A PAGE MANAGEMENT SCHEME FOR AN EDGE COLOURED MULTIGRAPH

a dissertation submitted in partial fulfilment of the requirements for the M.Tech.(Computer Science) degree of the Indian Statisctical Institute

by

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YEAR - 1992

ACKNOWLEDGEMENTS

I express my deep gratitude to my guides Dr. Aditya Bagchi and Mr. Amarnath Gupta for their invaluable guidance throughout this work.

I am also thankful to Krishnendu, Jha, Rajan, Jyoti, Jaydeep, Panda, Devi and Kamble for their assistance.

CONTENTS

SECTION 1

PROBLEM SPECIFICATION

All knowledge based systems need an underlying database facility to store, share and access structured data. This dissertation considers one such application in the field of Computer Vision.The problem is to create a database of models for visual objects. One simple proposition is to extract sufficient amount of features (known as feature vector) for each object and store them in a flat file. An input to this system is compared with each object linearly to get a suitable match. Such a system faces problem when the number of stored objects increases sufficiently. A search procedure will perform poorly in such a situation. Also there is a chance of huge amount of information repetition especially when all the objects or objects in groups have some structural uniformity.

The internal representation of a complete object is based upon the following intuitive observation:

Visual objects are normally decomposable into a hierarchy of coarse to fine descriptions. At any level there is one descriptor for each visual entity (for example for each subpart at that level of resolution), connected to other entities through a predefined set of spatial relations. These spatial relations are parametric allowing a tolerance range on the values of their parameters. The attirbutes belonging to one descriptor of a part or subpart may often constrain an attribute of another part or subpart of the same object.

Different objects of the same structural/functional class often share a set of part names in addition to descriptions. This information is stored in the name plane.However, it is not imperative that two objects sharing the same name will also share the corresponding description.

The name plane contains, for each object class, a one level **IS A** tree, and a **PART OF** tree for each object belonging to that class. At any arbitrary time, suppose there are k objects of the same class. For the i-th object the structure is a tree. However some nodes of the tree (each node designating a part name) would also be shared by the j-th object. It is assumed that a node at a certain level in the i-th **PART OF** tree will not appear at a different level for the j-th **PART OF** tree. If a colour is assigned to each object, and the arcs of the **PART OF** tree of that object is assigned that colour, then the general **PART OF** structure becomes an edge coloured multi-graph.

In the name plane objects of the same class consists of all those nodes in the **PART OF** structure that are visited by arcs of all colours. Introducing a unique colour for each object in a class achieves sufficient sharing of information among the objects.

This dissertation is concerned with the implementation of a persistent representation of the name plane and a study of its performance with respect to number of pages fetched and number of pages used.

SECTION 2

DATA STRUCTURE

The structure of the name plane proposed in section 1 is shown in figure 1. Figures 2 and 3 give an example of name sharing in a name plane In this section a suitable data structure for the name plane is presented.

□ Constants:

1. MAX_FANOUT: Maximum number of decomposed subparts of any part.
2. MAX_COLOR: Maximum number of specialization allowed.

□ Level-2 node:

Following are the fields :

1. # children: number of children, i.e., number of decomposed subparts of the part.
2. next_ptr: pointer to the next part in the current bucket.
3. offset: offset in current bucket.
4. desc_plane_ptr: pointer to the next associated description plane.
5. name: name of the part.
6. Incolor_reg: A bit register of size MAX_COLOR. The i-th part is ON iff the part is shared by a specialization having colour number i.
7. Outcolor_matrix (OCM): A bit matrix of size MAX_COLOR × MAX_FANOUT. Each row represents a colour and is a bit register of size MAX_FANOUT. The i-th bit is on iff the i-th part in the child level-2 bucket is a member in the named decomposition of the current part.

8. In_g_bit: A flag bit which is ON iff the part is visited by all the existing colours.

9. Out_g_bit: A flag bit which is ON iff the part undergoes a decomposition for all the participating colours.

10. # outcolours: number of outcolours in the outcolour matrix.

- Level-0 node:

It contains the following fields:

1. name: Name of the object class.
2. g_code: Bit register of size MAX_FANOUT. The i-th bit is ON iff the i-th name in the root level-2 bucket participates in the defition of the class.
3. specialization: Set of currently available specialization of the class.
4. # variant: Number of currently available specializations of the class.
5. child_ptr: Pointer to the root level-2 node.

- Level-1 node:

1. name: Name of the specialization.
2. color_number: Unique integer assigned to the name.
3. child_code: A bit register of size MAX_FANOUT. The i-th bit is ON iff the i-th name in the first level-2 node (root level-2 bucket) is a part in the first level decomposition of the specialization.

All the data structures defined so far collectively defines a name plane for the object class. It basically gives a name description of each specialization in the object class.

SECTION 3

THE PERSISTENT NAME PLANE

From pragmatic considerations level-0 and level-1 buckets essentially consist of the same structures and therefore belong to the same partition called the object partition of the name plane. The rest of the name plane is partitioned horizontally, all buckets of the same level being placed in the same bucket. These partitions are called segments and each partition is implemented as a random access file.

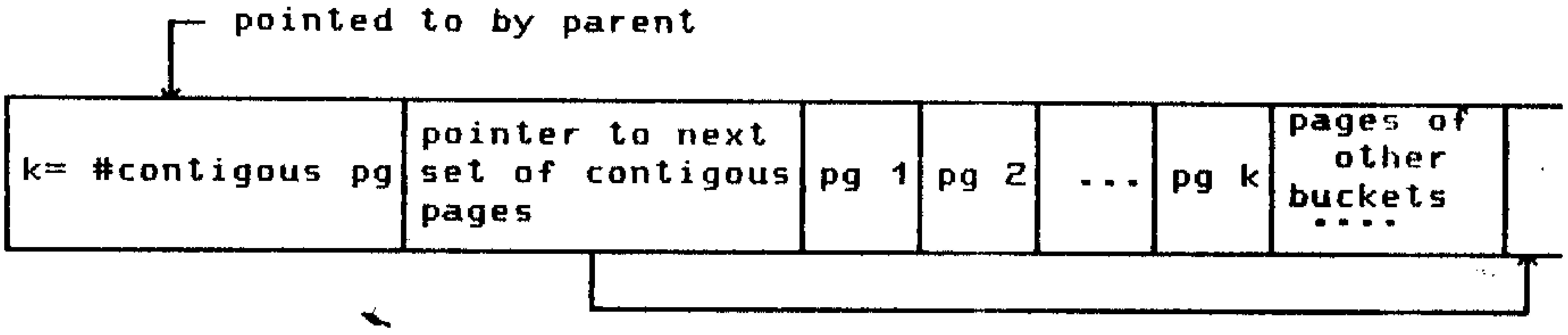
The data structures are dynamic both with respect to colour and with respect to the number of children of a specific node. The knowledge of the domain tells us that effect of the former would be more prominent than the effect of the latter because a high degree of name sharing is expected at each level of the name plane. Hence the outdegree colour matrix (OCM) is maintained in a different area managed through a slightly modified paging strategy compared to the buckets containing the main data items.

The Paging Strategy

Let us define two kinds of pages called data pages and overflow pages respectively. Let their page sizes be MAIN_PG_SIZE and OFL_PG_SIZE respectively. Thus the data page can hold MAIN_PG_SIZE data items and an overflow page can hold OFL_PG_SIZE data items respectively. The overflow page size is usually larger than the main page size. The data pages of a level are part of the horizontal partition for that level. Let main area denote these horizontal partitions.

There are two pointers in each level-2 node (these correspond to child_ptr field in the data structure of level-2 node given in Section 2). One of these pointers points to the main area and the other points into the overflow area.

The data in a partition in the main area is organized as shown below:



pointed to by parent
k= #contigous pg
pointer to next set of contigous pages
pg 1
pg 2
...
pg k
pages of other buckets ....

The oraganization of an overflow page is given below.

Page count = # of used fragments	Data item fragment	Next fragment pointer	.. Other fragments

Each fragment holds a data item. The pointer from the parent is the head of a fragment list that contains data items of the bucket that are not enough to fill a main page.

As long as on insertion, the length of the fragment chain is less than the data page size (i.e., # items in bucket MOD MAIN_PG_SIZE ≠ 0) insertion is done in the overflow area. However, if on insertion the length of the fragment chain equals the data page size (i.e., # items in bucket MOD MAIN_PG_SIZE = 0) a fresh page is allocated in the main area and the data fragments are copied to that page. The fragments freed in this process are added to an available fragments list maintained and the overflow area pointer of the parent is nullified. The page counts of the overflow page to which each freed fragment belongs is also decremented and if any page becomes free (page count = 0) the free fragments in that page are deleted from the available fragments list and the page freed. Thus fragmentation is minimized at the extra cost of new page formation time from overflow pages.

Next let us consider the OCM data item. Let there be one OCM segment for each main data area segment. The basic paging technique for the OCM area also involves page chaining. However, the insertion rate of a new colour register is faster than the insertion rate of a new data item. Unlike the earlier case it is more difficult to minimize fragmentation even if information migration takes place, simply because the degree of sharing can only be predicted statistically for any object class and no generalized model can be made to estimate the degree of name sharing.

The number of outcolours in an OCM page is given by the constant OUTCOLOR_PG_SIZE. An outcolour to be added to the OCM is added to the first page if it is not full, otherwise a fresh page is allocated and the new page is added to the head of the chain.

SECTION 4

IMPLEMENTATION

Each partition is implemented as a file whose name is the class name with an appropriate extention. Thus, HAMMER.LEVELO contains the object partition of the class HAMMER. The partitions for the various level-2 buckets are contained in HAMMER.LEVEL20, HAMMER.LEVEL21 and so on. The O.C.M partitions are in the files HAMMER.OUTCOLORSO, HAMMMER.OUTCOLORS1 and so on and the overflow area is implemented in HAMMER.OFL.

The level-2 nodes are indexed by their corresponding path expressions as shown below.

INDEX TABLE

Path expression	Pointer

The indexes are maintained in an index file whose name is the class name with the extension ".index" (e.g. HAMMER.INDEX).Pointer is a combination of the level numbers given by pointer **MOD** 10 and an offset into the file given by pointer **DIV** 10. A negative pointer indicates that the pointer is to the overflow area.

There are two changes in the data structure of the name plane given in Section 1 in the persistent implementation.

1. The child pointer is replaced by two pointers;

   Main_area_ofs: giving the offset of the first set of contiguous pages in the bucket in the main area.

Ofl_area_ofs: giving the offset of the head of the fragment list in the overflow area.

2. The O.C.M field is replaced by a pointer to the O.C.M file of the corresponding partition.

The algorithm for adding a subpart to a part given the path expression for the part is given below.

```
ALGORITHM insert(string  path_exp, level-2  x);
Step 1. find the pointer P corresponding to path_exp from the
index table.
Let level-no = abs(p) mod 10 and offset = abs(p) div 10.
Step 2. Locate the node corresponding to path_exp. If P is
negative then fetch it from the overflow area
        else fetch it from the partition area given by level_no.
Let t be the record fetched. (For this the corresponding page has
to be fetched if it is not already in the memory.)
Step 3. Increment t.# children.
Step 4. If t.# children mod MAIN_PG_SIZE = 0 then
begin
    t.main_area_ofs:=copy_to_main_area(level_no+1,x,
                              t.main_area_ofs,t.ofl_area_ofs);
    goto Step 7
end.
Step 5. If the available fragment list is not empty then allocate
a free fragment and decrement the page_cnt of the corresponding
page, else allocate a overflow page, allocate a free fragment
from it, add the other fragments in the page to the free fragment
```

list and set the page_cnt of the new page to 1.

Step 6. Set a data item field of the free fragment to x and insert the new *fragment* at the head of the fragment list and make an entry *for* x in *the index table.*

Step 7. Copy back the new value of t.

Step 8. exit.

Procedure copy_to_main_area(level,x,main area_ofs,ofl_area_ofs)

Step 1. *Allocate a fresh data page* in partition no. level (a page i allocated at the end of *the file) and* add x to it.

Step 2. If the new page is contiguous with the set *of* contiguous pages pointed to by main_area_ofs then the # contiguous pages count is incremented pointed to by main_area_ofs.

else # *contiguous pages* count *for* the new set of pages is set to 1 and *the new page is added to the head* of the list.

Step 3. The data fragments in the fragments *list pointed* to *by* off_area_ofs are copied to the new data page, the page count of the overflow page of each freed fragment is decremented and the index table entries corresponding to the data fragments are updated to *point to* the new lacation in the main area.

Step 4. The list of *freed fragments are added* to the available fragments list. If in the process of freeing the fragments any overflow pages become free (i.e., page count=0) the free fragments in those pages are deleted from the available fragmentslist and the overflow page released. This is done by making *a freed overflow pages* list *and adding* the *freed overflow* pages to that list.

