INDIAN INSTITUTE OF INFORMATION TECHNOLOGY

Dharwad
ज्ञानेन विकासः

# Linear and Binary Search


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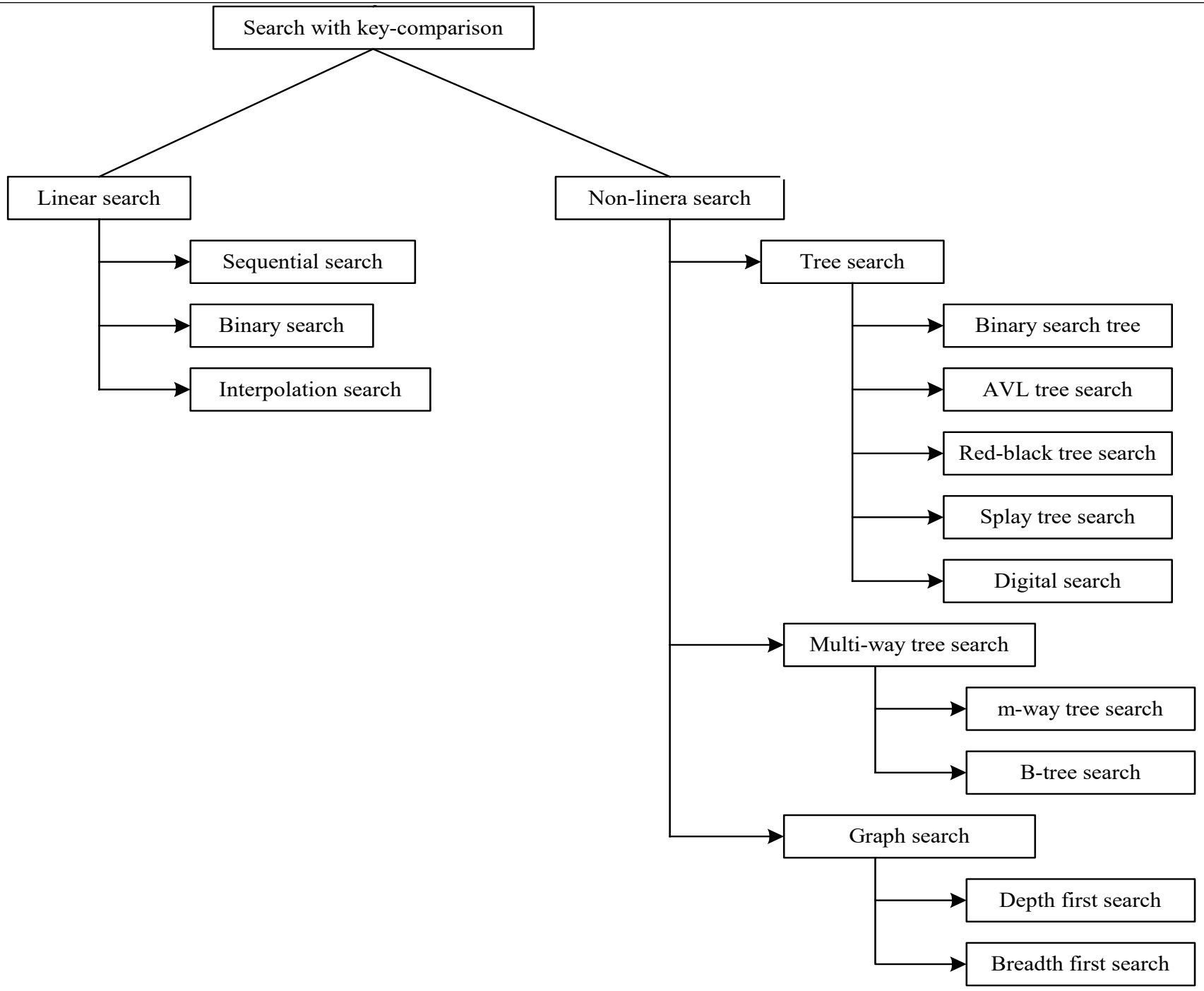
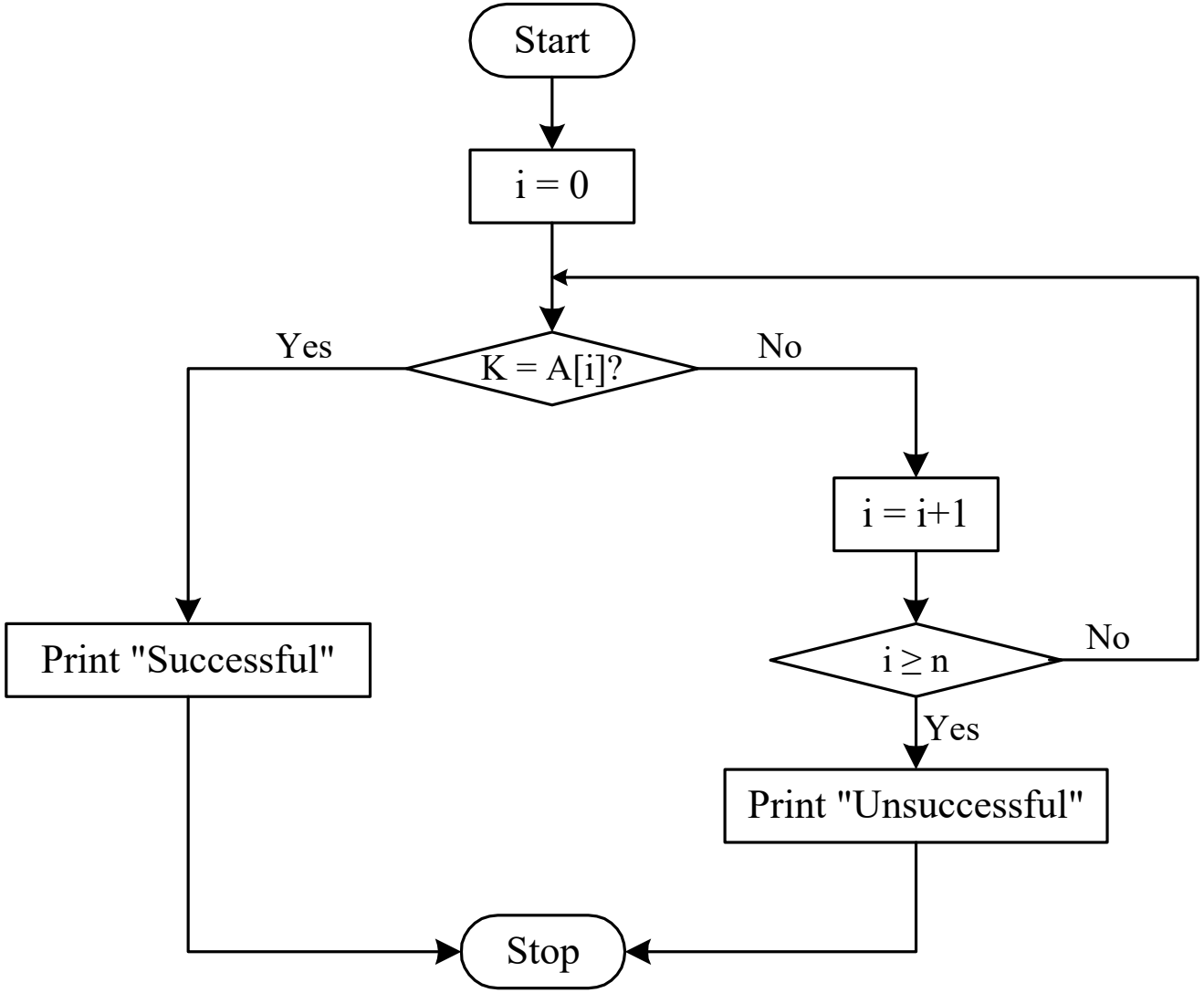

