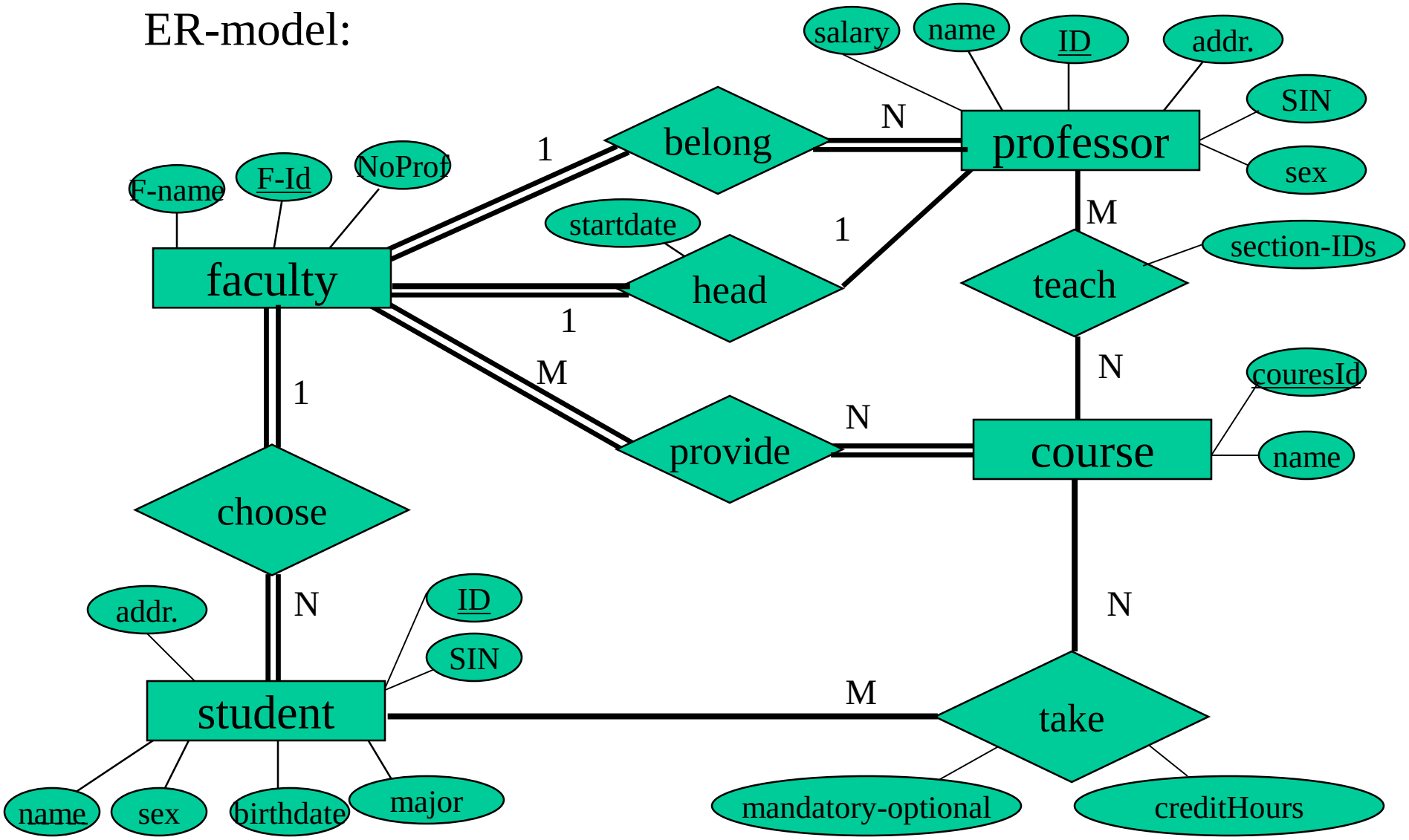
Analysis of Midterm-Examination

1.(15) Draw an ER-diagram to describe the following real world problem.

(a) A university is organized into faculties.
(b) Each faculty has a unique name, ID and number of professors and a specific professor is chosen as the faculty head.
(c) Each faculty provides a number of courses.
(d) Each course has a unique name and courseID.
(e) Each professor has a name, SIN, address, salary, sex and courses taught by him/her.
(f) Each professor belongs to a faculty and can teach several sections of a course.
(g) Each student has a name, ID, SIN, address, GPA, sex, and major.
(h) Each student can choose one faculty as his/her major faculty and take several courses with certain credit hours. Some of the courses are mandatory and some are optional.

Analysis of Midterm-Examination

ER-model:

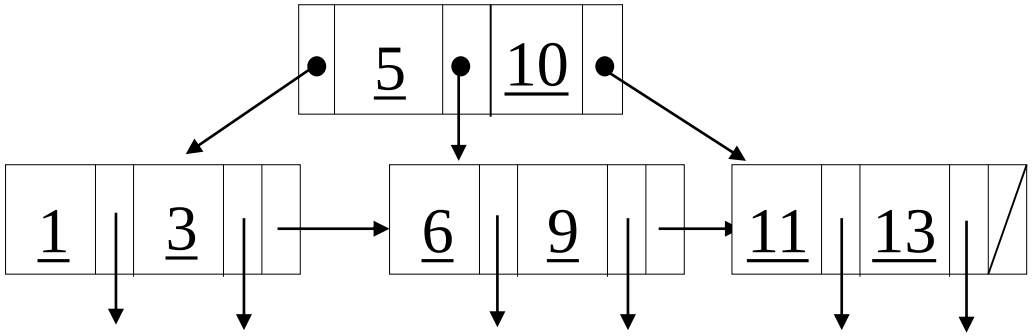


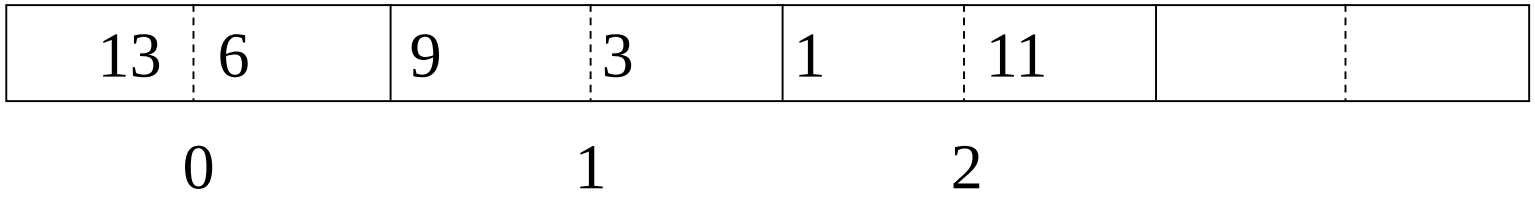
Analysis of Midterm-Examination

2. (20) (a) The following is the algorithm to search a tree in depth-first manner. Change it to an algorithm to store a B+-tree
(a linked list stored in main memory) in a data file. (10)