SECTION 5

PERFORMANCE STUDY

Four input trees are chosen for the study of the following parameters for 9 values overflow and main page sizes, each with OFL_PG_SIZE ≥ MAIN_PG_SIZE :

1.No of overflow pages used.

2.No of overflow pages freed in the process of copying to the main area.

3.No of main pages fetched.

4.No of overflow pages fetched.

The input trees are shown in fig. 4.

The values of the above mentioned parameters are found for all possible permutations of the order of insertions of the colours of a tree.The insertions and updations (updations of the input colour register and the OCM) for a new colour are done in a breadth first order.The histograms are plotted for these values and the average and maximum values found out.The number of pages fetched (i.e. Parameters 3 & 4) also depend on the main memory buffer size for each of the data and overflow pages. Both of these are assumed to be one so that a page has to be fetched from the disk unless it was the previous one to be acessed.

For the purpose of repeatedly creating a tree for different input colour sequences an input tree is read from a text file and stored in a data structure in the main memory as described below.

The data structure consists of nodes stored continously, levelwise (in a breadth first manner) in an array, the root being the first element.The fields of a node are given below.

1. Path_exp: Path expression of the node.

2. Incolor_reg: Input colour register of the node.

3. child_ptr: Array index of the first child of the node.

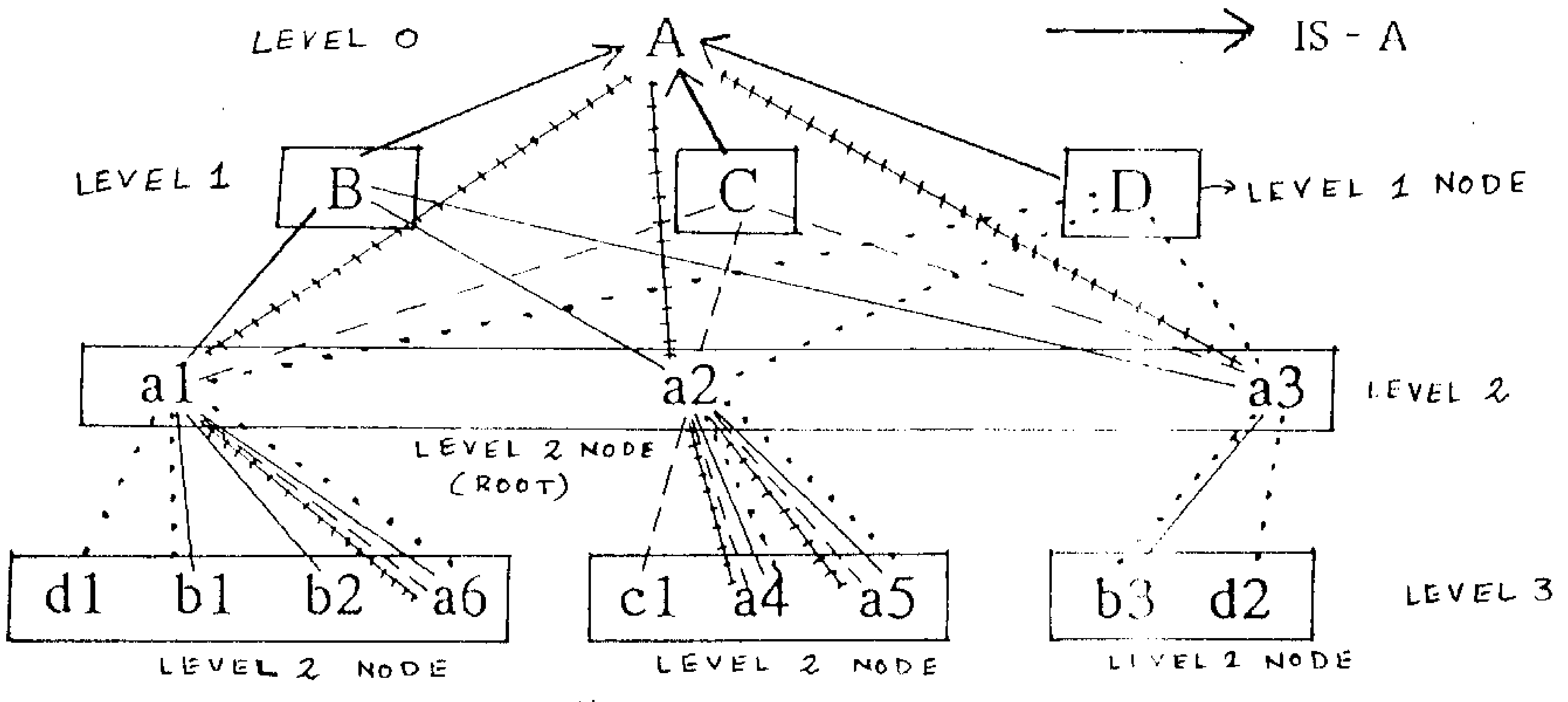
4. no_of_children: The number of children of the node.

5. visited: A boolean flag which is set whenever a new node is inserted into the name plane. So only an updation has to be made if this field is true.

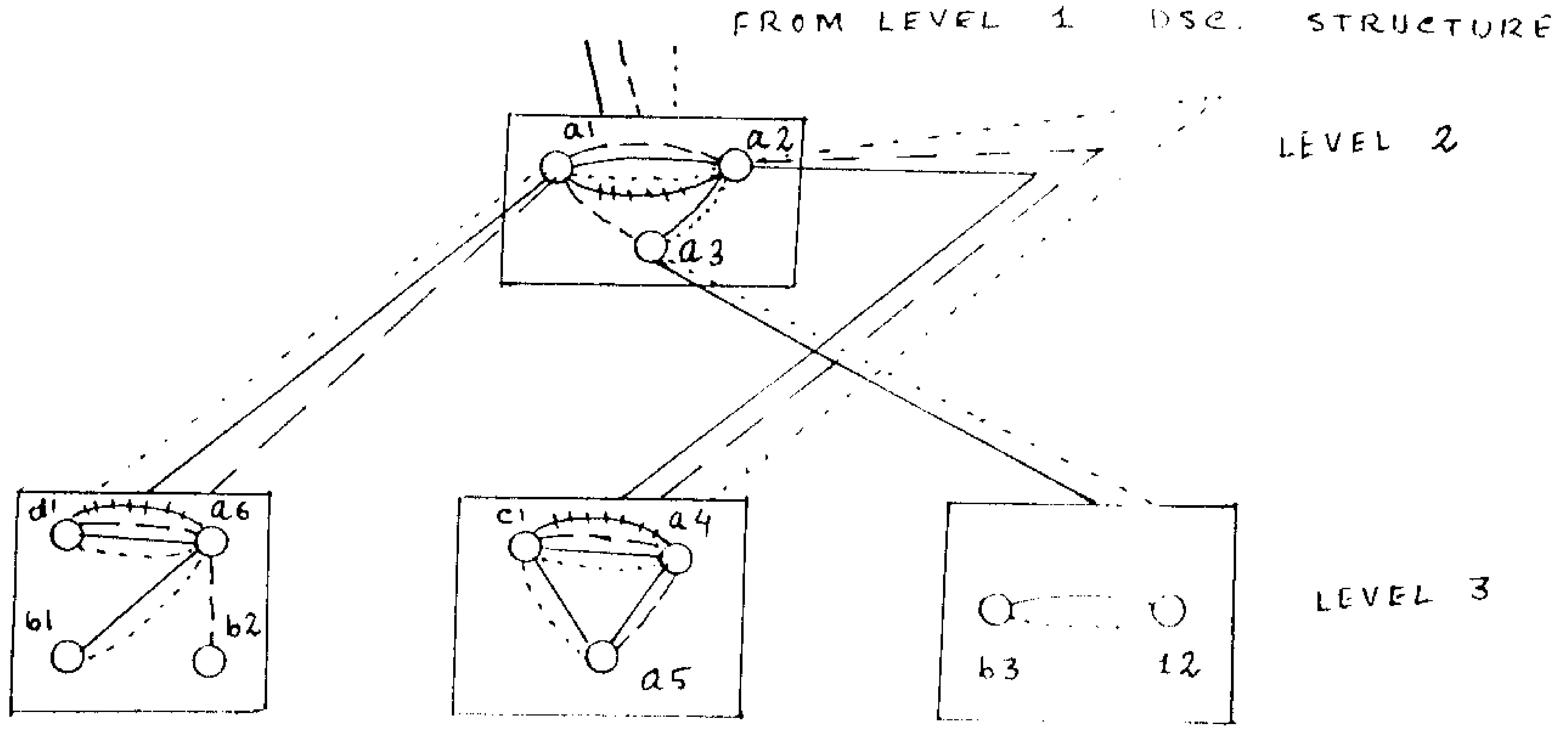
```
procedure study_performance(no_of_colors,mm_tree,no_of_nodes);
      for i:= 1 to no_of_colors do colors[i]:=i;
      initialise_for_permutations(colors,no_of_colors);
      for i:= 2 to no_of_nodes do tree[i].visited:=false;
      repeat
          initialise level-0 node;
          set all page counters to 0;
          for i:=1 to no_of_colors do
             for j:=1 to no_of_nodes do
                if tree[j].incolor_reg[colors[i]] is ON then
                  set all bits in out_color to 0;
                  for k:=tree[j].child_ptr to tree[j].child_ptr
                    + tree[j].no_of_children-1 do
                     if tree[k].incolor_reg[colors[i]] is ON
                     then
                        if tree[k].visited then
                             update incolor reg of level-2
                             node whose path expression is
```

```
                              tree[k].path_exp;
                          else
                               initialise   level-2   node   x
                              corresponding to tree[k];
                              insert(tree[j].Path_exp,x);
                              tree[k].visited:=true;
                          endif
                          out_color[k]:=1;
                       endif
                       add out_color  to  OCM  of  level-2  node
                       corresponding to tree[j].path_exp;
                    end do
                 end if
              end do
           end do
           write page counters to the output file;
       until next_permutation(colors)=false;
   end;
```

The summary of the results are given in Appendix 1 and the histograms are given in Appendix 2.



(a) NAME PLANE



(b) DESCRIPTION STRUCTURE

Fig 1. DESCRIPTION PLANE & NAME PLANE STRUCTURE.

- - - - } COLOR ARCS (LINKS).
. . . . .

+++++ GENERALIZATION ARCS (LINKS).

