GFS, the open source Hadoop Distributed File System (HDFS) [4] stores large files across multiple machines. It achieves reliability by replicating the data across multiple servers. Similarly to GFS, data is stored on multiple geo-diverse nodes. The file system is built from a cluster of data nodes, each of which serves blocks of data over the network using a block protocol specific to HDFS. Data is also provided over HTTP, allowing access to all content from a web browser or other types of clients. Data nodes can talk to each other to rebalance data distribution, to move copies around, and to keep the replication of data high.

An advantage of using the HDFS is data awareness between the jobtracker and tasktracker. The jobtracker schedules map/reduce jobs to tasktrackers with an awareness of the data location. An example of this would be if node A contained data (x,y,z) and node B contained data (a,b,c). The jobtracker will schedule node B to perform map/reduce tasks on (a,b,c) and node A would be scheduled to perform map/reduce tasks on (x,y,z). This reduces the amount of traffic that goes over the network and prevents unnecessary data transfer. When Hadoop is used with other filesystems this advantage is not available. This can have a significant impact on the performance of job completion times, which has been demonstrated when running data intensive jobs [10]

b) *Hadoop Mapreduce overview*

MapReduce [5] is one of the most popular programming models designed for data centers. It was originally proposed by Google to handle large-scale web search applications and has been proved to be an effective programming model for developing data mining, machine learning and search applications in data centers. In particular, MapReduce can enhance the productivity for junior developers who lack the experience of distributed/parallel development. Hadoop has been successfully used by many companies including AOL, Amazon, Facebook, and New York Times for running their applications on clusters. For example, AOL used it for running an application that analyzes the behavioral pattern of their users so as to offer targeted services.

Although Hadoop is successful in homogeneous computing environments, a performance study conducted by Matei Zaharia et al. [12] shows that MapReduce implemented in the standard distribution of Hadoop is unable to perform well in heterogeneous Cloud computing infrastructure such as Amazon EC2 . Experimental observations reveal that the homogeneity assumptions of MapReduce can cause wrong and often unnecessary.

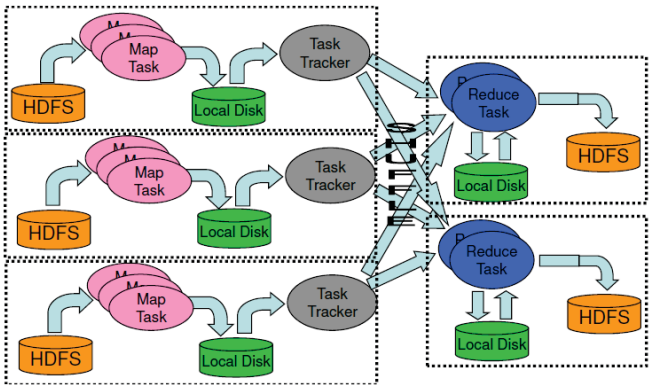

Fig 2: Hadoop Design

speculative execution in heterogeneous environments, sometimes resulting in even worse performance than with speculation disabled. This evaluation and performance results of their enhanced scheduler in Hadoop demonstrate that Cloud execution management systems need to be designed to handle heterogeneity that is present in workloads, applications, and computing infrastructure.

- Commodity machines (cheap, but unreliable)
- Commodity network
- Automatic fault-tolerance (fewer administrators)
- Easy to use (fewer programmers)

As shown in figure.2 a mapper will map the task to a datanode where the data is available. Task trackers will keep track of the work that is being carried by the datanodes.

IV. Performance Issues

Several Key factors exist that affect the performance of Hadoop.

a) *Cluster Hardware Configuration*

Hadoop was designed based on a new approach to storing and processing complex data. Instead of relying on a Storage as Network for massive storage and reliability then moving it to a collection of blades for processing, Hadoop handles large data volumes and reliability in the software tier. Hadoop distributes data across a cluster of balanced machines and uses replication to ensure data reliability and fault tolerance. Because data is distributed on machines with compute power, processing can be sent directly to the machines storing the data. Since each machine in a Hadoop cluster both stores and processes data, they need to be configured to satisfy both data storage and processing requirements. Table:1 gives the summary of the parameters that affect the cluster performance.