Search with key-comparison
Linear search
Sequential search
Binary search
Interpolation search
Non-linera search
Tree search
Binary search tree
AVL tree search
Red-black tree search
Splay tree search
Digital search
Multi-way tree search
m-way tree search
B-tree search
Graph search
Depth first search
Breadth first search

# Linear Search

# Flowchart: Sequential Search with Array



# Example: Sequential Search with Array

```
int main()
{
    int A[10], i, n, K, flag = 0;
    printf("Enter the size of an array: ");
    scanf("%d",&n);

    printf("Enter the elements of the array: ");
    for(i=0; i < n; i++)
        scanf("%d",&A[i]);
    printf("Enter the number to be searched: ");
    scanf("%d",&K);
    for(i=0;i<n;i++){
        if(a[i] == K){
            flag = 1; break;
        }
    }
    if(flag == 0)
        printf("The number is not in the list");
    else
        printf("The number is found at index %d",i);
    return 0;
}
```

# Complexity Analysis

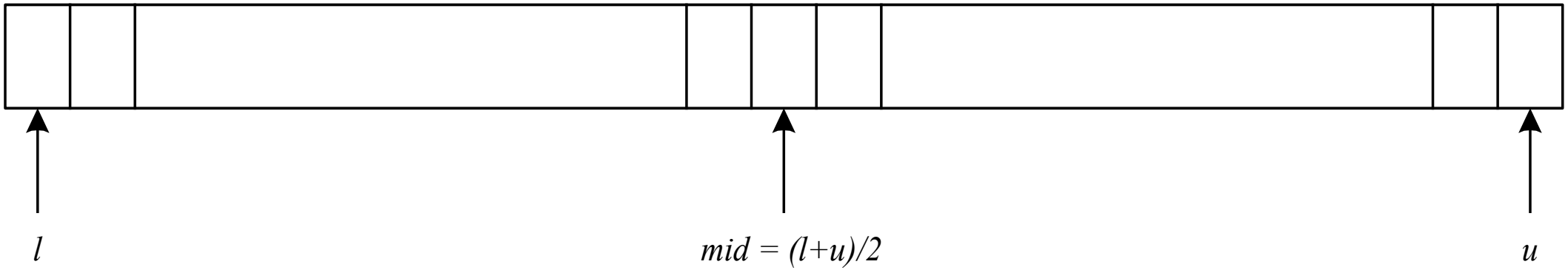
- Case 1: The key matches with the first element
  - $T(n) = 1$
- Case 2: Key does not exist
  - $T(n) = n$
- Case 3: The key is present at any location in the array
  - $T(n) = (n+1)/2$

# Complexity Analysis

| Case | Number of key comparisons | Asymptotic complexity | Remark |
|---|---|---|---|
| Case 1 | $T(n) = 1$ | $T(n) = \mathrm{O}(1)$ | Best case |
| Case 2 | $T(n) = n$ | $T(n) = \mathrm{O}(n)$ | Worst case |
| Case 3 | $T(n) = \frac{n+1}{2}$ | $T(n) = \mathrm{O}(n)$ | Average case |