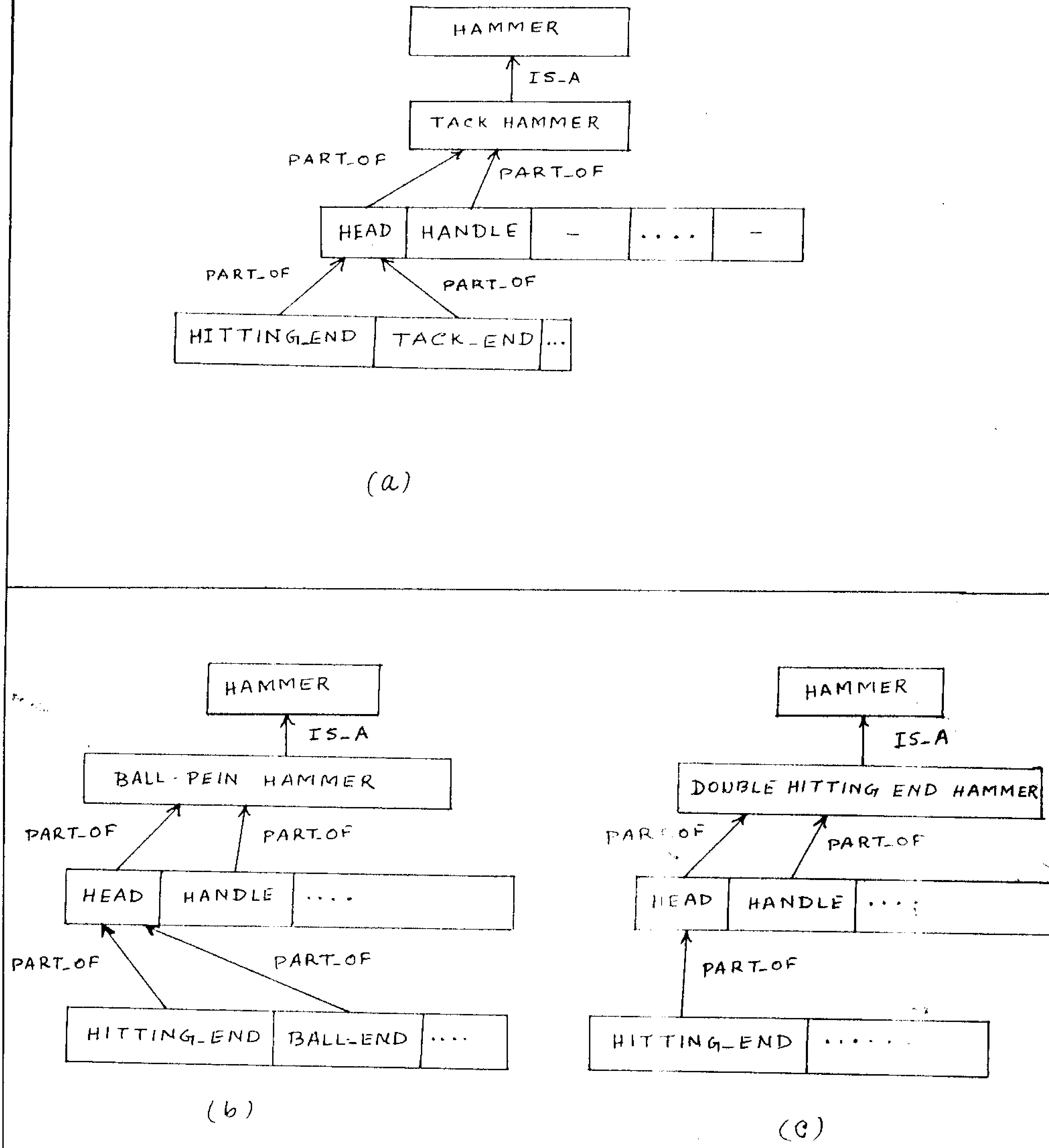
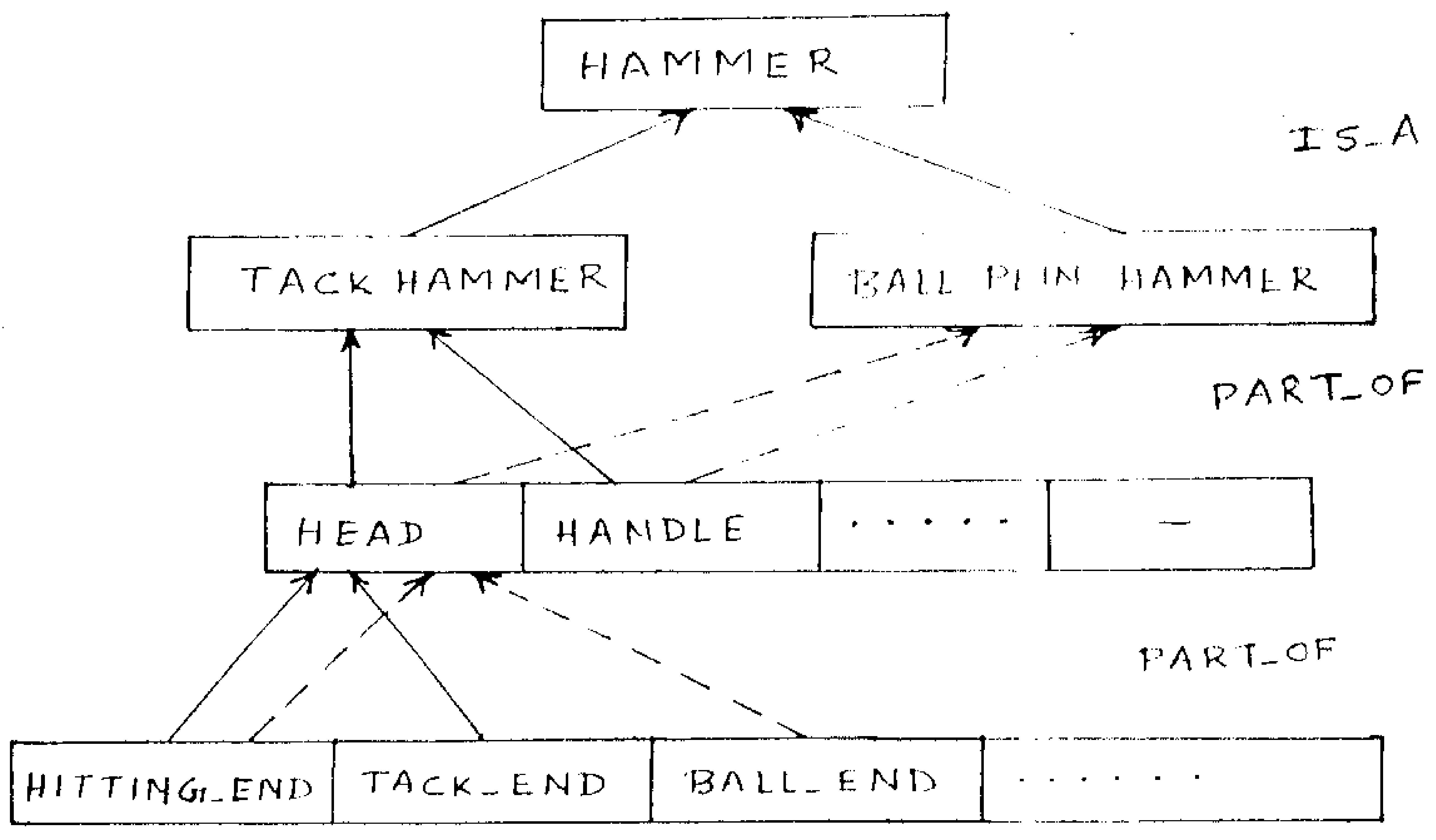


Fig 2 NAME PLANE STRUCTURE FOR DIFFERENT HAMMERS

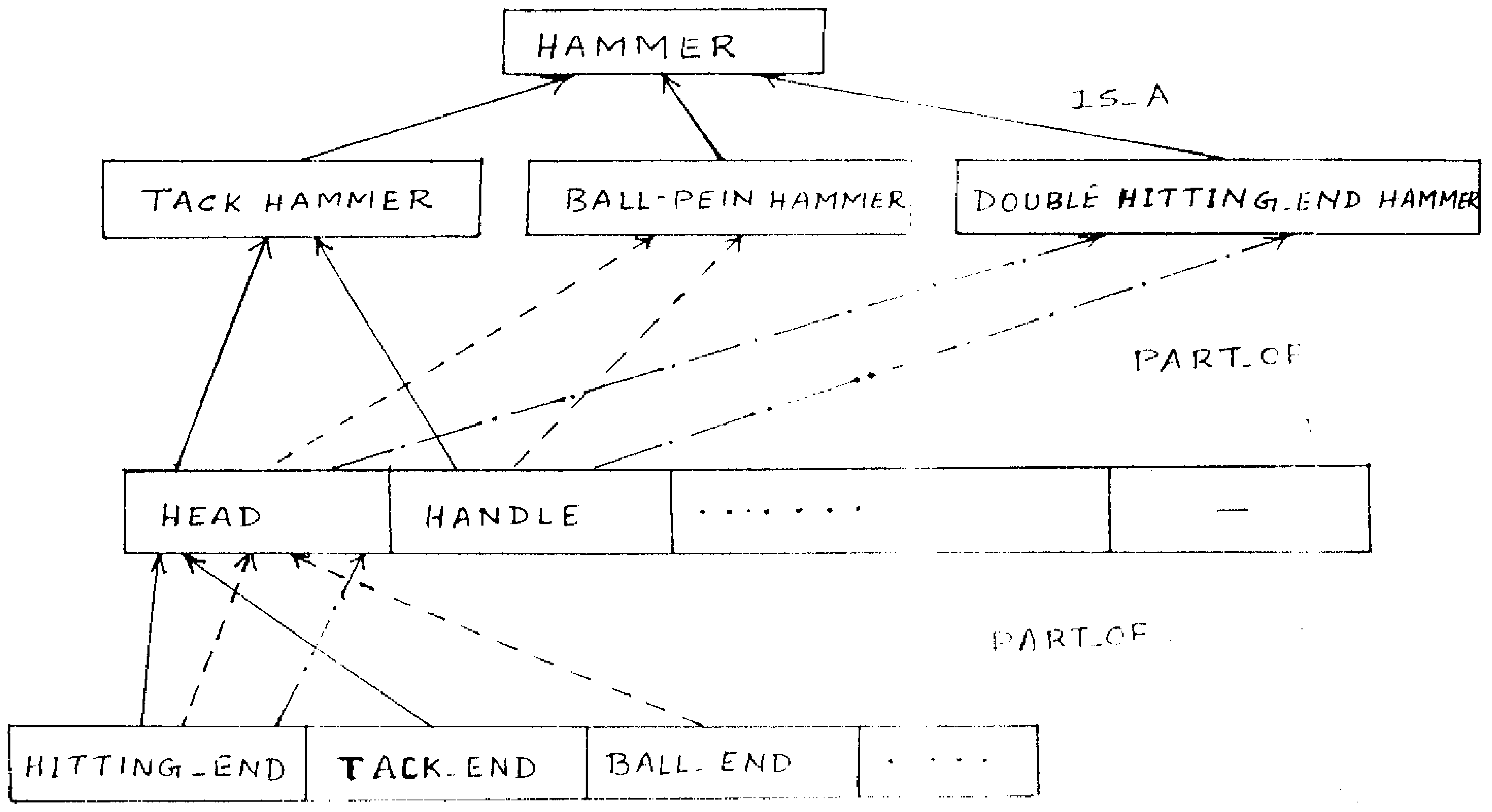
(a) TACK HAMMER

(b) BALL-PEIN HAMMER

(c) DOUBLE HITTING END HAMMER



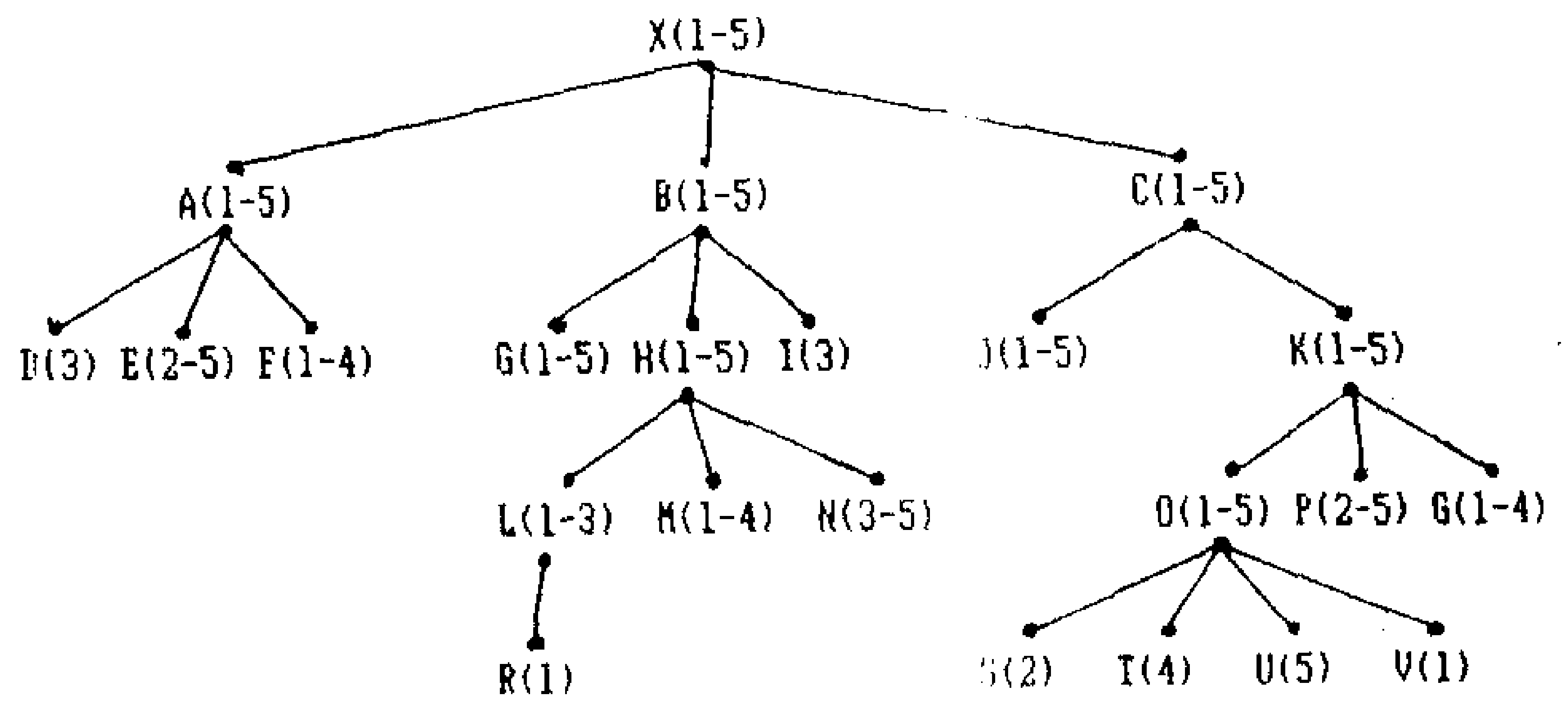
(a)