Parameter	Impact / Purpose
No.of Cores	Processing Speed
RAM	# trips to disk
Disks per node	To support rapid scale up
Disk speed	High throughput
Network Topology	Communication overhead

Table:1 Hardware Parameters that affect Hadoop Performance

There are four types of nodes in a basic Hadoop cluster. A node referred as a machine performing a particular task. Most of the machines will function as both datanodes and tasktrackers. These nodes both store data and perform processing functions. Recommended specifications for datanodes/tasktrackers in a balanced Hadoop cluster are:

- 4 1TB hard disks in a JBOD (Just a Bunch Of Disks) configuration
- 2 quad core CPUs, running at least 2-2.5GHz
- 16-24GBs of RAM (24-32GBs if you're considering HBase)
- Gigabit Ethernet

The namenode is responsible for coordinating data storage on the cluster and the jobtracker for coordinating data processing. The last type of node is the secondarynamenode, which can be colocated on the namenode machine for small clusters, and will run on the same hardware as the namenode for larger clusters. We recommend our customers purchase hardened machines for running the namenodes and jobtrackers, with redundant power and enterprise-grade RAIDed disks. Namenodes also require more RAM relative to the number of data blocks in the cluster. A good rule of thumb is to assume 1GB of namenode memory for every one million blocks stored in the distributed file system. With 100 datanodes in a cluster, 32GBs of RAM on the namenode provides plenty of room to grow. We also recommend having a standby machine to replace the namenode or jobtracker, in the case when one of these fails suddenly.

When you expect your Hadoop cluster to grow beyond 20 machines we recommend that the initial cluster be configured as it were to span two racks, where each rack has a top of rack gigabit switch, and those switches are connected with a 10 GigE interconnect or core switch. Having two logical racks gives the operations team a better understand of the network requirements for innerrack, and cross-rack communication.

With a Hadoop cluster in place the team can start identifying workloads and prepare to benchmark those workloads to identify CPU and IO bottlenecks. After some time benchmarking and monitoring, the team will have a good understanding as to how additional machines should be configured. It is common to have heterogeneous Hadoop clusters especially as they grow in size. Starting with a set of machines that are not perfect for your workload will not be a waste. Below is a list of various hardware configurations for different workloads, including our earlier recommendation[10]

- Light Processing Configuration (1U/machine):Two quad core CPUs, 8GB memory, and 4 disk drives (1TB or 2TB). Note that CPU-intensive work such as natural language processing involves loading large models into RAM before processing data and should be configured with 2GB RAM/core instead of 1GB RAM/core.
- Balanced Compute Configuration (1U/machine): Two quad core CPUs, 16 to 24GB memory, and 4 disk drives (1TB or 2TB) directly attached using the motherboard controller. These are often available as twins with two motherboards and 8 drives in a single 2U cabinet.
- Storage Heavy Configuration (2U/machine): Two quad core CPUs, 16 to 24GB memory, and 12 disk drives (1TB or 2TB). The power consumption for this type of machine starts around ~200W in idle state and can go as high as ~350W when active.
- ·Compute Intensive Configuration (2U/machine): Two quad core CPUs, 48-72GB memory, and 8 disk drives (1TB or 2TB). These are often used when a combination of large in-memory models and heavy reference data caching is required.

Purchasing appropriate hardware for a Hadoop cluster requires benchmarking and careful planning to fully understand the workload. Nevertheless, Hadoop clusters are commonly heterogeneous and we recommend deploying initial hardware with balanced specifications when getting started.

b) *application logic related*

i. *Tune the number of map and reduce tasks appropriately*

Tuning the number of map and reduce tasks for a job is important and easy to overlook. Here are some rules of thumb to set these parameters:

- If each task takes less than 30-40 seconds, reduce the number of tasks. The task setup and scheduling overhead is a few seconds, so if tasks finish very quickly, you're wasting time while not doing work. JVM reuse can also be enabled to solve this problem.
- If a job has more than 1TB of input, consider increasing the block size of the input dataset to 256M or even 512M so that the number of tasks will be smaller
- So long as each task runs for at least 30-40 seconds, increase the number of mapper tasks to some multiple of the number of mapper slots in the cluster.
- Don't schedule too many reduce tasks - for most jobs, we recommend a number of reduce tasks equal to or a bit less than the number of reduce slots in the cluster.

