

More Lists

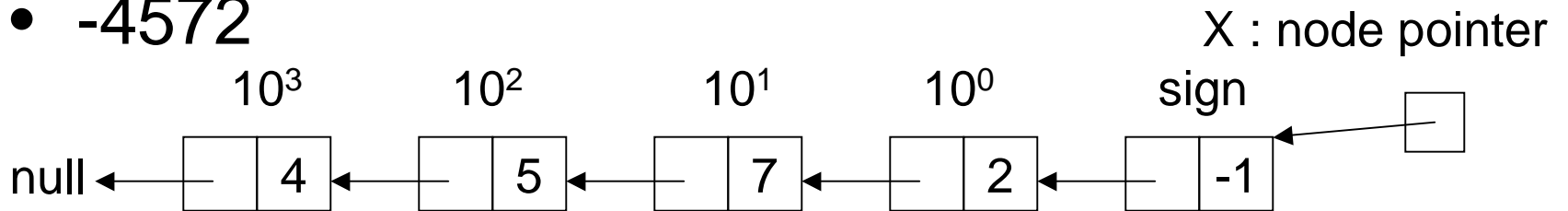
CSE 373

Data Structures

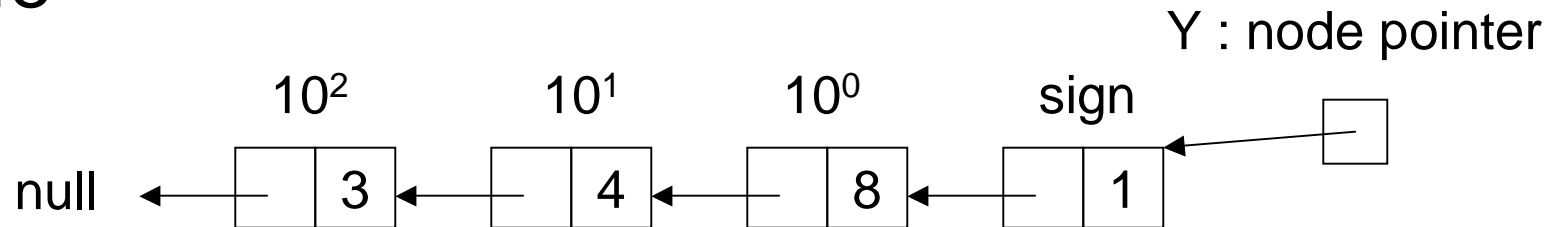
Lecture 4

Recall Unbounded Integers

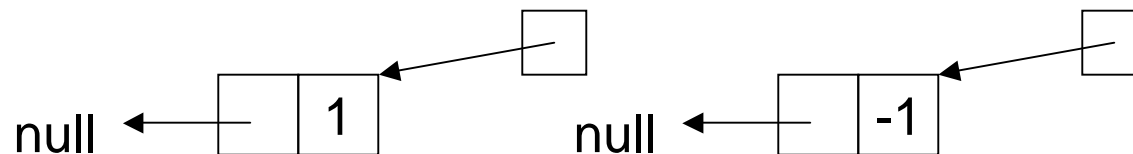
- -4572



- 348



- Zero

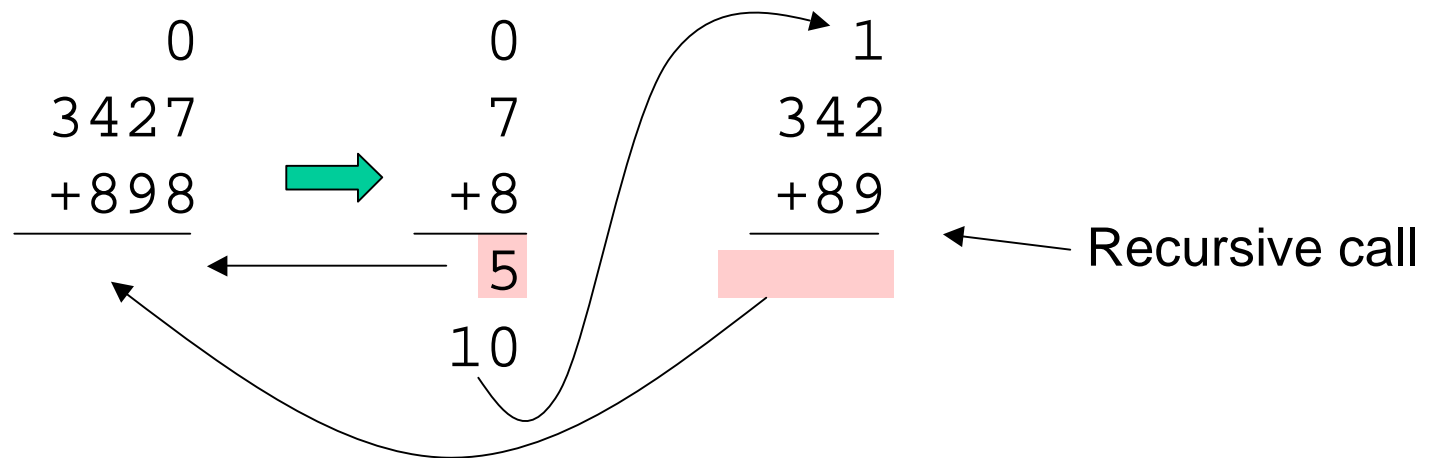


Alternative Addition

- Use an auxiliary function
 - › $\text{AddAux}(p, q : \text{node pointer}, cb : \text{integer})$ which returns the result of adding p and q and the carry/borrow cb .