(b)

Fig 3 DEVELOPMENT OF NAME PLANE
(a) AFTER INSERTION OF BALL PEIN HAMMER INTO Fig 2a.
(b) AFTER INSERTION OF DOUBLE HITTING END HAMMER INTO (

TREE 1



TREE 2

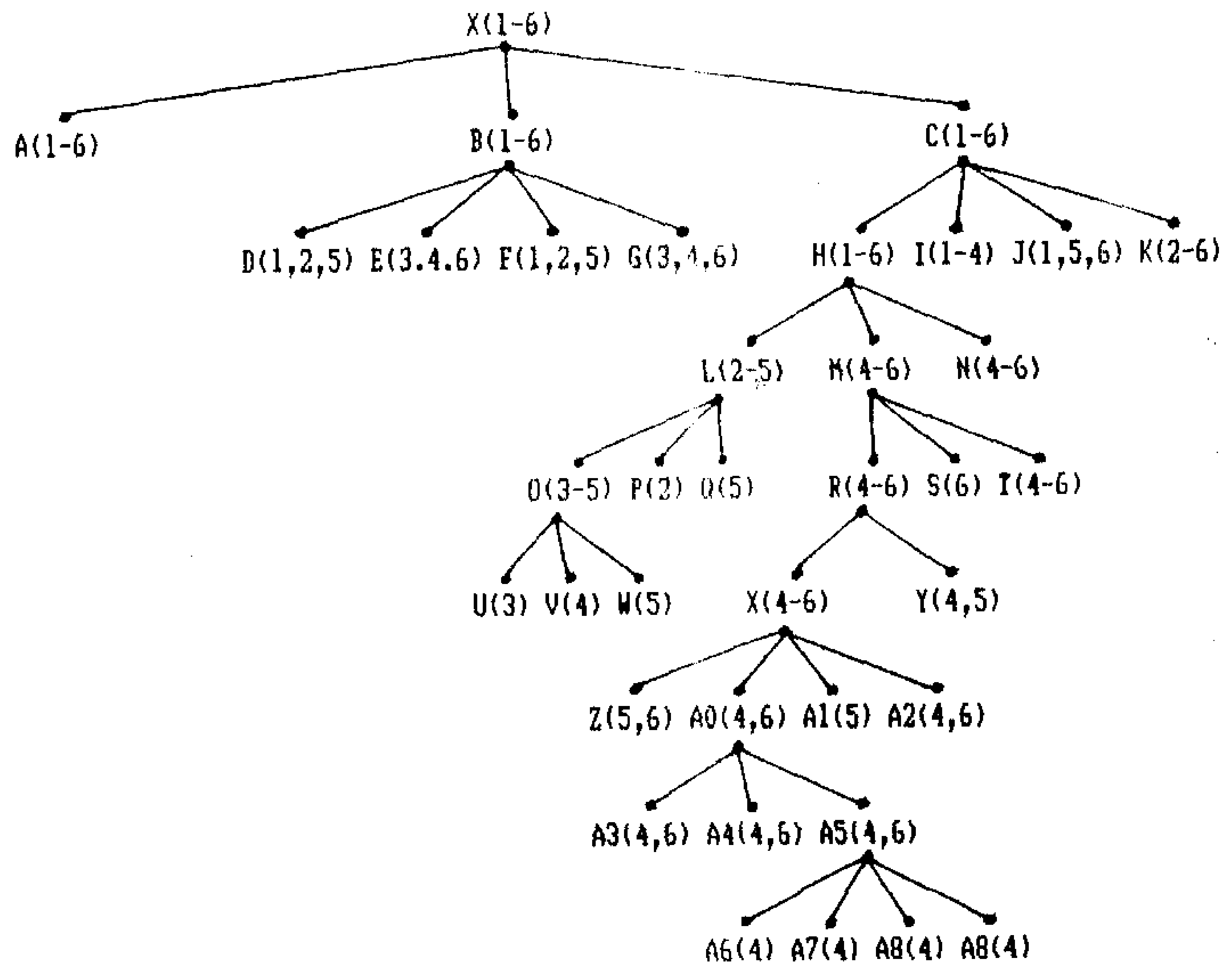
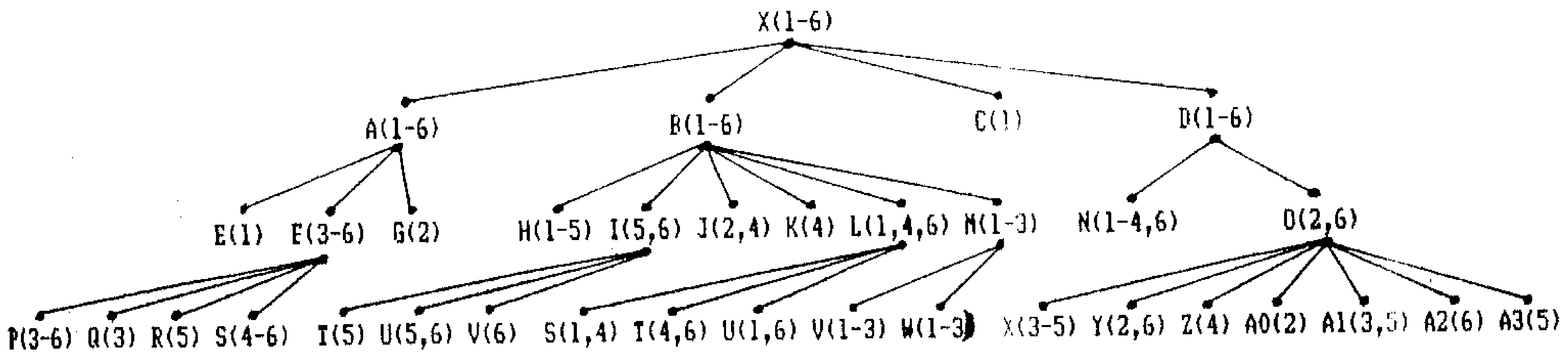


fig 4
Input Trees

Contd..

(Input colours are given in brackets)

TREE 3



TREE 4

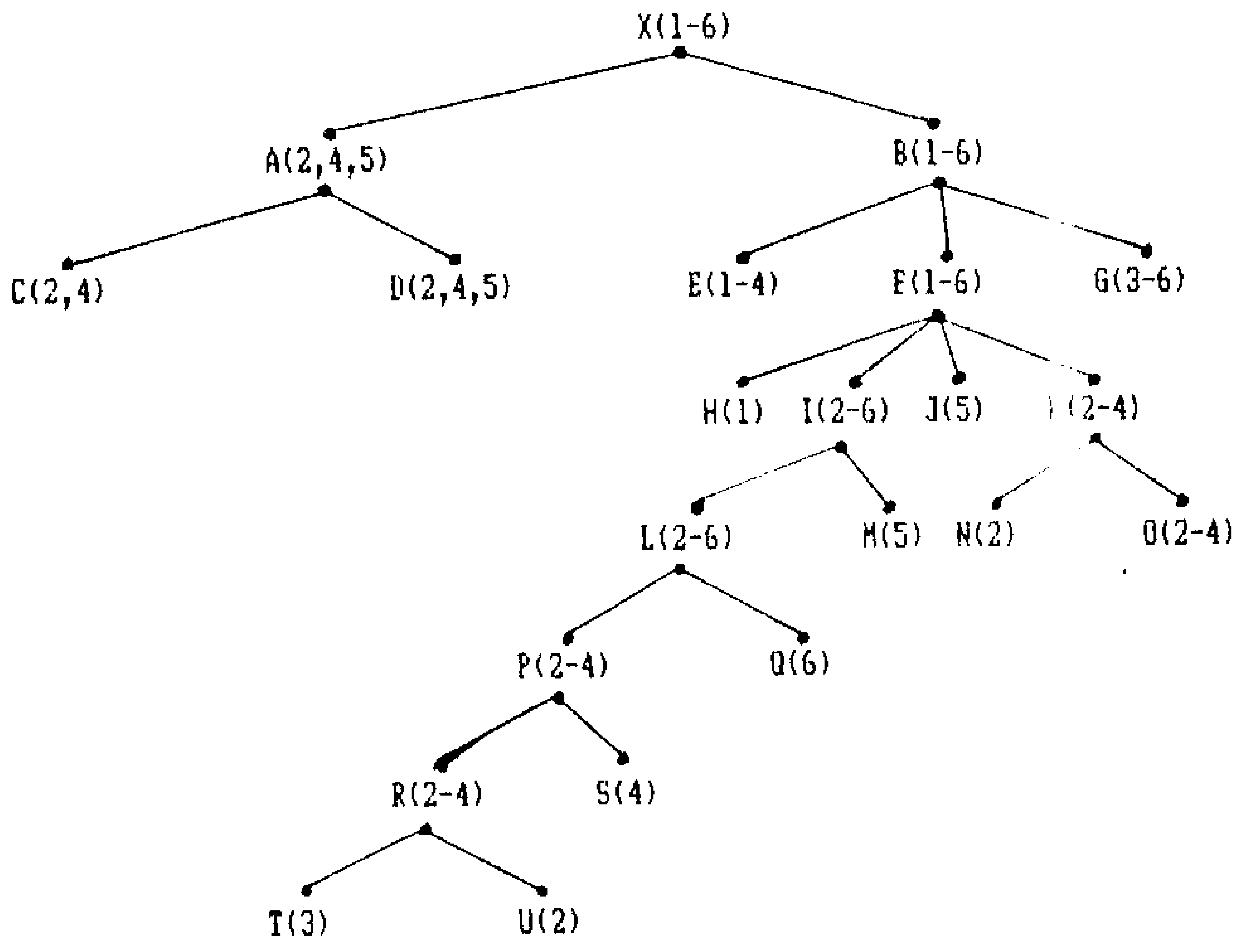


fig 4.
Input Trees

APPENDIX 1

SUMMARY OF RESULTS

Tree T1

Main Page Size	Ofl Page Size	OFL PAGES USED		MAIN PAGE FETCHES		OFL PAGE FETCHES	
		Max	Average	Maximum	Average	Max	Average
3	4	3	1.950	26	21.700	19	9.050
	5	2	1.550	26	21.700	13	6.217
	6	2	1.383	26	21.700	13	4.950
	7	2	1.358	26	21.700	13	4.842
4	5	5	4.350	1	1.000	46	31.117
	6	4	3.917	1	1.000	40	27.150
	7	3	3.000	1	1.000	39	27.333
5	6	4	4.000	0	0.000	40	27.900
	7	4	4.000	0	0.000	40	28.250

Tree T2

Main Page Size	Ofl Page Size	OFL PAGES USED		MAIN PAGE FETCHES		OFL PAGE FETCHES	
		Max	Average	Maximum	Average	Max	Average
3	4	4	2.803	34	29.417	24	15.664
	5	3	2.567	34	29.417	21	12.508
	6	3	2.354	34	29.417	22	11.468
	7	3	1.988	34	29.363	18	9.372
4	5	5	4.597	13	11.050	47	31.556
	6	4	4.000	13	11.050	38	29.140
	7	4	3.442	13	11.050	40	28.743
5	6	6	6.000	0	0.000	49	39.358
	7	6	6.000	0	0.000	52	37.775

Contd..