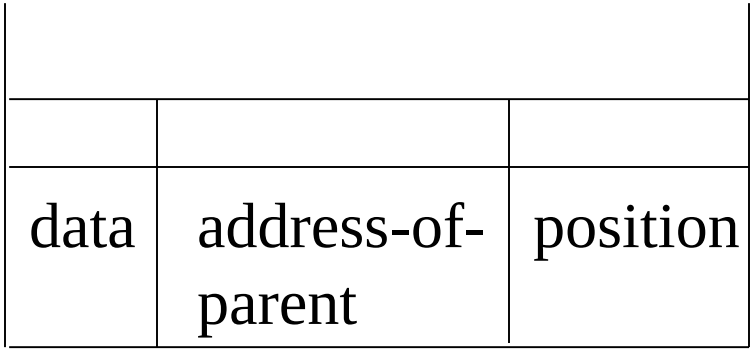
```
push(root);      (*push the root into stack.*)
while (stack is not empty) do
{   v := pop( );
    print(v);      (*or store v in a file.*)
    let v1, …, vk be the children of v;
    for (i = k to 1) {push(vi)};
}
```

(b) Apply the algorithm to the tree shown in Fig. 1 and give the result (i.e., the data file storing the tree). (10)





Store a B+-tree on hard disk



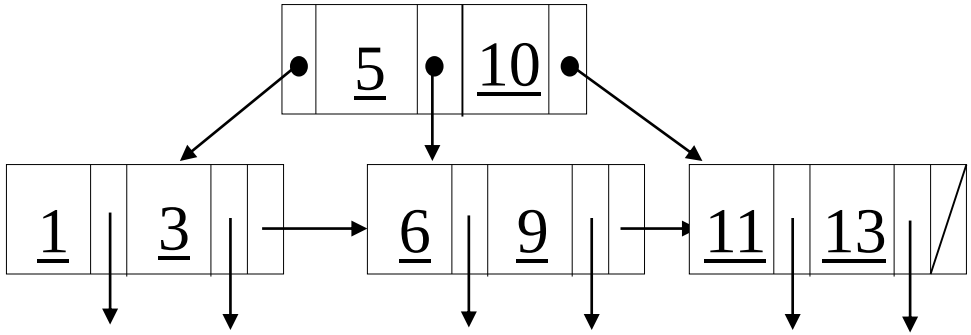
Algorithm:

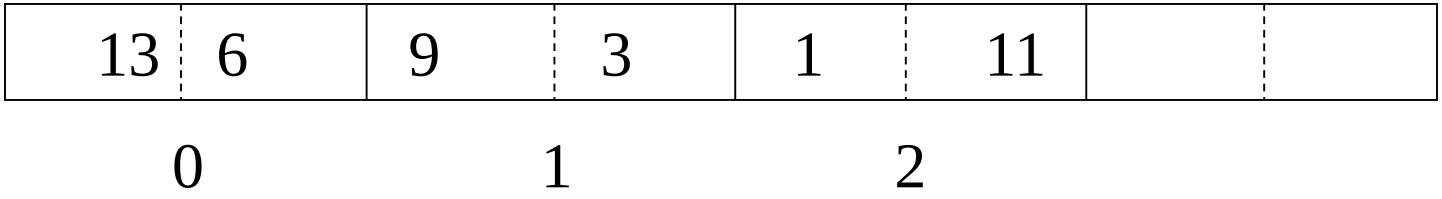
```
push(root, -1, -1);
while (S is not empty) do
{     x := pop( );
      store x.data in file F;
      assume that the address of x in F is ad;
      if x.address-of-parent ≠ -1 then {
            y := x.address-of-parent;
            z := x.position;
            write ad in page y at position z in F;
      }
      let x1, …, xk be the children of v;
      for (i = k to 1) {push(xi, ad, i)};
}
```

Analysis of Midterm-Examination

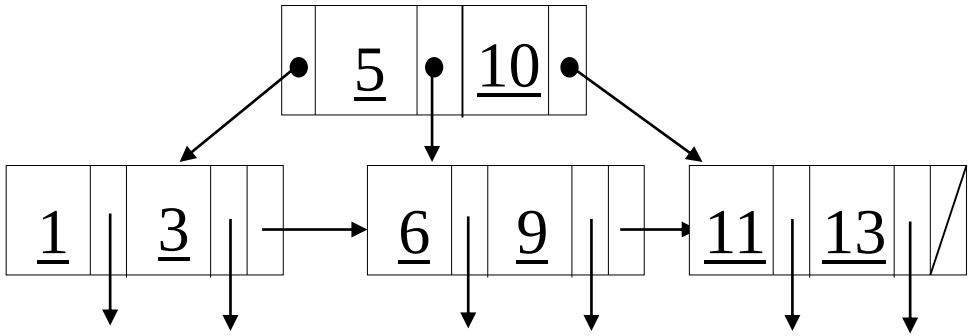
B+-tree stored in a file:

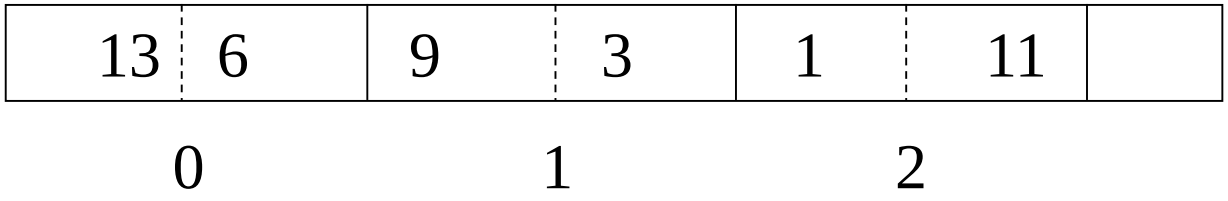
0	1	5	2	10	3	
1	1	2	3	1		
2	6	0	9	1		
3	11	2	13	0		