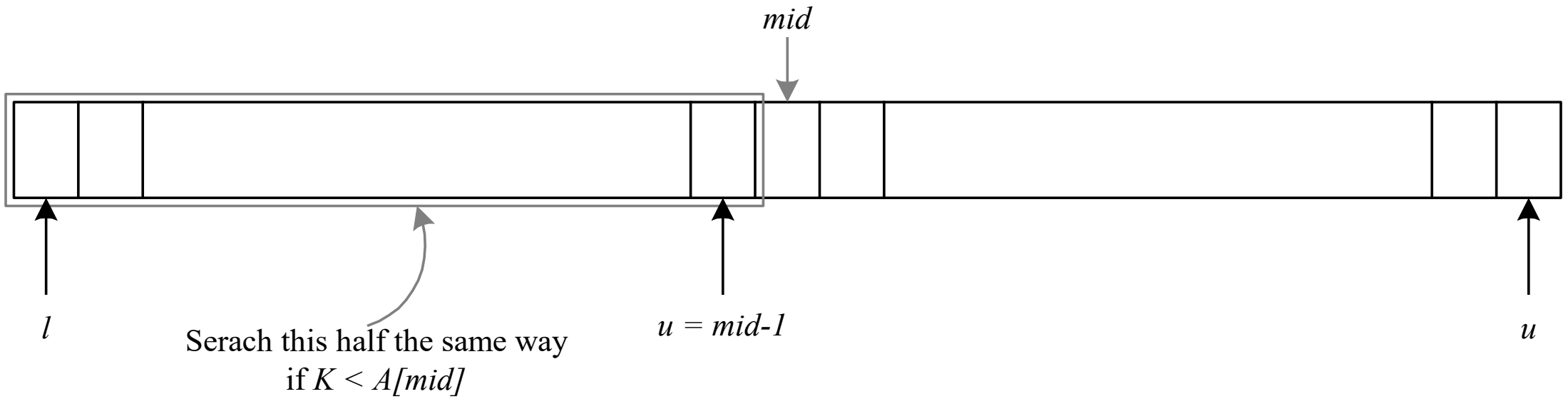
# Binary Search

# Binary Search



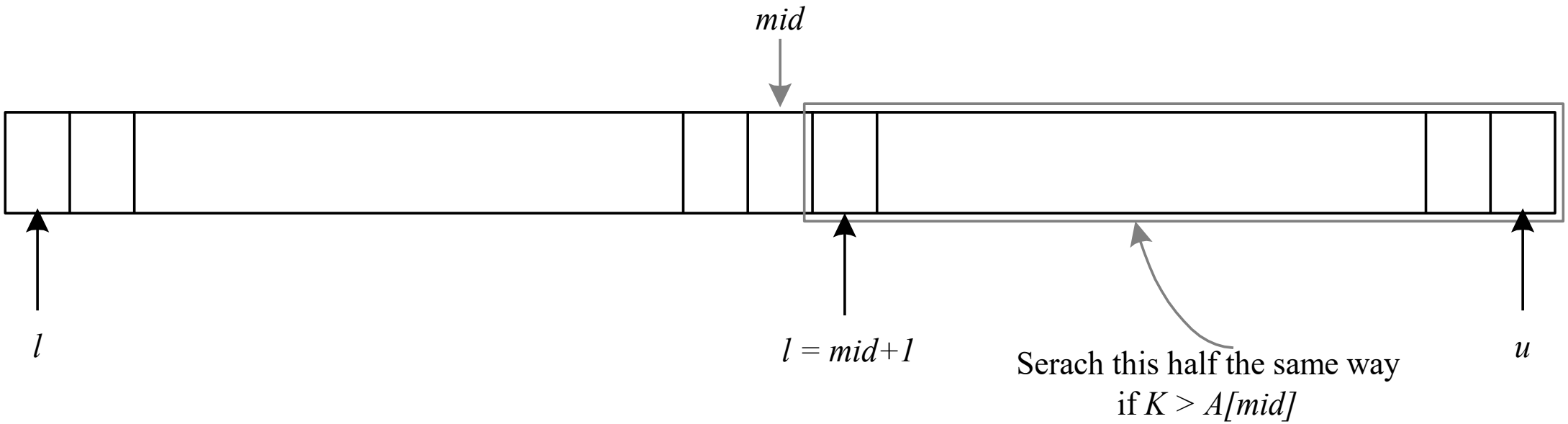

(a) An ordered array of elemnets with index values *l*, *u* and *mid*

# Binary Search



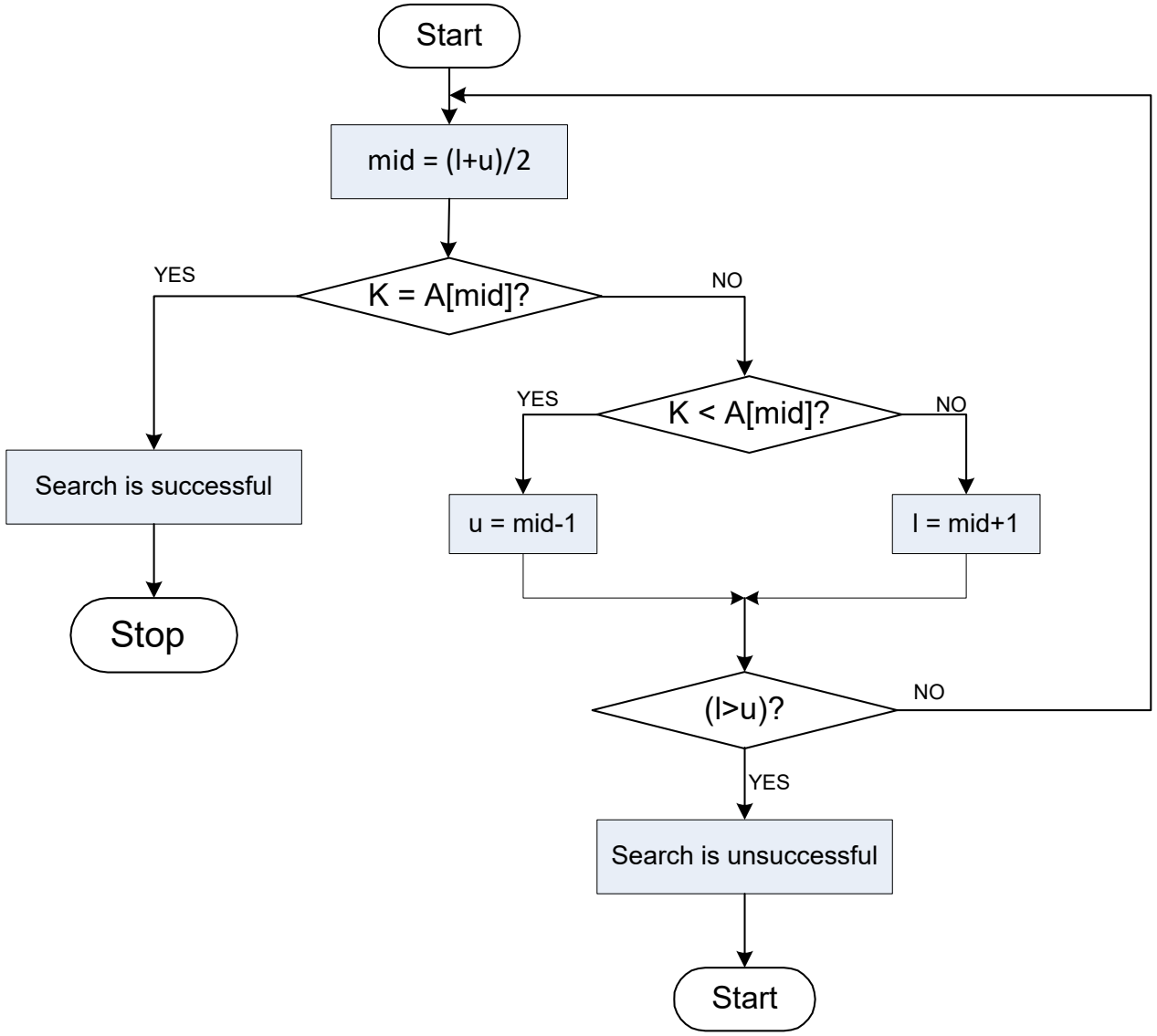

(b) Search the entire list turns into the searching of left-half only

# Binary Search

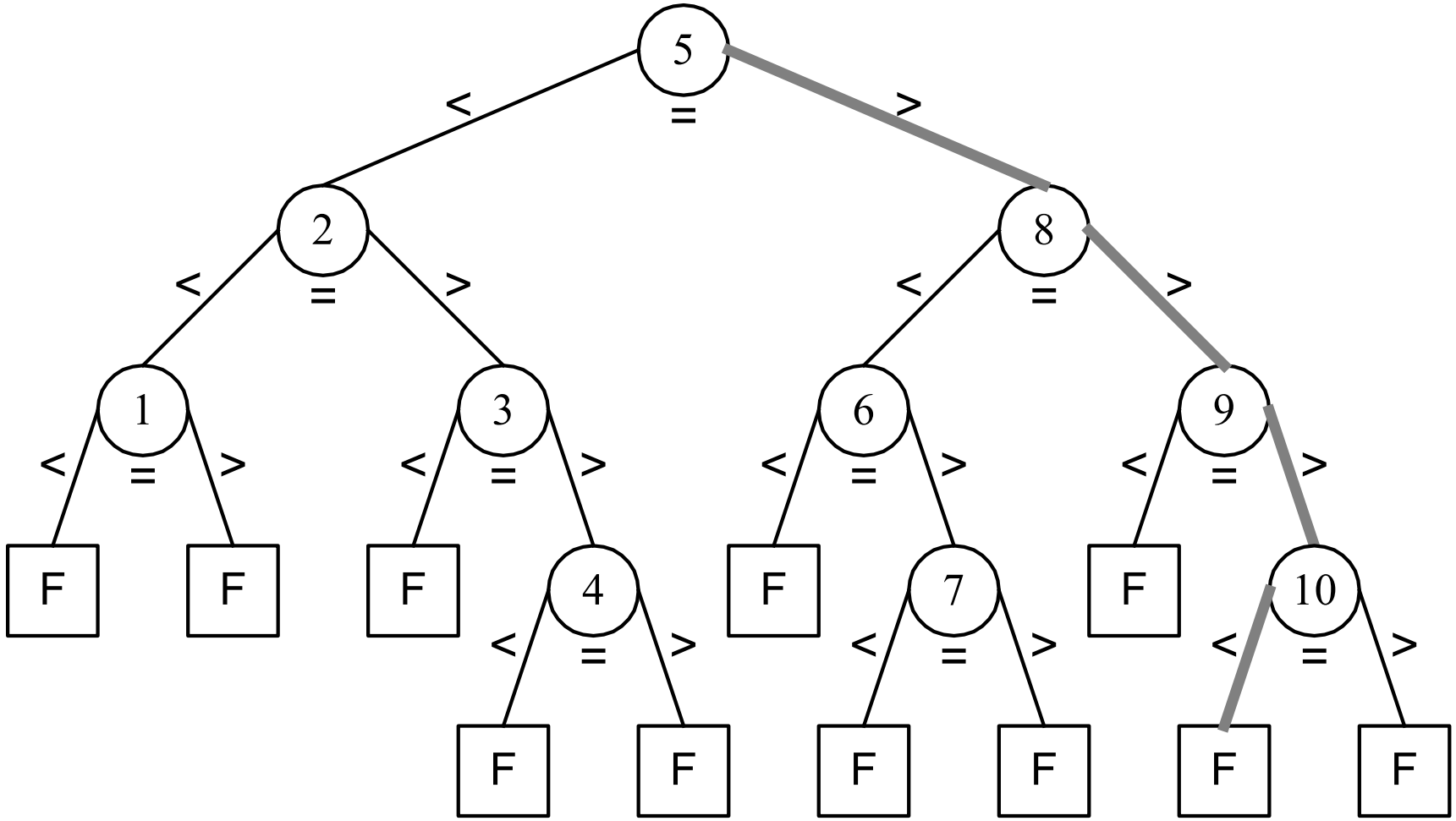



(c) Search the entire list turns into the searching of right-half only

# Flowchart: Binary Search with Array



# Binary Search



# Binary Search (Iteration)

```
#include <stdio.h>

int main()
{  int i, l, u, mid, n, K, data[100];

   printf("Enter number of elements\n");
   scanf("%d",&n);

   printf("Enter %d integers in sorted
                              order\n", n);

   for (i = 0; i < n; i++)
      scanf("%d",&array[i]);

   printf("Enter value to find\n");
   scanf("%d", &K);

   l = 0;
   u = n - 1;
   mid = (l+u)/2;
   while (l <= u) {
      if (data[mid] < K)
         l = mid + 1;
      else if (data[mid] == K) {
         printf("%d found at index %d.\n",
                                  search, mid+1);
         break;
      }
      else
         u = mid - 1;
      mid = (l + u)/2;
   }
   if (l > u)
      printf("%d is not present in the list.\n",
                                              K);
   return 0;
}
```