Tree T3

Main Page Size	Ofl Page Size	OFL PAGES USED		MAIN PAGE FETCHES		OFL PAGE FETCHES	
		Max	Average	Maximum	Average	Max	Average
3	4	4	3.017	31	25.422	35	22.486
	5	3	2.537	31	25.422	33	19.369
	6	3	2.182	31	25.422	33	17.764
	7	3	2.305	31	25.422	27	15.001
4	5	5	4.242	17	12.401	45	31.289
	6	4	3.686	17	12.401	41	28.829
	7	4	3.067	17	12.401	39	28.067
5	6	5	4.208	8	5.707	46	36.099
	7	4	4.000	8	5.707	45	36.172

Tree T4

Main Page Size	Ofl Page Size	OFL PAGES USED		MAIN PAGE FETCHES		OFL PAGE FETCHES	
		Max	Average	Maximum	Average	Max	Average
3	4	4	4.000	10	7.600	32	22.532
	5	3	3.000	10	7.600	30	20.372
	6	3	3.000	10	7.600	28	18.293
	7	3	3.000	10	7.600	23	14.900
4	5	4	4.000	1	1.000	41	28.472
	6	4	3.400	1	1.000	37	24.840
	7	3	3.000	1	1.000	33	23.281
5	6	4	4.000	0	0.000	38	27.339
	7	3	3.000	0	0.000	34	25.589

APPENDIX 2

HISTOGRAMS

HISTOGRAMS OF TREE 1

```
                   Main pg size=3 ofl pg size= 4.

               NO OF USED OVERFLOW PAGES
               -------------------------

                   8   16  24  32  40  48  56  64
                |---|---|---|---|---|---|---|---|------->freq
              1 |*****************
              2 |******************************
              3 |**************

Maximum= 3. Average= 1.950

                  NO OF OVERFLOW PAGES FREED
                  --------------------------

                   8   16  24  32  40  48  56  64  72
                |---|---|---|---|---|---|---|---|---|------->freq
              0 |**********************************
              1 |***************************

maximum= 1. Average= 0.450

                  NO OF MAIN PAGE FETCHES
                  -----------------------
                   4   8   12  16  20  24
                |---|---|---|---|---|---|------->freq
             17 |********
             18 |************
             19 |************
             20 |********
             21 |************************
             22 |************
             23 |********
             24 |************
             25 |
             26 |************************

Maximum= 26. Average= 21.700

                  NO OF OVERFLOW PAGE FETCHES
                  ---------------------------

                   4   8   12  16  20  24  28  32  36
                |---|---|---|---|---|---|---|---|---|------->freq
          1 - 3 |************************
          4 - 6 |********************
          7 - 9 |*************************
        10 - 12 |***
        13 - 15 |*********************************
        16 - 18 |***********
        19 - 21 |****

Maximum= 19. Average= 9.050
```

Contd..

```
               Main page size= 3. Ofl page size= 5.

                NO OF USED OVERFLOW PAGES
                -------------------------

          8  16  24  32  40  48  56  64  72
      |---|---|---|---|---|---|---|---|---|------->freq
    1 |***************************
    2 |*********************************

Maximum= 2. Average= 1.550


                NO OF OVERFLOW PAGES FREED
                --------------------------

          8  16  24  32  40  48  56  64
      |---|---|---|---|---|---|---|---|------->freq
    0 |******************************
    1 |******************************

Maximum= 1. Average= 0.500


                NO OF MAIN PAGE FETCHES
                -----------------------

          4   8  12  16  20  24
      |---|---|---|---|---|---|------->freq
   17 |********
   18 |************
   19 |************
   20 |********
   21 |************************
   22 |************
   23 |********
   24 |************
   25 |
   26 |************************

Maximum= 26. Average= 21.700


                NO OF OVERFLOW PAGE FETCHES
                ---------------------------

              4   8  12  16  20  24  28  32  36  40
          |---|---|---|---|---|---|---|---|---|---|------->freq
   1 -  2 |************************
   3 -  4 |
   5 -  6 |***************************
   7 -  8 |**************************************
   9 - 10 |*******************
  11 - 12 |*********
  13 - 14 |***

Maximum= 13. Average= 6.217
```

Contd..

```
              Main page size= 3. Ofl page size= 6.

                NO OF USED OVERFLOW PAGES
                -------------------------

        8  16  24  32  40  48  56  64  72  80
    ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------->freq
  1 ¦*************************************
  2 ¦***********************

Maximum= 2. Average= 1.383

                NO OF OVERFLOW PAGES FREED
                --------------------------

        8  16  24  32  40  48  56  64  72
    ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------->freq
  0 ¦***********************************
  1 ¦*************************

Maximum= 1. Average= 0.417

                NO OF MAIN PAGE FETCHES
                -----------------------

        4   8  12  16  20  24
     ¦---¦---¦---¦---¦---¦---¦------->freq
  17 ¦********
  18 ¦************
  19 ¦************
  20 ¦********
  21 ¦************************
  22 ¦************
  23 ¦********
  24 ¦************
  25 ¦
  26 ¦************************

Maximum= 26. Average= 21.700

                NO OF OVERFLOW PAGE FETCHES
                ---------------------------

              4   8  12  16  20  24  28  32  36
          ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------->freq
   1 -  2 ¦************************
   3 -  4 ¦************************************
   5 -  6 ¦*********************
   7 -  8 ¦*********************
   9 - 10 ¦************
  11 - 12 ¦***
  13 - 14 ¦***

Maximum= 13. Average= 4.950
```

Contd..

```
              Main page size= 3. Ofl page size= 7.

                  NO OF USED OVERFLOW PAGES
                  -------------------------

              8   16  24  32  40  48  56  64  72  80
          |---|---|---|---|---|---|---|---|---|---|------>freq
        1 |***************************************
        2 |**********************

Maximum= 2. Average= 1.358

                  NO OF OVERFLOW PAGES FREED
                  --------------------------

              8   16  24  32  40  48  56  64  72
          |---|---|---|---|---|---|---|---|---|------>freq
        0 |**********************************
        1 |***************************

Maximum= 1. Average= 0.442

                  NO OF MAIN PAGE FETCHES
                  -----------------------

              4   8   12  16  20  24
          |---|---|---|---|---|---|------>freq
       17 |********
       18 |************
       19 |************
       20 |********
       21 |************************
       22 |************
       23 |********
       24 |************
       25 |
       26 |************************

Maximum= 26. Average= 21.700

                  NO OF OVERFLOW PAGE FETCHE
                  ------------------------

              4   8   12  16  20  24  28   2  36
          |---|---|---|---|---|---|---|---  ---|------->freq
   1 -  2 |************************
   3 -  4 |************************************
   5 -  6 |**********************
   7 -  8 |*********************
   9 - 10 |***********
  11 - 12 |****
  13 - 14 |**

Maximum= 13. Average= 4.842
```

Contd..

```
                    Main page size= 4. Ofl page size= 5.

                         NO OF USED OVERFLOW PAGES
                         -------------------------

                       8   16   24   32   40   48   56   64   72   80
                   |---|---|---|---|---|---|---|---|---|---|------>freq
                 4 |***************************************
                 5 |*********************

         Maximum= 5. Average= 4.350

                         NO OF OVERFLOW PAGES FREED
                         --------------------------

                       8   16   24   32   40   48   56   64   72
                   |---|---|---|---|---|---|---|---|---|------>freq
                 0 |*********************************
                 1 |***************************

         Maximum= 1. Average= 0.450

                         NO OF MAIN PAGE FETCHES
                         -----------------------

                      16   32   48   64   80   96  112  128
                   |---|---|---|---|---|---|---|---|------>freq
                 1 |******************************

         Maximum= 1. Average= 1.000

                         NO OF OVERFLOW PAGE FETCHES
                         ---------------------------

                       4    8   12   16   20   24   28   32   36
                   |---|---|---|---|---|---|---|---|---|------>freq
           21 - 23 |************************************
           24 - 26 |************************************
           27 - 29 |
           30 - 32 |
           33 - 35 |
           36 - 38 |
           39 - 41 |************
           42 - 44 |************************
           45 - 47 |************

         Maximum= 46. Average= 31.117
```

Contd..

```
            Main page size= 4. Ofl page size= 6.

                 NO OF USED OVERFLOW PAGES
                 -------------------------

                 12  24  36  48  60  72  84  96  108 120
             |---|---|---|---|---|---|---|---|---|---|------->freq
           3 |***
           4 |*************************************

Maximum= 4. Average= 3.917

                 NO OF OVERFLOW PAGES FREED
                 --------------------------

                 12  24  36  48  60  72  84  96  108 120
             |---|---|---|---|---|---|---|---|---|---|------->freq
           0 |*************************************
           1 |***

Maximum= 1. Average= 0.083

                 NO OF MAIN PAGE FETCHES
                 -----------------------

                 16  32  48  64  80  96  112 128
             |---|---|---|---|---|---|---|---|------->freq
           1 |******************************

Maximum= 1. Average= 1.000

                 NO OF OVERFLOW PAGE FETCHES
                 ---------------------------

                  4   8  12  16  20  24  28  32  36  40
             |---|---|---|---|---|---|---|---|---|---|------->freq
    17 - 19  |****************************************
    20 - 22  |********
    23 - 25  |**********************
    26 - 28  |**
    29 - 31  |
    32 - 34  |
    35 - 37  |**********************************
    38 - 40  |**************

Maximum= 40. Average= 27.150
```

Contd..

```
            Main page size= 4. Ofl page size= 7.

                NO OF USED OVERFLOW PAGES
                -------------------------

              16  32  48  64  80  96  112 128
          |---|---|---|---|---|---|---|---|------->freq
        3 |******************************

Maximum= 3. Average= 3.000

                NO OF OVERFLOW PAGES FREED
                --------------------------

              16  32  48  64  80  96  112 128
          |---|---|---|---|---|---|---|---|------->freq
        0 |******************************

Maximum= 0. Average= 0.000

                NO OF MAIN PAGE FETCHES
                -----------------------

              16  32  48  64  80  96  112 128
          |---|---|---|---|---|---|---|---|------->freq
        1 |******************************

Maximum= 1. Average= 1.000

                NO OF OVERFLOW PAGE FETCHES
                ---------------------------

              4   8   12  16  20  24  28  32  36  40  44  48
          |---|---|---|---|---|---|---|---|---|---|---|---|----->freq
  15 - 17 |************************
  18 - 20 |
  21 - 23 |************************************************
  24 - 26 |
  27 - 29 |
  30 - 32 |
  33 - 35 |
  36 - 38 |****************************************
  39 - 41 |********

Maximum= 39. Average= 27.333
```

Contd..

```
                    Main page size= 5. Ofl page size= 6.

                          NO OF USED OVERFLOW PAGES
                          -------------------------

                       16  32  48  64  80  96  112 128
                   |---|---|---|---|---|---|---|---|-   ---->freq
                 4 |******************************

          Maximum= 4. Average= 4.000

                          NO OF OVERFLOW PAGES FREED
                          --------------------------

                       16  32  48  64  80  96  112 128
                   |---|---|---|---|---|---|---|---|-   ---->freq
                 0 |******************************

          Maximum= 0. Average= 0.000

                          NO OF MAIN PAGE FETCHES
                          -----------------------

                       16  32  48  64  80  96  112 128
                   |---|---|---|---|---|---|---|---|------->freq
                 0 |******************************

          Maximum= 0. Average= 0.000

                          NO OF OVERFLOW PAGE FETCHES
                          ---------------------------

                       4   8   12  16  20  24  28  32  36  40  44
                   |---|---|---|---|---|---|---|---|---|---|---|------->freq
           18 - 20 |******************************************
           21 - 23 |******
           24 - 26 |************************
           27 - 29 |
           30 - 32 |
           33 - 35 |
           36 - 38 |**********************************
           39 - 41 |**************

          Maximum= 40. Average= 27.900
```

Contd..

```
             Main page size= 5. Ofl page size= 7.

                 NO OF USED OVERFLOW PAGES
                 -------------------------

             16  32  48  64  80  96  112 128
          |---|---|---|---|---|---|---|---|  ------>freq
        4 |******************************

Maximum= 4. Average= 4.000


                 NO OF OVERFLOW PAGES FREED
                 --------------------------

             16  32  48  64  80  96  112 128
          |---|---|---|---|---|---|---|---|------>freq
        0 |******************************

Maximum= 0. Average= 0.000


                 NO OF MAIN PAGE FETCHES
                 -----------------------

             16  32  48  64  80  96  112 128
          |---|---|---|---|---|---|---|---|------>freq
        0 |******************************

Maximum= 0. Average= 0.000


                 NO OF OVERFLOW PAGE FETCHES
                 ---------------------------

              4   8   12  16  20  24  28  32  36  40  44  48
           |---|---|---|---|---|---|---|---|---|---|---|---|---->freq
  16 - 18  |************************
  19 - 21  |
  22 - 24  |************************************************
  25 - 27  |
  28 - 30  |
  31 - 33  |
  34 - 36  |
  37 - 39  |************************************
  40 - 42  |************

Maximum= 40. Average= 28.250
```

HISTOGRAMS OF TREE T2

Main page size=3. Ofl page size=4.

```
                 NO OF USED OVERFLOW PAGES
                 -------------------------

          60  120 180 240 300 360 420 480 540
        ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------->freq
      2 ¦***********
      3 ¦***********************************
      4 ¦**

Maximum= 4. Average= 2.803

                 NO OF OVERFLOW PAGES FREED
                 --------------------------

          40  80  120 160 200 240 280 320 360 400 440
        ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------->freq
      0 ¦**************************
      1 ¦******************************************
      2 ¦****

Maximum= 2. Average= 0.694

                 NO OF MAIN PAGE FETCHES
                 -----------------------

          16  32  48  64  80  96  112 128 144 160
        ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------->freq
     25 ¦***
     26 ¦*********
     27 ¦*******************
     28 ¦**************************
     29 ¦*************************************
     30 ¦***********************************
     31 ¦****************************
     32 ¦*****************
     33 ¦*******
     34 ¦**

Maximum= 34. Average= 29.417

                 NO OF OVERFLOW PAGE FETCHES
                 ---------------------------

          16  32  48  64  80  96  112 128 144 160
        ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------->freq
  7 -  8 ¦**
  9 - 10 ¦************
 11 - 12 ¦******************
 13 - 14 ¦**********************************
 15 - 16 ¦***************************************
 17 - 18 ¦**********************************
 19 - 20 ¦***************************
 21 - 22 ¦************
 23 - 24 ¦**

Maximum= 24. Average= 15.664
```