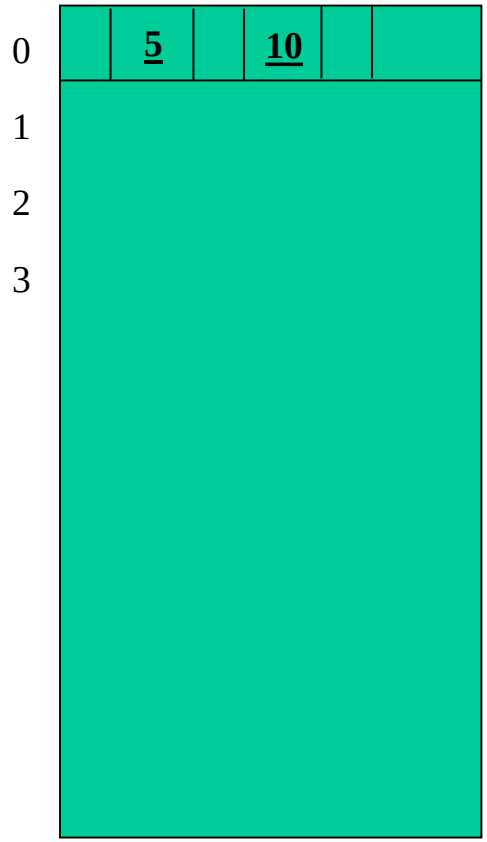


Analysis of Midterm-Examination

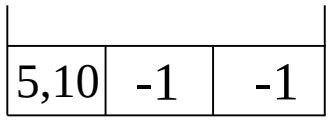


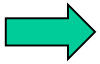


B+-tree stored in a file:



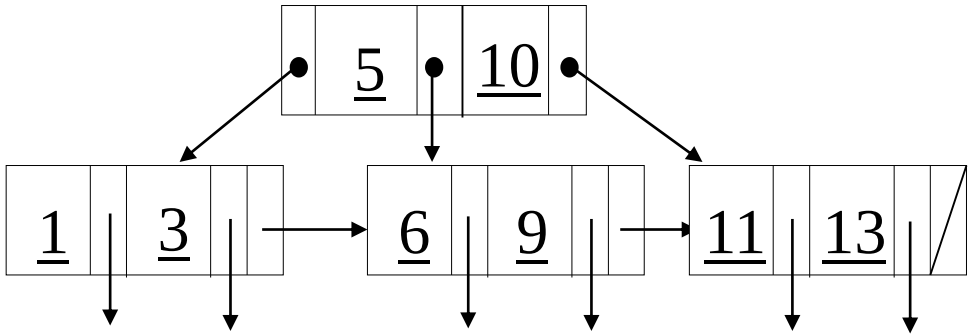
Stack:





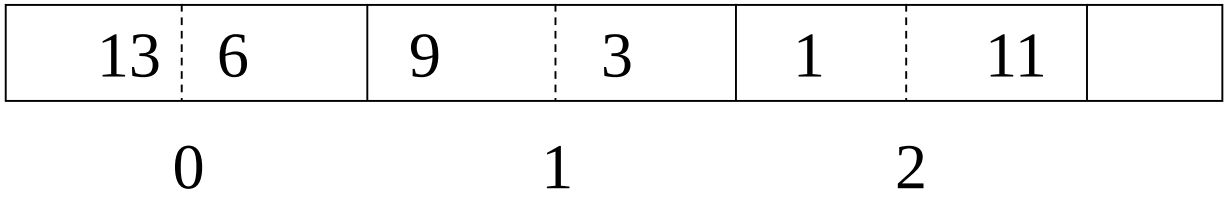
1, 3	0	1
6, 9	0	2
11, 13	0	3

Analysis of Midterm-Examination



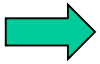
B+-tree stored in a file:

0	1	5	2	10	3	
1	1	2	3	1		
2	6	0	9	1		
3	11	2	13	0		



Stack:

1, 3	0	1
6, 9	0	2
11, 13	0	3



6, 9	0	2
11, 13	0	3

Analysis of Midterm-Examination

3.(10) Given the relation schemas shown in Fig. 2, construct expressions (using SQL language) to evaluate the following query:
Find the names of employees who works on all the projects controlled by department ‘Applied Computer Science’.