# Binary Search (Recursion)

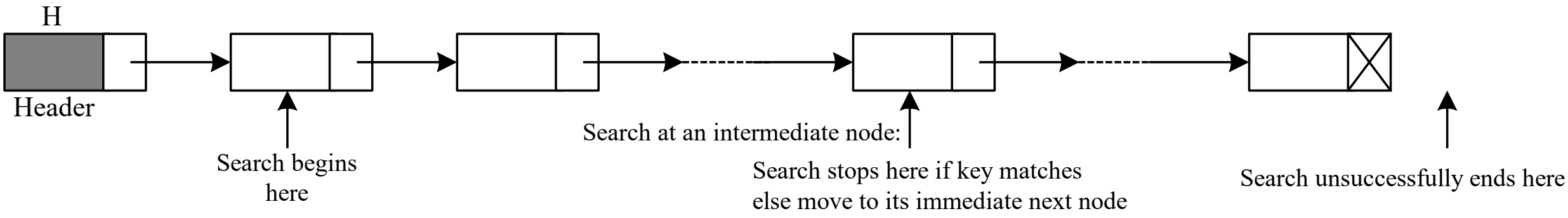
```
#include<stdio.h>
int main(){
    int data[100],i, n, K, flag, l, u;
    printf("Enter the size of an array: ");
    scanf("%d",&n);
    printf("Enter the elements of the
                array in sorted order: " );

    for(i=0;i<n;i++)
         scanf("%d",&a[i]);
    printf("Enter the number to be search: ");
    scanf("%d",&K);

    l=0,u=n-1;
    flag = binarySearch(data,n,K,l,u);
    if(flag==0)
         printf("Number is not found.");
    else
         printf("Number is found.");

    return 0; }
```

```
int binary(int a[],int n,int K,int l,int u){

    int mid;

    if(l<=u){
         mid=(l+u)/2;
         if(K==a[mid]){
              return(1);
         }
         else if(K<a[mid]){
              return binarySearch(a,n,K,l,mid-1);
         }
         else
              return binarySearch(a,n,m,mid+1,u);
    }
    else return(0);
}
```