Contd..

```
            Main page size= 3. Ofl page size= 5.

                NO OF USED OVERFLOW PAGES
                -------------------------

              40  80  120 160 200 240 280 320 360 400 440
          ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------>freq
        2 ¦*******************************
        3 ¦*****************************************

Maximum= 3. Average= 2.567


                NO OF OVERFLOW PAGES FREED
                --------------------------

              60  120 180 240 300 360 420 480 540 600
          ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------>freq
        0 ¦****************************************
        1 ¦**********

Maximum= 1. Average= 0.178


                NO OF MAIN PAGE FETCHES
                -----------------------

              16  32  48  64  80  96  112 128 144 160
          ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------>freq
       25 ¦***
       26 ¦*********
       27 ¦*******************
       28 ¦**************************
       29 ¦*************************************
       30 ¦***********************************
       31 ¦****************************
       32 ¦*****************
       33 ¦*******
       34 ¦**

Maximum= 34. Average= 29.417


                NO OF OVERFLOW PAGE FETCHES
                ---------------------------

              20  40  60  80  100 120 140 160 180 200 220 240
          ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------>freq
    6 - 7 ¦****
    8 - 9 ¦*************
  10 - 11 ¦**************************************
  12 - 13 ¦********************************************
  14 - 15 ¦************************
  16 - 17 ¦********
  18 - 19 ¦*********
  20 - 21 ¦***

Maximum= 21. Average= 12.508
```

Contd..

```
           Main page size= 3. Ofl page size= 6.

               NO OF USED OVERFLOW PAGES
               -------------------------

              46  92  138 184 230 276 322 36  414 460
          ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------->freq
        1 ¦*
        2 ¦***************************************
        3 ¦***********************

 Maximum= 3. Average= 2.354

               NO OF OVERFLOW PAGES FREED
               --------------------------

              60  120 180 240 300 360 420 48  540 600
          ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------->freq
        0 ¦***************************************
        1 ¦*********

 Maximum= 1. Average= 0.188

               NO OF MAIN PAGE FETCHES
               ------------------------

              16  32  48  64  80  96  112 12  144 160
          ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------->freq
       25 ¦***
       26 ¦*********
       27 ¦*******************
       28 ¦**************************
       29 ¦*************************************
       30 ¦***********************************
       31 ¦****************************
       32 ¦*****************
       33 ¦*******
       34 ¦**

 Maximum= 34. Average= 29.417

               NO OF OVERFLOW PAGE FETCHES
               ---------------------------

              20  40  60  80  100 120 140 160 180 200
          ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------->freq
    3 -  4 ¦
    5 -  6 ¦****
    7 -  8 ¦********************
    9 - 10 ¦***********************************
   11 - 12 ¦**************************************
   13 - 14 ¦***********************
   15 - 16 ¦*************
   17 - 18 ¦******
   19 - 20 ¦****
   21 - 22 ¦**

 Maximum= 22. Average= 11.468
```

Contd..

```
            Main page size= 3. Ofl page size= 7

                   NO OF USED OVERFLOW PAGES
                   -------------------------

                 60  120 180 240 300 360 420 480 540 600 660
               |---|---|---|---|---|---|---|---|---|---|---|------>freq
             1 |**
             2 |******************************************
             3 |*

Maximum= 3. Average= 1.988


                   NO OF OVERFLOW PAGES FREED
                   --------------------------

                 60  120 180 240 300 360 420 480 540 600
               |---|---|---|---|---|---|---|---|---|---|------>freq
             0 |***************************************
             1 |******

Maximum= 1. Average= 0.139


                   NO OF MAIN PAGE FETCHES
                   -----------------------

                 12  24  36  48  60  72  84  96  108 120 132 144
               |---|---|---|---|---|---|---|---|---|---|---|---|---->freq
            25 |****
            26 |***********
            27 |*************************
            28 |*********************************
            29 |**********************************************
            30 |********************************************
            31 |*******************************
            32 |********************
            33 |*********
            34 |**

Maximum= 34. Average= 29.365


                   NO OF OVERFLOW PAGE FETCHES
                   ---------------------------

                 16  32  48  64  80  96  112 128 144 160 176 192
               |---|---|---|---|---|---|---|---|---|---|---|---|---->freq
         1 - 2 |***
         3 - 4 |***
         5 - 6 |*********************
         7 - 8 |******************************** *************
        9 - 10 |******************************** ****
       11 - 12 |*******************************
       13 - 14 |*********************
       15 - 16 |******
       17 - 18 |**

Maximum= 18. Average= 9.372
```

Contd..

```
          Main page size= 4. Ofl page size= 5.

              NO OF USED OVERFLOW PAGES
              -------------------------

           40  80  120 160 200 240 280 320 360 400 440
         |---|---|---|---|---|---|---|---|---|---|---|---|------->freq
       4 |*****************************
       5 |*******************************************

Maximum= 5. Average= 4.597

              NO OF OVERFLOW PAGES FREED
              --------------------------

           40  80  120 160 200 240 280 320 360 400 440 480
         |---|---|---|---|---|---|---|---|---|---|---|---|---|----->freq
       0 |*********************************************
       1 |***************************

Maximum= 1. Average= 0.369

              NO OF MAIN PAGE FETCHES
              -----------------------

           20  40  60  80  100 120 140 160 180 200 220
         |---|---|---|---|---|---|---|---|---|---|---|---|------->freq
       6 |*****
       7 |*****
       8 |*********
       9 |********
      10 |*******************
      11 |********************
      12 |*******************************************
      13 |***********************************

Maximum= 13. Average= 11.050

              NO OF OVERFLOW PAGE FETCHES
              ---------------------------

           32  64  96  128 160 192 224 256 288 320
         |---|---|---|---|---|---|---|---|---|---|---|------->freq
 23 - 25 |*
 26 - 28 |***************
 29 - 31 |****************************************
 32 - 34 |*******************
 35 - 37 |******
 38 - 40 |****
 41 - 43 |**
 44 - 46 |**
 47 - 49 |*

Maximum= 47. Average= 31.556
```

Contd..

```
              Main page size= 4. Ofl page size= 6

                  NO OF USED OVERFLOW PAGES
                  -------------------------

               80  160 240 320 400 480 560 640 720
            |---|---|---|---|---|---|---|---|---|------->freq
          4 |************************************

Maximum= 4. Average= 4.000

                  NO OF OVERFLOW PAGES FREED
                  --------------------------

               60  120 180 240 300 360 420 480 540 600 660
            |---|---|---|---|---|---|---|---|---|---|---|------->freq
          0 |******************************************
          1 |******

Maximum= 1. Average= 0.133

                  NO OF MAIN PAGE FETCHES
                  -----------------------

               20  40  60  80  100 120 140 160 180 200 220
            |---|---|---|---|---|---|---|---|---|---|---|------->freq
          6 |*****
          7 |*****
          8 |*********
          9 |********
         10 |*******************
         11 |********************
         12 |*******************************************
         13 |***********************************

Maximum= 13. Average= 11.050

                  NO OF OVERFLOW PAGE FETCHES
                  ---------------------------

               16  32  48  64  80  96  112 128 144 160
            |---|---|---|---|---|---|---|---|---|---|------->freq
    20 - 21 |***
    22 - 23 |*******
    24 - 25 |***************
    26 - 27 |****************************************
    28 - 29 |****************************************
    30 - 31 |******************************
    32 - 33 |*********************
    34 - 35 |*****************
    36 - 37 |*********
    38 - 39 |*

Maximum= 38. Average= 29.140
```

Contd..

```
          Main page size= 4. Ofl page size= 7.

               NO OF USED OVERFLOW PAGES
               -------------------------

          40  80 120 160 200 240 280 320 360 400 440
       |---|---|---|---|---|---|---|---|---|---|---|------->freq
     3 |****************************************
     4 |********************************

Maximum= 4. Average= 3.442

               NO OF OVERFLOW PAGES FREED
               --------------------------

          40  80 120 160 200 240 280 320 360 400 440 480
       |---|---|---|---|---|---|---|---|---|---|---|---|---->freq
     0 |***********************************************
     1 |*************************

Maximum= 1. Average= 0.353

               NO OF MAIN PAGE FETCHES
               -----------------------

          20  40  60  80 100 120 140 160 180 200 220
       |---|---|---|---|---|---|---|---|---|---|---|------->freq
     6 |*****
     7 |*****
     8 |*********
     9 |********
    10 |*******************
    11 |********************
    12 |*******************************************
    13 |***********************************

Maximum= 13. Average= 11.050

               NO OF OVERFLOW PAGE FETCHES
               ---------------------------

          16  32  48  64  80  96 112 128 144 160 176
       |---|---|---|---|---|---|---|---|---|---|---|------->freq
19 - 21 |*********
22 - 24 |****************************
25 - 27 |****************************************
28 - 30 |*****************************************
31 - 33 |*****************************
34 - 36 |***********************
37 - 39 |**********
40 - 42 |*

Maximum= 40. Average= 28.743
```

Contd..

```
                Main page size= 5. Ofl page size= 6.

                 NO OF USED OVERFLOW PAGES
                 -------------------------

              80  160 240 320 400 480 560 640 720
           |---|---|---|---|---|---|---|---|---|------>freq
         6 |************************************

Maximum= 6. Average= 6.000

                 NO OF OVERFLOW PAGES FREED
                 --------------------------

              80  160 240 320 400 480 560 640 720
           |---|---|---|---|---|---|---|---|---|------>freq
         0 |************************************

Maximum= 0. Average= 0.000

                 NO OF MAIN PAGE FETCHES
                 ------------------------

              80  160 240 320 400 480 560 640 720
           |---|---|---|---|---|---|---|---|---|------>freq
         0 |************************************

Maximum= 0. Average= 0.000

                 NO OF OVERFLOW PAGE FETCHES
                 ---------------------------

              24  48  72  96  120 144 168 192 216 240 264
           |---|---|---|---|---|---|---|---|---|---|---|------>freq
  32 - 33  |***
  34 - 35  |************
  36 - 37  |*****************************************
  38 - 39  |*********************
  40 - 41  |***********
  42 - 43  |******
  44 - 45  |******
  46 - 47  |**************
  48 - 49  |*******

Maximum= 49. Average= 39.358
```

Contd..

```
                  Main page size= 5. Ofl page size= 7.

                   NO OF USED OVERFLOW PAGES
                   -------------------------

                 80  160 240 320 400 480 560 640 720
             |---|---|---|---|---|---|---|---|---|---|------->freq
          6  |************************************

Maximum= 6. Average= 6.000

                   NO OF OVERFLOW PAGES FREED
                   --------------------------

                 80  160 240 320 400 480 560 640 720
             |---|---|---|---|---|---|---|---|---|---|------->freq
          0  |************************************

Maximum= 0. Average= 0.000

                   NO OF MAIN PAGE FETCHES
                   -----------------------

                 80  160 240 320 400 480 560 640 720
             |---|---|---|---|---|---|---|---|---|---|------->freq
          0  |************************************

Maximum= 0. Average= 0.000

                   NO OF OVERFLOW PAGE FETCHES
                   ---------------------------

                 20  40  60  80  100 120 140 160 180 200 220
             |---|---|---|---|---|---|---|---|---|---|---|---|------->freq
   29 - 31   |**********
   32 - 34   |******************************************
   35 - 37   |*******************************************
   38 - 40   |*****************
   41 - 43   |****
   44 - 46   |*******
   47 - 49   |*****************
   50 - 52   |****

Maximum= 52. Average= 37.775
```