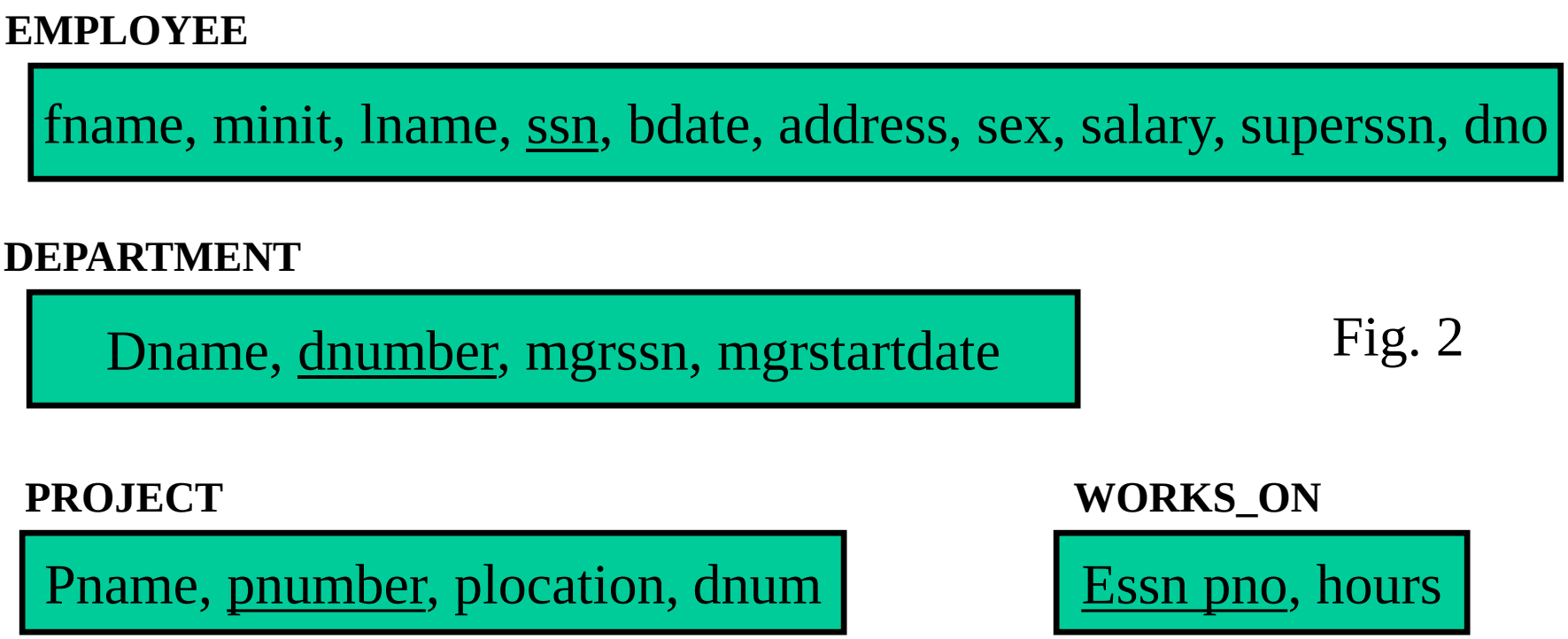


Fig. 2

Analysis of Midterm-Examination

```
SELECT E.FNAME,E.MINIT,E.LNAME
FROM EMPLOYEE E
WHERE
NOT EXISTS
        (SELECT P.pname FROM PROJECT AS P, DEPARTMENT D
        WHERE P.dnum = D.dnumber AND
                D.DNAME = "Applied Computer Science"))
                NOT EXISTS
                        (SELECT * FROM WORKS_ON AS W,
                        WHERE P.pnumber = W.pno AND
                        W.essn=E.ssn ))
```

There is no project that the employee does not work on.

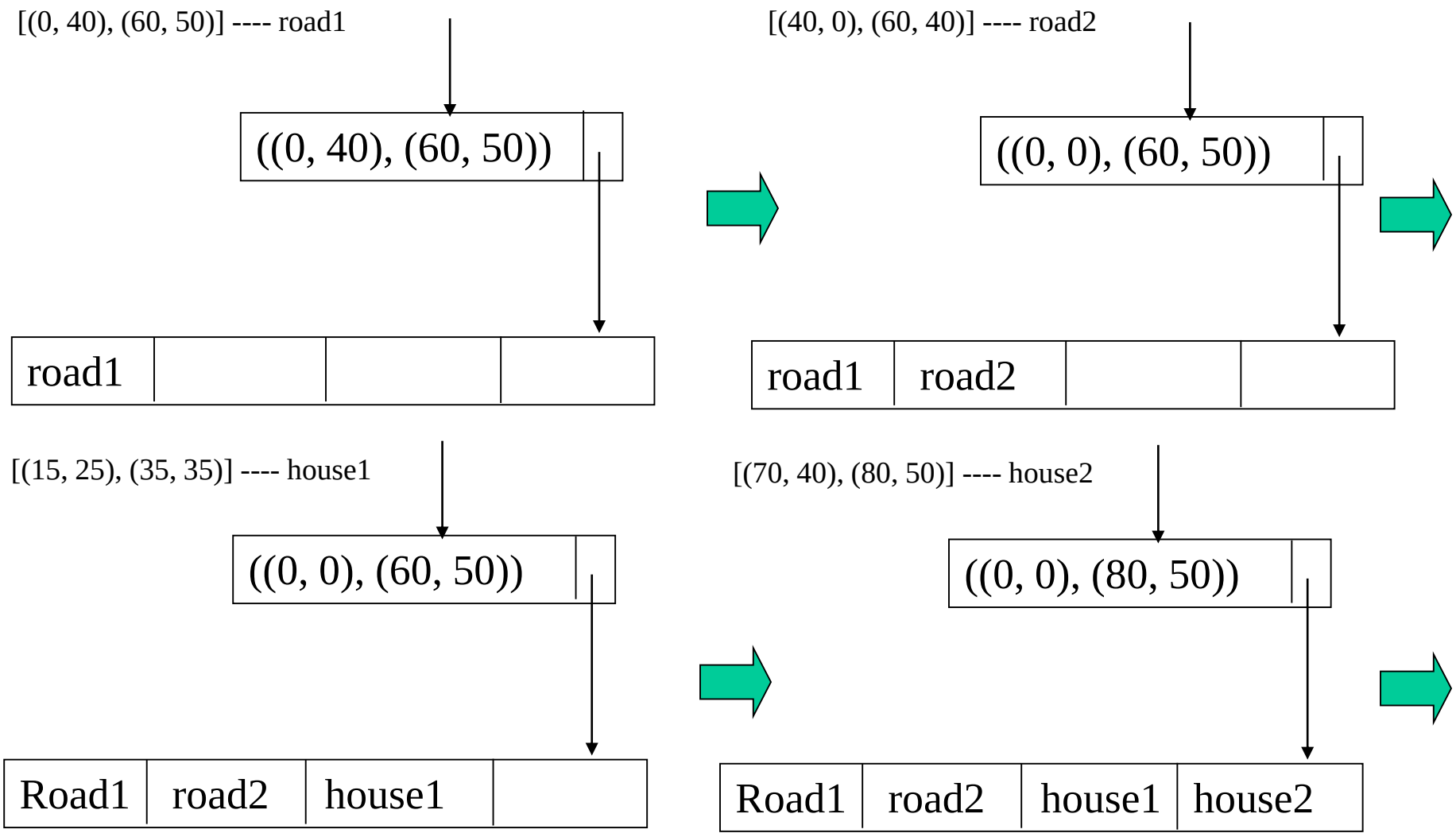
controlled by Department of "Applied Computer Science"

4. (15) Construct an R-tree over a set of records for geographical objects with the following coordinates [($x1$, $y1$), ($x2$, $y2$)]:

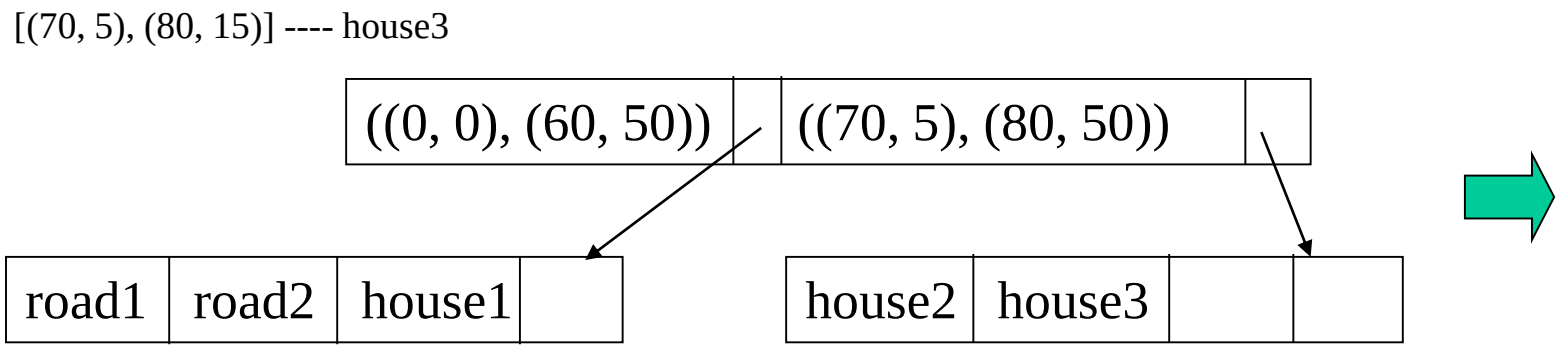
[(0, 40), (60, 50)] ---- road1
[(40, 0), (60, 40)] ---- road2
[(15, 25), (35, 35)] ---- house1
[(70, 40), (80, 50)] ---- house2
[(70, 5), (80, 15)] ---- house3
[(35, 25), (80, 35)] ---- pipeline

Assume that each leaf node can have at most 4 pointers and at least two pointers; and each internal node at most 2 pointers and at least 1 pointer.
Please give the computation process.

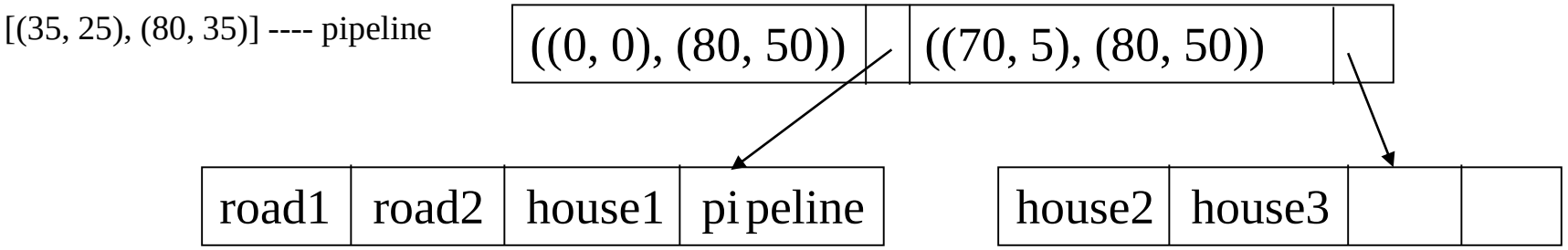
Analysis of Midterm-Examination



Analysis of Midterm-Examination

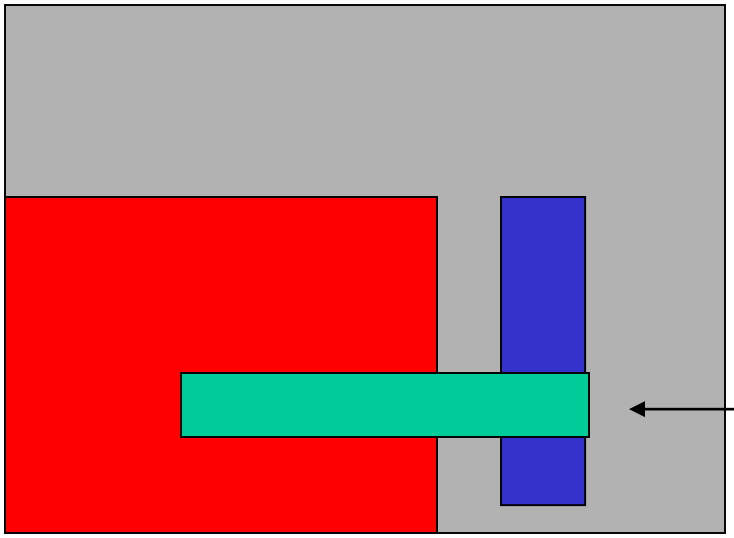


- If we expand the first subregion in the internal node, then we add 1000 square units to the region.
- If we extend the other subregion in the internal, then we add 1575 square units.



Analysis of Midterm-Examination

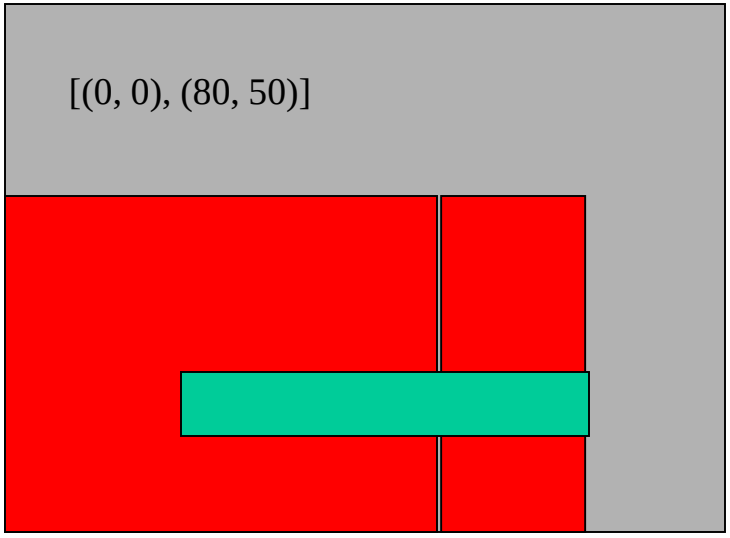
[(0, 0), (60, 50)]



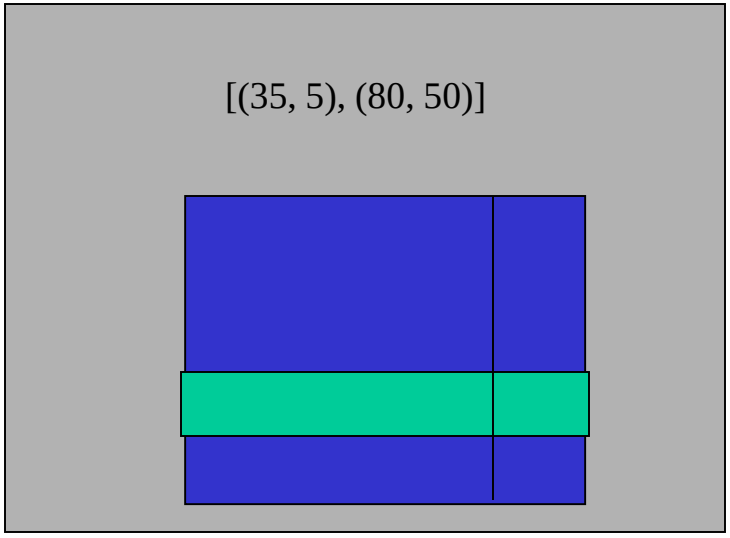
[(70, 5), (80, 50)]