ii. *Take Data locality into consideration*

In a cluster where each node has a local disk, it is efficient to move data processing operations to nodes where application data are located. If data are not locally available in a processing node, data have to be migrated via network interconnects to the node that performs the data processing operations. Migrating huge amount of data leads to excessive network congestion, which in turn can deteriorate system performance. HDFS enables Hadoop MapReduce applications to transfer processing operations toward nodes storing application data to be processed by the operations. In a heterogeneous cluster, the computing capacities of nodes may vary significantly. A high-speed node can finish processing data stored in a local disk of the node faster than low-speed counterparts. After a fast node complete the processing of its local input data, the node must support load sharing by handling unprocessed data located in one or more remote slow nodes. When the amount of transferred data due to load sharing is very large, the overhead of moving unprocessed data from slow nodes to fast nodes becomes a critical issue affecting Hadoop's performance. To boost the performance of Hadoop in heterogeneous clusters, we aim to minimize data movement between slow and fast nodes. This goal can be achieved by a data placement scheme[11] that distribute and store data across multiple heterogeneous nodes based on their computing capacities. Data movement can be reduced if the number of file fragments placed on the disk of each node is proportional to the node's data processing speed.To achieve the best I/O performance, one may make replicas of an input data file of a Hadoop application in a way that each node in a Hadoop cluster has a local copy of the input data. Such a data replication scheme can, of course, minimize data transfer among slow and fast nodes in the cluster during the execution of the Hadoop application. The datareplication approach has several limitations. First, it is very expensive to create replicas in a large-scale cluster. Second, distributing a large number of replicas canwasterfully consume scarce network bandwidth in Hadoop clusters. Third, storing replicas requires an unreasonably large amount of disk capacity, which in turn increases the cost of Hadoop clusters. Although all replicas can be produced before the execution of Hadoop applications, significant efforts must be make to reduce the overhead of generating replicas. If the datareplication approach is employed in Hadoop, one has to address the problem of high overhead for creating file replicas by implementing a low-overhead filereplication mechanism. For example, Shen and Zhu developed a proactive lowoverhead file replication scheme for structured peer-to-peer networks [13]. Shen and Zhu's scheme may be incorporated to overcome this limitation.

c) *System Bottlenecks & Resource Under-utilization*

i. *Replication*

HDFS is designed to run on highly unreliable hardware. On Yahoo's long-running clusters we observe a node failure rate of 2-3 per 1000 nodes a day. On new (recently out of the factory) nodes, the rate is three times higher. In order to provide data reliability HDFS uses block replication. Initially, each block is replicated by the client to three data-nodes. The block copies are called replicas. A replication factor of three is the default system parameter, which can either be configured or specified per file at creation time.

Once the block is created, its replication is maintained by the system automatically. The name-node detect sfailed data-nodes, or missing or corrupted individual replicas, and restores their replication by directing the copying of the remaining replicas to other nodes. Replication is the simplest of known data-recovery techniques. Other techniques, such as redundant block striping or erasure codes, are applicable and have been used in other distributed file systems such as GFS, PVFS and Lustre [6, 7, 8]. These approaches, although more space efficient, also involve performance tradeoffs for data recovery. With striping, depending on the redundancy requirements, the system may need to read two or more of the remaining data segments from the nodes it has been striped to in order to reconstruct the missing one. Replication always needs only one copy. For HDFS, the most important advantage of the replication technique is that it provides high availability of data in high demand. This is actively exploited by the MapReduce framework, as it increases replications of configuration and job library files to avoid contention during the job startup, when multiple tasks access the same files simultaneously.

Each block replica on a data-node is represented by a local (native file system) file. The size of this file equals the actual length of the block and does not require extra space to round it up to the maximum block size, as traditional file systems do. Thus, if a block is half full it needs only half of the space of the full block on the local drive. A slight overhead is added, since HDFS also stores a second, smaller metadata file for each block replica, which contains the checksums for the block data.

ii. *Block reports, heartbeats*

The name-node maintains a list of registered data-nodes and blocks belonging to each data-node. A data-node identifies block replicas in its possession to the namenode by sending a block report. A block report contains block ID, length, and the generation stamp for each block replica. The first block report is sent immediately after the data-node registration. It reveals block locations, which are not maintained in the namespace image or in the journal on the name-node.