HISTOGRAMS OF TREE 13

```
              Main page size= 3. Ofl page size= 4.

                 NO OF USED OVERFLOW PAGES
                 -------------------------

            48  96 144 192 240 288 336 384 432 480 528 576
         ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---->freq
       2 ¦*******
       3 ¦**********************************************
       4 ¦********

Maximum= 4. Average= 3.017

                 NO OF OVERFLOW PAGES FREED
                 --------------------------

            40  80 120 160 200 240 280 320 360 400 440 480
         ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---->freq
       0 ¦**********************
       1 ¦***********************************************
       2 ¦****

Maximum= 2. Average= 0.750

                 NO OF MAIN PAGE FETCHES
                 -----------------------

            12  24  36  48  60  72  84  96 108 120 132 144
         ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---->freq
      20 ¦*
      21 ¦******
      22 ¦****************
      23 ¦********************
      24 ¦****************************************
      25 ¦*********************************************
      26 ¦**************************************
      27 ¦**********************************
      28 ¦********************
      29 ¦**************
      30 ¦******
      31 ¦*
Maximum= 31. Average= 25.422

                 NO OF OVERFLOW PAGE FETCHES
                 ---------------------------

            16  32  48  64  80  96 112 128 144 160
         ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------->freq
 14 - 15 ¦***
 16 - 17 ¦*************
 18 - 19 ¦***********************
 20 - 21 ¦**********************************
 22 - 23 ¦**************************************
 24 - 25 ¦*******************************
 26 - 27 ¦************************
 28 - 29 ¦*********
 30 - 31 ¦****
 32 - 33 ¦**

Maximum= 35. Average= 22.486                         Contd..
```

```
                    Main page size= 3. Ofl page size= 5.

                      NO OF USED OVERFLOW PAGES
                      -------------------------

                40  80  120 160 200 240 280 320 360 400
            |---|---|---|---|---|---|---|---|---|---|------->freq
          2 |*********************************
          3 |***************************************

Maximum= 3. Average= 2.537

                      NO OF OVERFLOW PAGES FREED
                      --------------------------

                40  80  120 160 200 240 280 320 360 400 440
            |---|---|---|---|---|---|---|---|---|---|---|------->freq
          0 |****************************************
          1 |********************************

Maximum= 1. Average= 0.443

                      NO OF MAIN PAGE FETCHES
                      -----------------------

                12  24  36  48  60  72  84  96  108 120 132 144
            |---|---|---|---|---|---|---|---|---|---|---|---|---->freq
         20 |*
         21 |******
         22 |****************
         23 |********************
         24 |****************************************
         25 |*********************************************
         26 |**************************************
         27 |**********************************
         28 |********************
         29 |**************
         30 |******
         31 |*

Maximum= 31. Average= 25.422

                      NO OF OVERFLOW PAGE FETCHES
                      ---------------------------

                16  32  48  64  80  96  112 128 144 160 176
            |---|---|---|---|---|---|---|---|---|---|---|------->freq
    10 - 11 |*
    12 - 13 |*****
    14 - 15 |*******************
    16 - 17 |*********************************
    18 - 19 |******************************************
    20 - 21 |************************************
    22 - 23 |************************
    24 - 25 |***********
    26 - 27 |*****
    28 - 29 |***
    30 - 31 |**
    32 - 33 |*

Maximum= 33. Average= 19.369
```

Contd..

```
              Main page size= 3. Ofl page size= 6.

                NO OF USED OVERFLOW PAGES
                -------------------------

              60  120 180 240 300 360 420 480 540 600
           |---|---|---|---|---|---|---|---|---|---|------->freq
         2 |***************************************
         3 |*********

Maximum= 3. Average= 2.182

                NO OF OVERFLOW PAGES FREED
                --------------------------

              40  80  120 160 200 240 280 320 360 400 440
           |---|---|---|---|---|---|---|---|---|---|---|------->freq
         0 |******************************
         1 |******************************************

Maximum= 1. Average= 0.585

                NO OF MAIN PAGE FETCHES
                ------------------------

              12  24  36  48  60  72  84  96  108 120 132 144
           |---|---|---|---|---|---|---|---|---|---|---|---|----->freq
        20 |*
        21 |******
        22 |****************
        23 |********************
        24 |****************************************
        25 |*********************************************
        26 |**************************************
        27 |**********************************
        28 |********************
        29 |**************
        30 |******
        31 |*

Maximum= 31. Average= 25.422

                NO OF OVERFLOW PAGE FETCHES
                ---------------------------

              16  32  48  64  80  96  112 128 144 160 176
           |---|---|---|---|---|---|---|---|---|---|---|------->freq
    9 - 10 |***
   11 - 12 |************
   13 - 14 |*************************
   15 - 16 |*****************************************
   17 - 18 |**************************************
   19 - 20 |************************
   21 - 22 |***********
   23 - 24 |***********
   25 - 26 |********
   27 - 28 |*****
   29 - 30 |**
   31 - 32 |*
   33 - 34 |

Maximum= 33. Average= 17.764                                 Contd..
```

```
          Main page size= 3. Ofl page size= 7.

                 NO OF USED OVERFLOW PAGES
                 -------------------------

             60  120 180 240 300 360 420 480 540 600 660 720
          |---|---|---|---|---|---|---|---|---|---|---|---|---->freq
        1 |*
        2 |*********************************************
        3 |**

Maximum= 3. Average= 2.035

                 NO OF OVERFLOW PAGES FREED
                 --------------------------

             60  120 180 240 300 360 420 480 540 600 660
          |---|---|---|---|---|---|---|---|---|---|---|------->freq
        0 |****************************************
        1 |********

Maximum= 1. Average= 0.157

                 NO OF MAIN PAGE FETCHES
                 -----------------------

             12  24  36  48  60  72  84  96  108 120 132 144
          |---|---|---|---|---|---|---|---|---|---|---|---|---->freq
       20 |*
       21 |******
       22 |****************
       23 |********************
       24 |****************************************
       25 |*********************************************
       26 |**************************************
       27 |**********************************
       28 |********************
       29 |**************
       30 |******
       31 |*

Maximum= 31. Average= 25.422

                 NO OF OVERFLOW PAGE FETCHES
                 ---------------------------

             16  32  48  64  80  96  112 128 144 160 176
          |---|---|---|---|---|---|---|---|---|---|---|------->freq
    5 - 6 |*
    7 - 8 |***
   9 - 10 |***********
  11 - 12 |******************************
  13 - 14 |*****************************************
  15 - 16 |***************************************
  17 - 18 |********************************
  19 - 20 |************
  21 - 22 |*****
  23 - 24 |*****
  25 - 26 |***
  27 - 28 |

Maximum= 27. Average= 15.001                              Contd..
```

```
            Main page size= 4. Ofl page size= 5.

                NO OF USED OVERFLOW PAGES
                -------------------------

       48  96 144 192 240 288 336 384 432 480 528 576
    ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---->freq
  4 ¦**********************************************
  5 ¦***************

Maximum= 5. Average= 4.242

                NO OF OVERFLOW PAGES FREED
                --------------------------

       60 120 180 240 300 360 420 480 540 600 660 720
    ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---->freq
  0 ¦*********************************************
  1 ¦***

Maximum= 1. Average= 0.061

                NO OF MAIN PAGE FETCHES
                -----------------------

       12  24  36  48  60  72  84  96 108 120
    ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------>freq
  7 ¦**
  8 ¦******
  9 ¦***************
 10 ¦***************************
 11 ¦***********************************
 12 ¦*********************************
 13 ¦*************************************
 14 ¦************************************
 15 ¦*****************************
 16 ¦****************
 17 ¦****

Maximum= 17. Average= 12.461

                NO OF OVERFLOW PAGE FETCHES
                ---------------------------

           16  32  48  64  80  96 112 128 144 160 176
        ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------>freq
22 - 23 ¦***
24 - 25 ¦******
26 - 27 ¦**********************
28 - 29 ¦******************************
30 - 31 ¦******************************************
32 - 33 ¦***********************************
34 - 35 ¦********************
36 - 37 ¦************
38 - 39 ¦*****
40 - 41 ¦****
42 - 43 ¦**
44 - 45 ¦*

Maximum= 45. Average= 31.289
```

Contd..

```
                    Main page size= 4. Ofl page size= 6.

                         NO OF USED OVERFLOW PAGES
                         -------------------------

                   48  96  144 192 240 288 336 384 432 480 528
                 |---|---|---|---|---|---|---|---|---|---|---|------>freq
              3  |*******************
              4  |*****************************************

 Maximum= 4. Average= 3.686

                         NO OF OVERFLOW PAGES FREED
                         --------------------------

                   60  120 180 240 300 360 420 480 540 600 660 720
                 |---|---|---|---|---|---|---|---|---|---|---|---|--->freq
              0  |***********************************************
              1  |*

 Maximum= 1. Average= 0.031

                         NO OF MAIN PAGE FETCHES
                         -----------------------

                   12  24  36  48  60  72  84  96  108 120
                 |---|---|---|---|---|---|---|---|---|---|------>freq
              7  |**
              8  |******
              9  |***************
             10  |***************************
             11  |***********************************
             12  |*********************************
             13  |*************************************
             14  |************************************
             15  |*****************************
             16  |****************
             17  |****

 Maximum= 17. Average= 12.461

                         NO OF OVERFLOW PAGE FETCHES
                         ---------------------------

                   16  32  48  64  80  96  112 128 144 160
                 |---|---|---|---|---|---|---|---|---|---|------>freq
        20 - 21  |*
        22 - 23  |*********
        24 - 25  |**********************
        26 - 27  |***************************************
        28 - 29  |************************************
        30 - 31  |*******************************
        32 - 33  |************************
        34 - 35  |**********
        36 - 37  |*****
        38 - 39  |***
        40 - 41  |*

 Maximum= 41. Average= 28.829
```

Contd..

```
            Main page size= 4. Ofl page size= 7.

              NO OF USED OVERFLOW PAGES
              -------------------------

         60  120 180 240 300 360 420 480 540 600 660 720
     |---|---|---|---|---|---|---|---|---|---|---|---|----->freq
   3 |*********************************************
   4 |***

Maximum= 4. Average= 3.067

              NO OF OVERFLOW PAGES FREED
              --------------------------

         60  120 180 240 300 360 420 480 540 600 660 720
     |---|---|---|---|---|---|---|---|---|---|---|---|----->freq
   0 |************************************************

Maximum= 0. Average= 0.000

              NO OF MAIN PAGE FETCHES
              -----------------------

         12  24  36  48  60  72  84  96  108 120
     |---|---|---|---|---|---|---|---|---|---|------->freq
   7 |**
   8 |******
   9 |***************
  10 |***************************
  11 |***********************************
  12 |*********************************
  13 |*************************************
  14 |************************************
  15 |*****************************
  16 |****************
  17 |****

Maximum= 17. Average= 12.461

              NO OF OVERFLOW PAGE FETCHES
              ---------------------------

         12  24  36  48  60  72  84  96  108 120 132 144
     |---|---|---|---|---|---|---|---|---|---|---|---|----->freq
18 - 19 |*
20 - 21 |***********
22 - 23 |*****************
24 - 25 |****************************************
26 - 27 |******************************************
28 - 29 |**********************************************
30 - 31 |************************************
32 - 33 |********************
34 - 35 |****************
36 - 37 |*********
38 - 39 |**

Maximum= 39. Average= 28.067
```

Contd..

```
                Main page size= 5. Ofl page size= 6.

                 NO OF USED OVERFLOW PAGES
                 -------------------------

             48  96  144 192 240 288 336 381 432 480 528 576
           |---|---|---|---|---|---|---|---|---|---|---|---|---  >freq
         4 |************************************************
         5 |*************

Maximum= 5. Average= 4.208

                 NO OF OVERFLOW PAGES FREED
                 --------------------------

             60  120 180 240 300 360 420 480 540 600 660 720
           |---|---|---|---|---|---|---|---|---|---|---|---|---->freq
         0 |***********************************************
         1 |*

Maximum= 1. Average= 0.031

                 NO OF MAIN PAGE FETCHES
                 -----------------------

             32  64  96  128 160 192 224 256 288 320 352
           |---|---|---|---|---|---|---|---|---|---|---|------>freq
         4 |***********
         5 |********************
         6 |*******************************************
         7 |************
         8 |*****

Maximum= 8. Average= 5.767

                 NO OF OVERFLOW PAGE FETCHES
                 ---------------------------

             16  32  48  64  80  96  112 128 144 160
           |---|---|---|---|---|---|---|---|---|---|------>freq
   27 - 28 |**
   29 - 30 |********
   31 - 32 |**********************
   33 - 34 |********************************
   35 - 36 |**************************************
   37 - 38 |********************************
   39 - 40 |*************************
   41 - 42 |****************
   43 - 44 |*****
   45 - 46 |***

Maximum= 46. Average= 36.099
```

Contd..

```
          Main page size= 5. Ofl page size= 7.

             NO OF USED OVERFLOW PAGES
             -------------------------

          80  160 240 320 400 480 560 640 720
       |---|---|---|---|---|---|---|---|---|------->freq
     4 |*************************************

Maximum= 4. Average= 4.000

             NO OF OVERFLOW PAGES FREED
             --------------------------

          80  160 240 320 400 480 560 640 720
       |---|---|---|---|---|---|---|---|---|------->freq
     0 |*************************************

Maximum= 0. Average= 0.000

             NO OF MAIN PAGE FETCHES
             -----------------------

          32  64  96  128 160 192 224 256 288 320 352
       |---|---|---|---|---|---|---|---|   |---|---|------->freq
     4 |***********
     5 |********************
     6 |*******************************************
     7 |************
     8 |*****

Maximum= 8. Average= 5.767

             NO OF OVERFLOW PAGE FETCHES
             ---------------------------

          20  40  60  80  100 120 140 160 180 200
       |---|---|---|---|---|---|---|---|---|---|------->freq
 28 - 29 |*
 30 - 31 |********
 32 - 33 |*******************
 34 - 35 |*********************************
 36 - 37 |***************************************
 38 - 39 |***********************
 40 - 41 |************
 42 - 43 |*******
 44 - 45 |**

Maximum= 45. Average= 36.172
```