# Sequential Search with Linked List

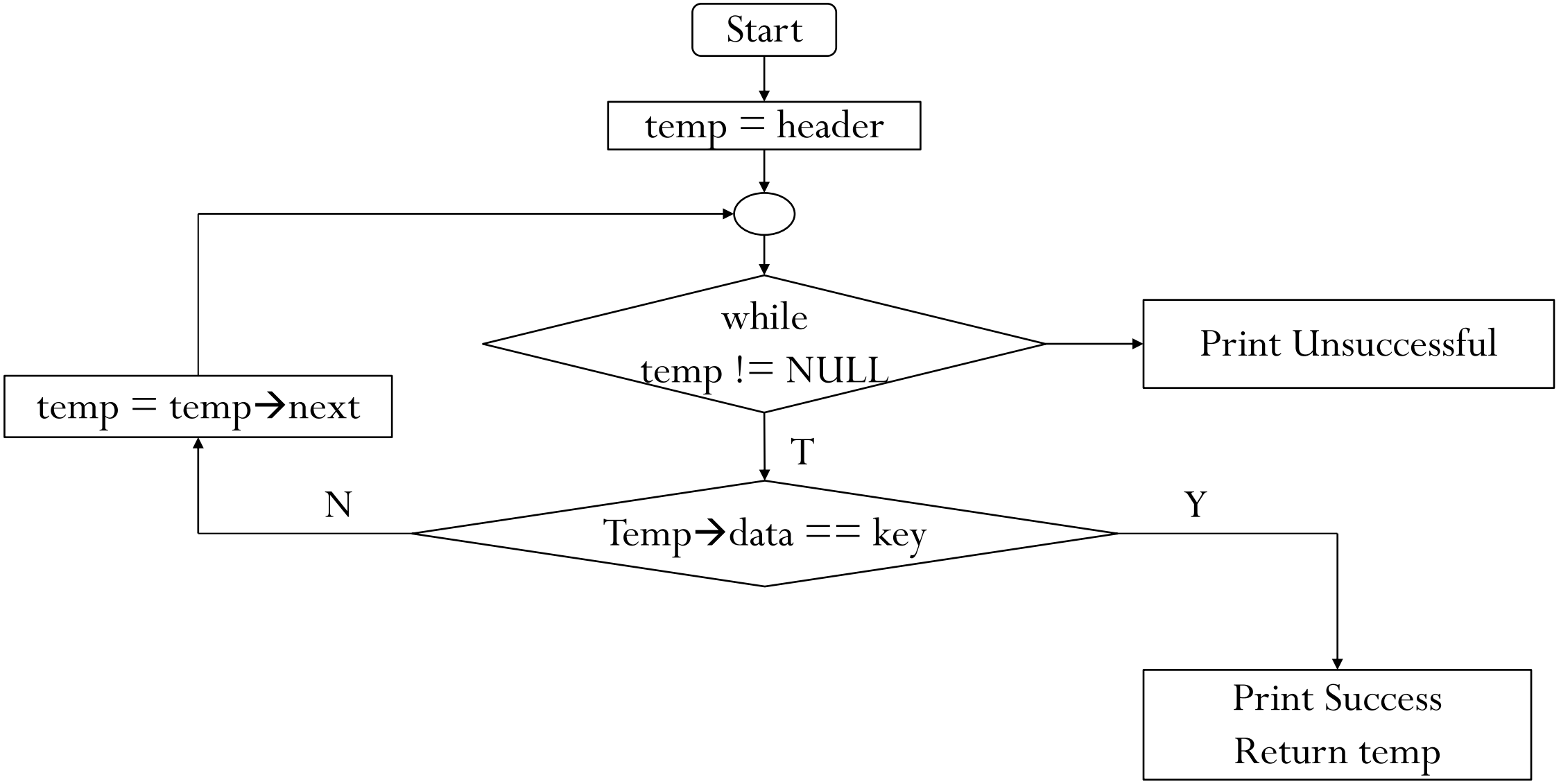
# Sequential Search with Linked List


(a) Structure of a node in the linked list




(b) Linear search on a linked list

# Flow Chart: Sequential Search with LL



# Sequential Search with Linked List

```
#include <stdio.h>
#include <stdlib.h>

struct node
{    int data;
     struct node *next; };

int main()
{    struct node *header = NULL;
     int K, n;

     printf("Enter the number of nodes: ");
     scanf("%d", &n);
     printf("\nDisplaying the list\n");
     generate(header, num);
     printf("\nEnter key to search: ");
     scanf("%d", &key);
     searchBinary(header, K);
     delete(header);

     return 0;  }
```

# Linear Search with Linked List

```
void generate(struct node *head, int n)
{   int i;
    struct node *temp;

    for (i = 0; i < num; i++)
    {   temp = (struct node *)malloc(sizeof(struct node));
        temp->data = rand() % n;
        if (*header == NULL)
        {   *header = temp;
            temp->next = NULL;
        }
        else
        {   temp->next = header;
            header = temp;
        }
        printf("%d  ", temp->data);
    }
}
```

# Linear Search with Linked List

```
void searchBinary(struct node *temp, int K)
{   while (temp != NULL)
    {   if (temp->data == K)
        {   printf("key found\n");
            return;
        }
        else temp = temp->next;
    }
    printf("Key not found\n");
}

void delete(struct node *header)
{   struct node *temp;
    temp = header;
    while (temp != NULL)
    {   temp = temp->next;
        free(header);
        header = temp;
    }
}
```

# Complexity Analysis

| Case | Number of key comparisons | Asymptotic complexity | Remark |
|---|---|---|---|
| Case 1 | $T(n) = 1$ | $T(n) = \mathrm{O}(1)$ | Best case |
| Case 2 | $T(n) = \frac{n+1}{2}$ | $T(n) = \mathrm{O}(n)$ | Average case |
| Case 3 | $T(n) = n$ | $T(n) = \mathrm{O}(n)$ | Worst case |

# References


- Debasis Samanta, Computer Science & Engineering, Indian Institute of Technology Kharagpur, Spring-2017, Programming and Data Structures. https://cse.iitkgp.ac.in/~dsamanta/courses/pds/index.html

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