[(35, 25), (80, 35)] ---- pipeline

[(0, 0), (80, 50)]



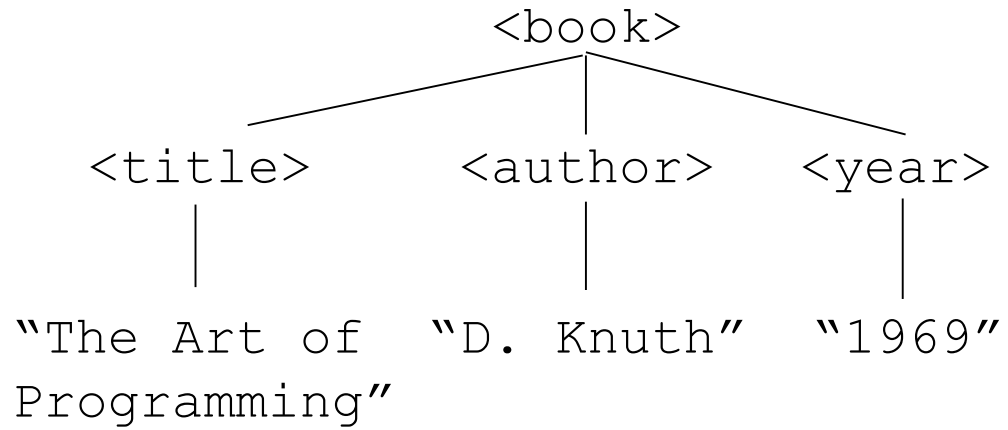
[(35, 5), (80, 50)]



Analysis of Midterm-Examination

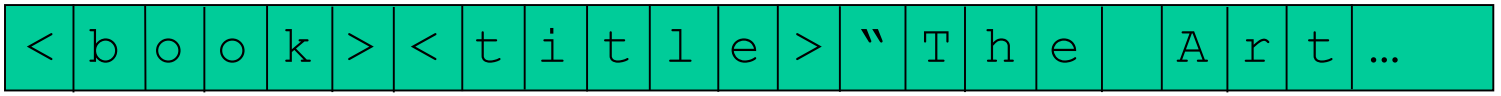
5. (10) Given the algorithm for transforming any XML document to a tree structure, apply the algorithm to the following document and trace the computation process.

```
<book>
    <title>
        "The Art of Programming"
    </title>
    <author>
        "D. Knuth"
    </author>
    <year>
        "1969"
    </year>
</book>
```

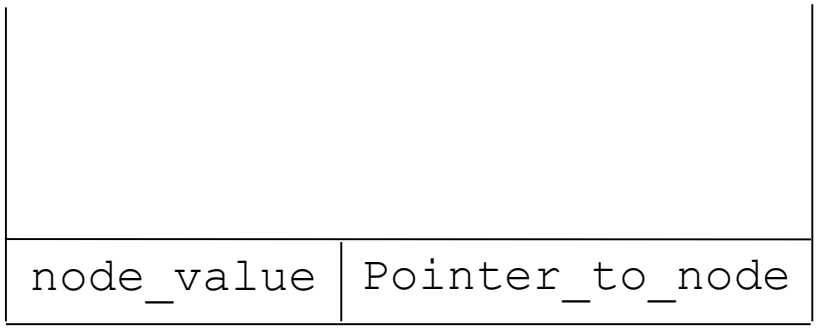


Transform an XML document to a tree

Read a file into a character array `A`:



stack S:



Transform an XML document to a tree

```
Algorithm:

Scan array A;
If A[i] is '<' and A[i+1] is a character then {
      generate a node x for A[i..j],
      where A[j] is '>' directly after A[i];
      let y = S.top().pointer_to_node;
      make x be a child of y; S.push(A[i..j], x);
If A[i] is ' " ', then {
      genearte a node x for A[i..j],
      where A[j] is ' " ' directly after A[i];
      let y = S.top().pointer_to_node;
      make x be a child of y;
If A[i] is '<' and A[i+1] is '/', then S.pop();
```

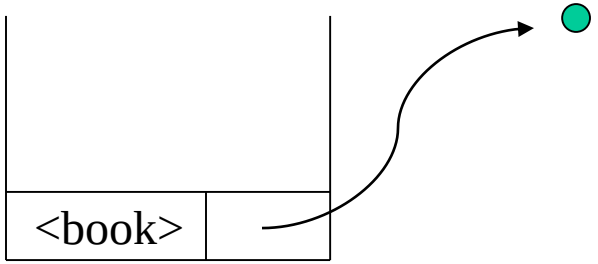
Generating a node for an opening tag.

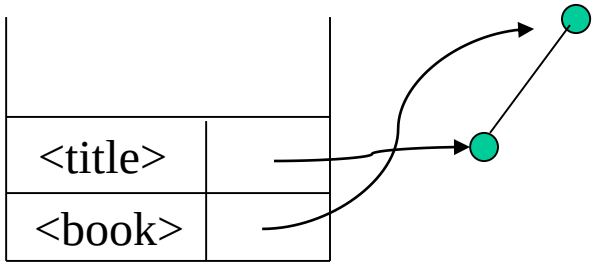
Generating a leaf node for a string value.

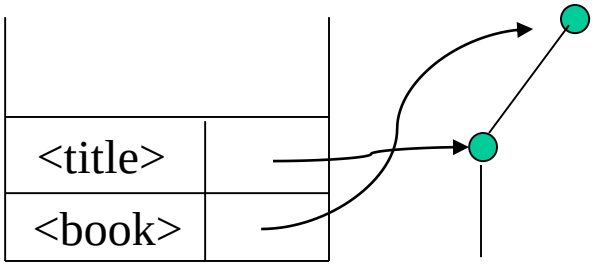
Popping out the stack when meeting a closing tag.