HISTOGRAMS OF TREE T4

```
Main page size= 3. Ofl page size= 4.

          NO OF USED OVERFLOW PAGES
          -------------------------

       80  160 240 320 400 480 560 640 720
   ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------->freq
 4 ¦************************************

Maximum= 4. Average= 4.000

          NO OF OVERFLOW PAGES FREED
          --------------------------

       80  160 240 320 400 480 560 640 720
   ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------->freq
 0 ¦************************************

Maximum= 0. Average= 0.000

          NO OF MAIN PAGE FETCHES
          -----------------------

       20  40  60  80  100 120 140 160 180 200 220 240
   ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦----->freq
 3 ¦*****
 4 ¦**********
 5 ¦*****
 6 ¦***********************
 7 ¦*******
 8 ¦**********************************************
 9 ¦****************
10 ¦****************************

Maximum= 10. Average= 7.600

          NO OF OVERFLOW PAGE FETCHES
          ---------------------------

            16  32  48  64  80  96  112 128 144 160 176
        ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------->freq
16 - 17 ¦********
18 - 19 ¦************************
20 - 21 ¦***************************************
22 - 23 ¦*****************************************
24 - 25 ¦*************************
26 - 27 ¦*****************
28 - 29 ¦**************
30 - 31 ¦******
32 - 33 ¦*

Maximum= 32. Average= 22.532
                                                     Contd..
            Main page size= 3. Ofl page size= 5.

                 NO OF USED OVERFLOW PAGES
                 -------------------------

       80 160 240 320 400 480 560 640 720
    ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------->freq
  3 ¦************************************

Maximum= 3. Average= 3.000

                 NO OF OVERFLOW PAGES FREED
                 --------------------------

       80 160 240 320 400 480 560 640 720
    ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦------->freq
  0 ¦************************************

Maximum= 0. Average= 0.000

                 NO OF MAIN PAGE FETCHES
                 -----------------------

       20  40  60  80 100 120 140 160 180 200 220 240
    ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---->freq
  3 ¦*****
  4 ¦**********
  5 ¦*****
  6 ¦************************
  7 ¦*******
  8 ¦************************************************
  9 ¦*****************
 10 ¦*****************************

Maximum= 10. Average= 7.600

                 NO OF OVERFLOW PAGE FETCHES
                 ---------------------------

          16  32  48  64  80  96 112 128 144 160 176 192
        ¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---¦---->freq
13 - 14 ¦******
15 - 16 ¦*****************
17 - 18 ¦*************************
19 - 20 ¦**************************************
21 - 22 ¦********************************************
23 - 24 ¦********************************************
25 - 26 ¦****
27 - 28 ¦*
29 - 30 ¦**

Maximum= 30. Average= 20.372
```

Contd..

```
                    Main page size= 3. Ofl page size= 6.

                      NO OF USED OVERFLOW PAGES
                      -------------------------

                 80  160 240 320 400 480 560 640 720
               |---|---|---|---|---|---|---|---|---|---|------->freq
             3 |************************************

Maximum= 3. Average= 3.000

                      NO OF OVERFLOW PAGES FREED
                      --------------------------

                 80  160 240 320 400 480 560 640 720
               |---|---|---|---|---|---|---|---|---|---|------->freq
             0 |************************************

Maximum= 0. Average= 0.000

                      NO OF MAIN PAGE FETCHES
                      -----------------------

                 20  40  60  80  100 120 140 160 180 200 220 240
               |---|---|---|---|---|---|---|---|---|---|---|---|---|----->freq
             3 |*****
             4 |**********
             5 |*****
             6 |************************
             7 |*******
             8 |************************************************
             9 |*****************
            10 |*****************************

Maximum= 10. Average= 7.600

                      NO OF OVERFLOW PAGE FETCHES
                      ---------------------------

                 16  32  48  64  80  96  112 128 144 160
               |---|---|---|---|---|---|---|---|---|---|---|------->freq
       13 - 14 |*******************************
       15 - 16 |**************************************
       17 - 18 |*****************
       19 - 20 |***************************************
       21 - 22 |***************************************
       23 - 24 |***************
       25 - 26 |**
       27 - 28 |*

Maximum= 28. Average= 18.293
```

Contd..

```
                    Main page size= 3. Ofl page size= 7

                     NO OF USED OVERFLOW PAGES
                     -------------------------

                   80  160 240 320 400 480 560 640 720
                |---|---|---|---|---|---|---|---|---|------->freq
              3 |************************************

Maximum= 3. Average= 3.000

                     NO OF OVERFLOW PAGES FREED
                     --------------------------

                   80  160 240 320 400 480 560 640 720
                |---|---|---|---|---|---|---|---|---|------->freq
              0 |************************************

Maximum= 0. Average= 0.000

                     NO OF MAIN PAGE FETCHES
                     -----------------------

                   20  40  60  80  100 120 140 160 180 200 220 240
                |---|---|---|---|---|---|---|---|---|---|---|---|----->freq
              3 |*****
              4 |**********
              5 |*****
              6 |************************
              7 |*******
              8 |************************************************
              9 |*****************
             10 |*****************************

Maximum= 10. Average= 7.600

                     NO OF OVERFLOW PAGE FETCHES
                     ---------------------------

                   16  32  48  64  80  96  112 128 144 160
                |---|---|---|---|---|---|---|---|---|---|------->freq
          8 - 9 |******************
         10 - 11 |**************************************
         12 - 13 |********************
         14 - 15 |*******************
         16 - 17 |****************************
         18 - 19 |**********************
         20 - 21 |**************************
         22 - 23 |***********

Maximum= 23. Average= 14.900
```

Contd..

```
                         Main page size= 4. Ofl page size= 5.

                           NO OF USED OVERFLOW PAGES
                           -------------------------

                        80  160 240 320 400 480 560 640 720
                     |---|---|---|---|---|---|---|---|---|------->freq
                   4 |************************************

Maximum= 4. Average= 4.000

                           NO OF OVERFLOW PAGES FREED
                           --------------------------

                        80  160 240 320 400 480 560 640 720
                     |---|---|---|---|---|---|---|---|---|------->freq
                   0 |************************************

Maximum= 0. Average= 0.000

                           NO OF MAIN PAGE FETCHES
                           -----------------------

                        80  160 240 320 400 480 560 640 720
                     |---|---|---|---|---|---|---|---|---|------->freq
                   1 |************************************

Maximum= 1. Average= 1.000

                           NO OF OVERFLOW PAGE FETCHES
                           ---------------------------

                        24  48  72  96  120 144 168 192 216 240 264
                     |---|---|---|---|---|---|---|---|---|---|---|------->freq
             18 - 20 |*********
             21 - 23 |************
             24 - 26 |*****************
             27 - 29 |*****************************************
             30 - 32 |*************
             33 - 35 |***************
             36 - 38 |**********
             39 - 41 |***

Maximum= 41. Average= 28.472
```

Contd..

```
                  Main page size= 4. Ofl page size= 6.

                    NO OF USED OVERFLOW PAGES
                    -------------------------

                  40  80  120 160 200 240 280 320 360 400 440
              |---|---|---|---|---|---|---|---|---|---|---|------->freq
            3 |*******************************************
            4 |*****************************

Maximum= 4. Average= 3.400

                    NO OF OVERFLOW PAGES FREED
                    --------------------------

                  60  120 180 240 300 360 420 480 540 600 660 720
              |---|---|---|---|---|---|---|---|---|---|---|---|----->freq
            0 |**********************************************
            1 |**

Maximum= 1. Average= 0.033

                    NO OF MAIN PAGE FETCHES
                    -----------------------

                  80  160 240 320 400 480 560 640 720
              |---|---|---|---|---|---|---|---|---|------->freq
            1 |************************************

Maximum= 1. Average= 1.000

                    NO OF OVERFLOW PAGE FETCHES
                    ---------------------------

                  12  24  36  48  60  72  84  96  108 120 132 144
              |---|---|---|---|---|---|---|---|---|---|---|---|----->freq
      16 - 17 |*
      18 - 19 |*******************
      20 - 21 |******************************************
      22 - 23 |************************************************
      24 - 25 |******************************
      26 - 27 |*************************************
      28 - 29 |********************
      30 - 31 |*************
      32 - 33 |*********************
      34 - 35 |*******
      36 - 37 |*

Maximum= 37. Average= 24.840
```

Contd..

```
                    Main page size= 4. Ofl page size= 7

                     NO OF USED OVERFLOW PAGES
                     -------------------------

                 80  160 240 320 400 480 560 640 720
              |---|---|---|---|---|---|---|---|---|------->freq
            3 |************************************

Maximum= 3. Average= 3.000

                     NO OF OVERFLOW PAGES FREED
                     --------------------------

                 80  160 240 320 400 480 560 640 720
              |---|---|---|---|---|---|---|---|---|------->freq
            0 |************************************

Maximum= 0. Average= 0.000

                     NO OF MAIN PAGE FETCHES
                     -----------------------

                 80  160 240 320 400 480 560 640 720
              |---|---|---|---|---|---|---|---|---|------->freq
            1 |************************************

Maximum= 1. Average= 1.000

                     NO OF OVERFLOW PAGE FETCHES
                     ---------------------------

                 12  24  36  48  60  72  84  96  108 120 132 144
              |---|---|---|---|---|---|---|---|---|---|---|---|----->freq
      13 - 14 |***
      15 - 16 |********************
      17 - 18 |*************************
      19 - 20 |****************
      21 - 22 |********************************
      23 - 24 |*************************************************
      25 - 26 |*******************************
      27 - 28 |********************************
      29 - 30 |*****************
      31 - 32 |*********
      33 - 34 |*****

Maximum= 33. Average= 23.281
```

Contd..

```
              Main page size= 5. Ofl page size  6

                  NO OF USED OVERFLOW PAGES
                  -------------------------

                80  160 240 320 400 480 560 640 720
               |---|---|---|---|---|---|---|---|---|------->freq
             4 |************************************

Maximum= 4. Average= 4.000

                  NO OF OVERFLOW PAGES FREED
                  --------------------------

                80  160 240 320 400 480 560 640 720
               |---|---|---|---|---|---|---|---|---|------->freq
             0 |************************************

Maximum= 0. Average= 0.000

                  NO OF MAIN PAGE FETCHES
                  -----------------------

                80  160 240 320 400 480 560 640 720
               |---|---|---|---|---|---|---|---|---|------->freq
             0 |************************************

Maximum= 0. Average= 0.000

                  NO OF OVERFLOW PAGE FETCHES
                  ---------------------------

                12  24  36  48  60  72  84  96  108 120 132 144
               |---|---|---|---|---|---|---|---|---|---|---|---|---->freq
     20 - 21   |***********
     22 - 23   |****************************************
     24 - 25   |*************************************************
     26 - 27   |***************************************************
     28 - 29   |*****************
     30 - 31   |********************
     32 - 33   |********************
     34 - 35   |********************
     36 - 37   |**********
     38 - 39   |**

Maximum= 38. Average= 27.339
```

Contd..

```
                    Main page size= 5. Ofl page size= 7.

                      NO OF USED OVERFLOW PAGES
                      -------------------------

                   80  160 240 320 400 480 560 640 720
               |---|---|---|---|---|---|---|---|---|------->freq
             3 |************************************

Maximum= 3. Average= 3.000

                      NO OF OVERFLOW PAGES FREED
                      --------------------------

                   80  160 240 320 400 480 560 640 720
               |---|---|---|---|---|---|---|---|---|------->freq
             0 |************************************

Maximum= 0. Average= 0.000

                      NO OF MAIN PAGE FETCHES
                      ------------------------

                   80  160 240 320 400 480 560 640 720
               |---|---|---|---|---|---|---|---|---|------->freq
             0 |************************************

Maximum= 0. Average= 0.000

                      NO OF OVERFLOW PAGE FETCHES
                      ---------------------------

                   20  40  60  80  100 120 140 160 180 200
               |---|---|---|---|---|---|---|---|---|---|------->freq
   17 - 18     |**
   19 - 20     |********************************
   21 - 22     |*****
   23 - 24     |*
   25 - 26     |**************************************
   27 - 28     |*************************
   29 - 30     |*************************
   31 - 32     |***************
   33 - 34     |**

Maximum= 34. Average= 25.589
```

REFERENCES

(1) VMDB : An OODB Approach towards
Creating a Model Base for Visual Objects.

- Dr. Aditya Bagchi
Mr. Amarnath Gupta