 - › $\text{Add}(p, q) := \text{Add}(p, q, 0)$
 - › Advantage: more like what we learned in grade school.

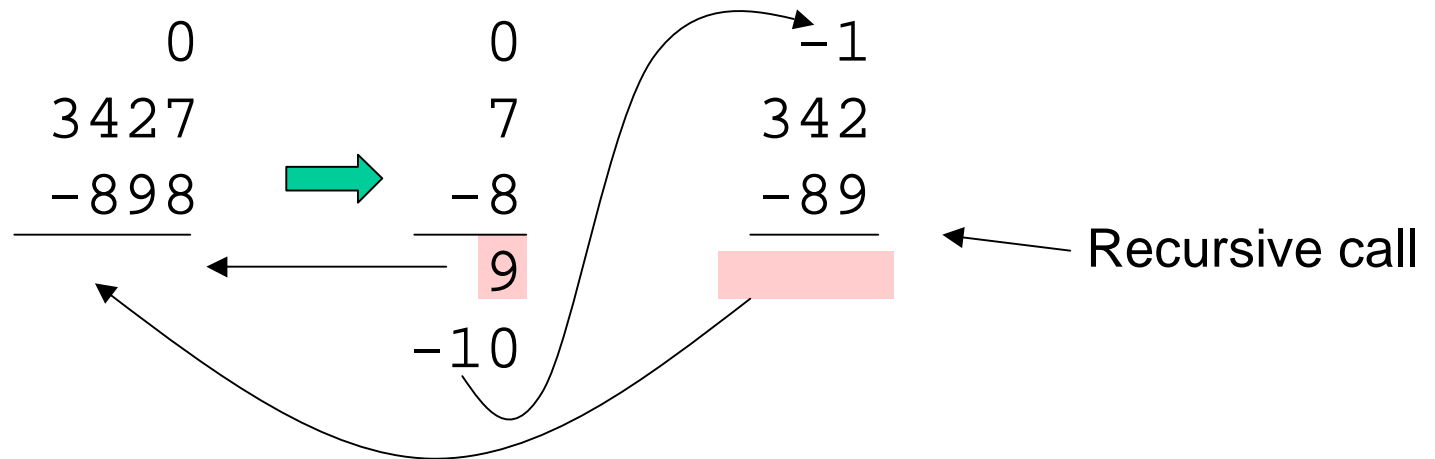
Auxiliary Addition

- Positive numbers (or negative numbers)



Auxiliary Addition

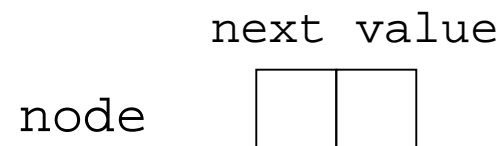
- Mixed numbers



Copy

- Class participation.
- Design a recursive algorithm to make a copy of an integer.

```
Copy(p : node pointer) : node pointer {  
  ???  
}
```