Analysis of Midterm-Examination

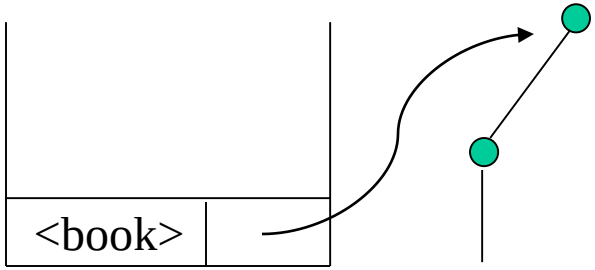
```
<book>
    <title>
        "The Art of Programming"
    </title>
    <author>
        "D. Knuth"
    </author>
    <year>
        "1969"
    </year>
</book>
```







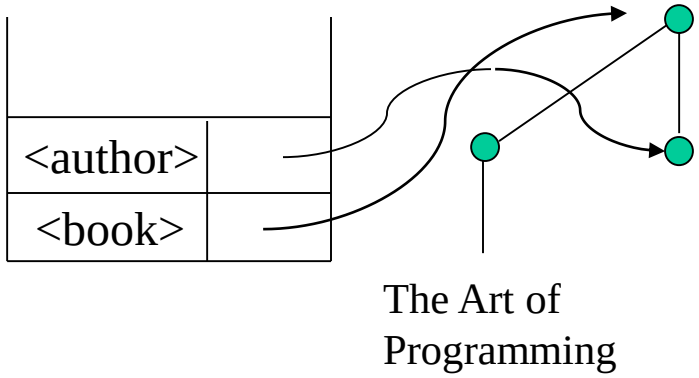
The Art of Programming

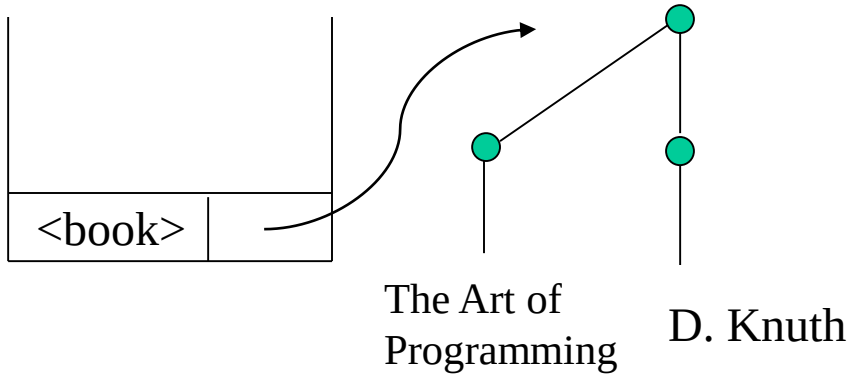


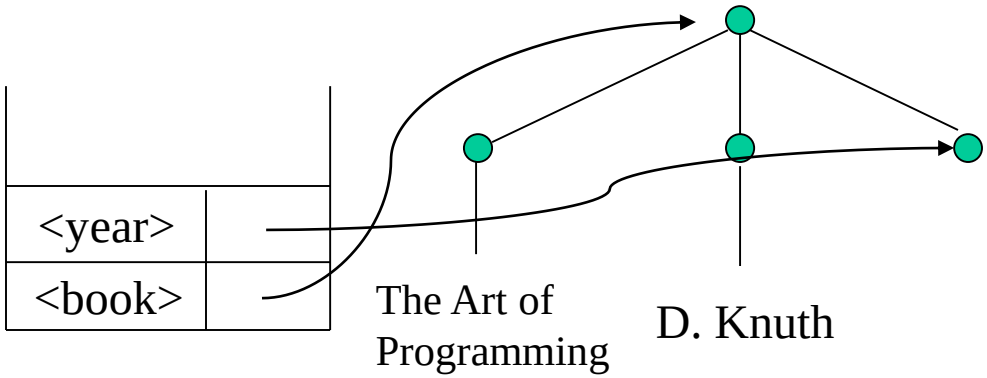
The Art of Programming

Analysis of Midterm-Examination

```
<book>
    <title>
        "The Art of Programming"
    </title>
    <author>
        "D. Knuth"
    </author>
    <year>
        "1969"
    </year>
</book>
```