Subsequently, block reports are sent periodically every hour by default and serve as a sanity check, providing that the namenode has an up-to-date view of block replica distribution on the cluster. During normal operation, data-nodes periodically send heartbeats to the name-node to indicate that the data-node is alive. The default heartbeat interval is three seconds. If the name-node does not receive a heartbeat from a data-node in 10 minutes, it pronounces the data-node dead and schedules its blocks for replication on other nodes.

Heartbeats also carry information about total and used disk capacity and the number of data transfers currently performed by the node, which plays an important role in the name-node's space and load-balancing decisions. The communication on HDFS clusters is organized in such a way that the name-node does not call data-nodes directly. It uses heartbeats to reply to the data nodes with important instructions. The instructions include commands to:

- Replicate blocks to other nodes. Remove local block replicas
- Re-register or shut down the node
- Send an urgent block report

These commands are important for maintaining the overall system integrity; it is therefore imperative to keep heartbeats frequent even on big clusters. The name-node is optimized to process thousands of heartbeats per second without affecting other namenode operations.

d) *Scale*

i. *Namespace Limitations*

HDFS is based on an architecture where the namespace is decoupled from the data. The namespace forms the file system metadata, which is maintained by a dedicated server called the ***name-node***. The data itself resides on other servers called ***data-nodes***. The namespace consists of files and directories. Files are divided into large (128 MB) blocks. To provide data reliability, HDFS uses block replication. Each block by default is replicated to three data-nodes. Once the block is created its replication is maintained by the system automatically. The block copies are called ***replicas***.

The name-node keeps the entire namespace in RAM. This architecture has a natural limiting factor: the memory size; that is, the number of namespace objects (files and blocks) the single namespace server can handle. Estimates show that the name-node uses less than 200 bytes to store a single metadata object (a file inode or a block). According to statistics on Y! clusters, a file on average consists of 1.5 blocks. Which means that it takes 600 bytes (1 file object + 2 block objects) to store an average file in name-node's RAM. For example to store 100 million files (referencing 200 million blocks), a name-node should have at least 60 GB of RAM.We have learned by now that the name-node can use 70% of its time to process external client requests. Even with a handful of clients one can saturate the name-node performance by letting the clients send requests to the name-node with very high frequency. The name-node most probably would become unresponsive, potentially sending the whole cluster into a tailspin because internal load requests do not have priority over regular client requests. In practice, the extreme load bursts are uncommon. Regular Hadoop clusters run Map Reduce jobs, and jobs perform conventional file reads or writes. To get or put data from or to HDFS, a client first accesses the name-node and receives block locations, and then directly talks to data-nodes to transfer file data. Thus the frequency of name-node requests is bound by the rate of data transfer from data-nodes.

V. Conclusion

In this paper we have presented the overview of Hadoop and several issues that affect the performance of hadoop in heterogeneous clusters in cloud environments. We have also proposed some guidelines on how to overcome these issues to improve the performance of hadoop. As hadoop is open source implementation, we hope our work will provide a better understanding of the performance challenges of Hadoop in heterogeneous clusters, and pave the way for further research in this area.

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- Left Margin: 0.65
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- Font type of all text should be Times New Roman.
- Paper Title should be of Font Size 24 with one Column section.
- Author Name in Font Size of 11 with one column as of Title.
- Abstract Font size of 9 Bold, "Abstract" word in Italic Bold.
- Main Text: Font size 10 with justified two columns section
- Two Column with Equal Column with of 3.38 and Gaping of .2
- First Character must be two lines Drop capped.
- Paragraph before Spacing of 1 pt and After of 0 pt.
- Line Spacing of 1 pt
- Large Images must be in One Column
- Numbering of First Main Headings (Heading 1) must be in Roman Letters, Capital Letter, and Font Size of 10.
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You can use your own standard format also.
Author Guidelines:

1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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Papers: These are reports of significant research (typically less than 7000 words equivalent, including tables, figures, references), and comprise:

(a)Title should be relevant and commensurate with the theme of the paper.

(b) A brief Summary, "Abstract" (less than 150 words) containing the major results and conclusions.

(c) Up to ten keywords, that precisely identifies the paper's subject, purpose, and focus.

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(g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.

(h) Brief Acknowledgements.

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References

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The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

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- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
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- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.
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- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.

- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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