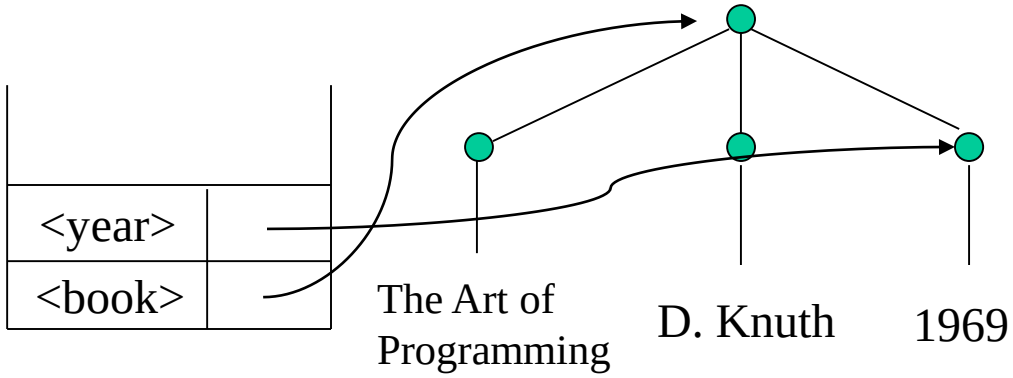


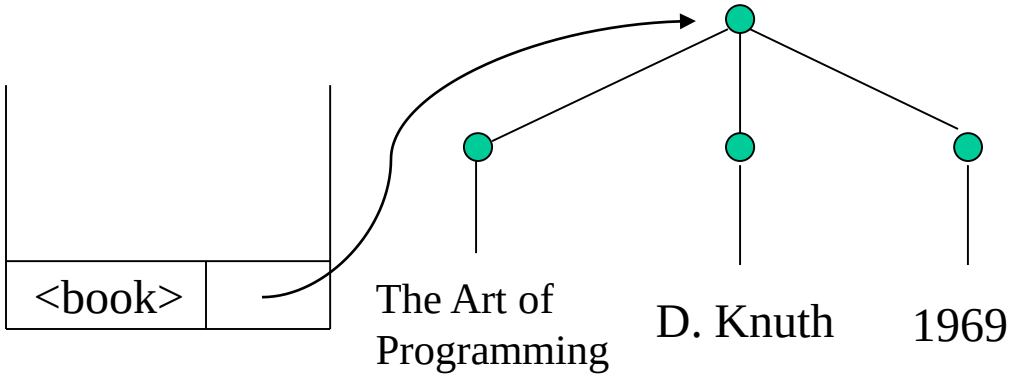


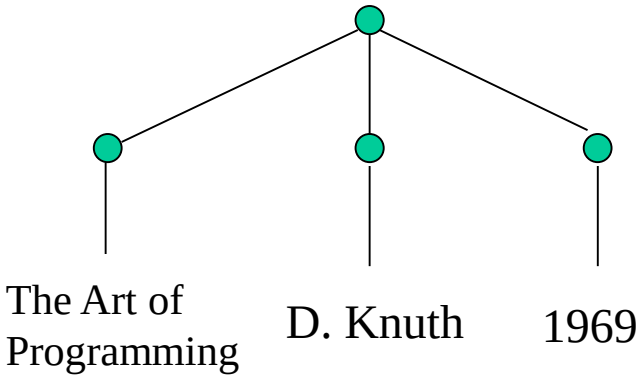


Analysis of Midterm-Examination

```
<book>
    <title>
        "The Art of Programming"
    </title>
    <author>
        "D. Knuth"
    </author>
    <year>
        "1969"
    </year>
</book>
```







6. (10) Fig. 3 is a DTD for a set of XML documents on movie and stars. Please produce a FLWR expression to find all those stars, who live at 123 Maple St., Malibu.

```
<!DOCTYPE Stars [
    <!ELEMENT Stars (Star*)>
    <!ELEMENT Star (Name, Address+, Movies)>
    <!ELEMENT Name (#PCDATA)>
    <!ELEMENT Address (Street, City)>
    <!ELEMENT Street (#PCDATA)>
    <!ELEMENT City (#PCDATA)>
    <!ELEMENT Movies (Movie*)>
    <!ELEMENT Movie (Title, Year)>
    <!ELEMENT Title (#PCDATA)>
    <!ELEMENT Year (#PCDATA)>
]>
```

Fig. 3

Assume that all the documents are stored in a file “stars.xml”.

Analysis of Midterm-Examination

```
let     $stars := doc("stars.xml")
for     $s in $stars/Stars/Star, $s1 in $s/Address
where   $s1/Street = "123 Maple St." and
        $s1//City = "Malibu"
return $s/Name
```

```
let     $stars := doc("stars.xml")
for     $s in $stars/Stars/Star/Address
where   $s/Street = "123 Maple St." and
        $s//City = "Malibu"
return $s/Name
```

```
let     $stars := doc("stars.xml")
for     $s in $stars/Stars/Star
where $s/Address/Street = "123 Maple St."
        and $s/Address/City = "Malibu"
return $s/Name
```

<---------- This is wrong!

Analysis of Midterm-Examination

Query: find all the stars that live at 123 Maple St., Malibu.

The following FLWR seems correct. But it does not work.

```
let     $stars := doc("stars.xml")
for     $s in $stars/Stars/Star
where $s/Address/Street = "123 Maple St."
        and $s/Address/City = "Malibu"
return $s/Name
```

Correct query:

```
let     $stars := doc("stars.xml")
for     $s in $stars/Stars/Star,
        $s1 in $s/Address
where $s1/Street = "123 Maple St." and
        $s1//City = "Malibu"
return $s/Name
```

```
<? Xml version = "1.0" encoding = "utf-8" … ?>
<Stars>
    <Star>
        <Name>Fay Wray</Name>
        <Address>
            <Street>123 Maples St.</street>
            <City>Hollywood</City>
        </Address>
        <Address>
            <Street>5 Locust Ave.</Street>
            <City>Mallibu</City>
        </Address>
    </Star>
            … more stars
</Stars>
```

Analysis of Midterm-Examination

7. (10) The following is an XML schema, please define a DTD which is equivalent to it.

```
<? Xml version = “1.0” encoding = “utf-8” ?>
<xs: schema xmlns: xs = “http://www.w3.org/2001/XMLSchema”>

<xs: complexType name = “movieType”>
    <xs: attribute name = “title” type = “xs: string” use = “required” />
    <xs: attribute name = “year” type = “xs: integer” use = “required” />
</xs: complexType>

<xs: element name = “Movies”>
    <xs: complexTyp>
        <xs: sequence>
            <xs: element name = “Movie” type = “movieType”
                minOccurs = “0” maxOcurs = “unbouned” />
            <xs: element name = “Star” type = “xs:string”
                minOccurs = “0” maxOcurs = “unbouned” />
        </xs: sequence>
    </xs: complexTyp>
</xs: element>
</xs: schema>
```

Answer:

```
<!DOCTYPE Movies [
        <!ELEMENT  Movies (Movie*, Star*) >
        <!ELEMENT  Movie EMPTY >
                <!ATTLIST    Movie
                        Title    CDATA #REQUIRED
                        Year    CDATA #REQUIRED
                >
         <!ELEMENT Star    #PCDATA >
]>
```

8. (10) Concerning the linear hash, answer the following questions:

(a) What is a phase?
(b) When to split a bucket?
(c) How to split a bucket?
(d) What bucket will be chosen to split next?
(e) How do we find a record inserted into a linear hashing file?

Answer:

a) In the linear hash process, a series of hash functions: h_0, h_1, h_2, … are used. In each phase i, h_i and h_{i+1} will be used. When the size of the primary area is doubled, phase i is completed.

$$h_i(\text{key}) = \text{key mod } (2^i * \text{M}).$$

Answer:

b) When an overflow occurs or when the load factor becomes larger than a certain threshold, we choose a bucket to split.
c) In phase *i*, we use h_{i+1} to split the records in the corresponding bucket.
d) A pointer variable *n* is maintained to indicate what bucked is chosen to split. Initially, *n* is set to 0. After each splitting *n* is increased by 1.
e) When we want to find a certain key value *k* in a linear hash file, we will try $h_j(k)$, and $h_{j+1}(k)$, where *j* is the number of phases made during the hash file's construction.

e) How do we find a record inserted into a linear hashing file?

M – the size of the initial primary area
j – the last phase
n – the next bucket to be split

Algorithm find(KEY, M, *j*, *n*)

if $j = 0$ **then** return $h_0(\text{KEY}) = \text{KEY} \bmod M$;
else

BUCKET_LOC := $h_{j-1}(\text{KEY}) = \text{KEY} \bmod 2^{j-1}M$;
if BUCKET_LOC < *n* **then** return $h_j(\text{KEY})$
else return BUCKET_LOC;