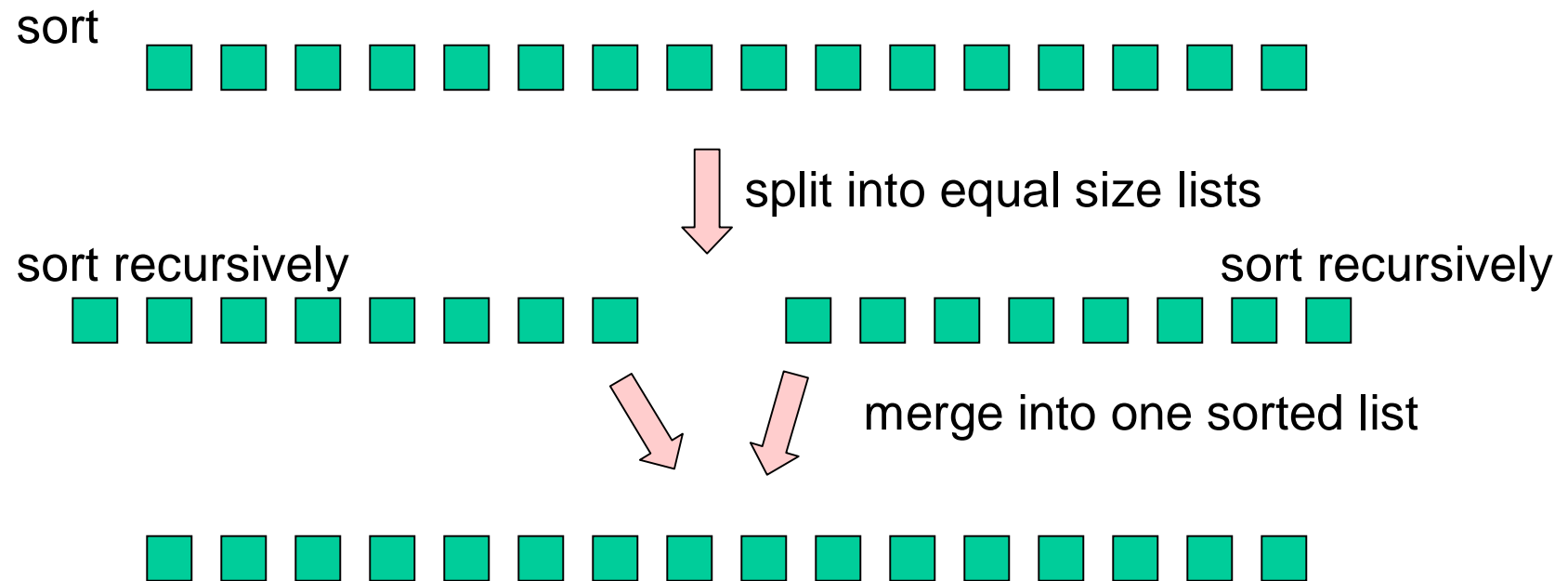


Comparing Integers

```
IsZero(p : node pointer) : boolean {
return p.next = null;
}
IsPositive(p: node pointer) : boolean {
return not IsZero(p) and p.value = 1;
}
Negate(p : node pointer) : node pointer { //destructive
if p.value = 1 then p.value := -1
else p.value := 1;
return p
}
LessThan(p,q :node pointer) : boolean {
p1,q1 : node pointer;
p1 := Copy(p); q1 := Copy(q);
return IsPositive(Add(q1,Negate(p1))); // x < y iff 0 < y - x
//We assume Add and Negate are destructive
}
```

List Mergesort

- Overall sorting plan



Mergesort pseudocode

```
Mergesort(p : node pointer) : node pointer {
Case {
  p = null : return p; //no elements
  p.next = null : return p; //one element
  else
    d : duo pointer; // duo has two fields first,second
    d := Split(p);
    return Merge(Mergesort(d.first),Mergesort(d.second));
}
}
```

Note: Mergesort is destructive.

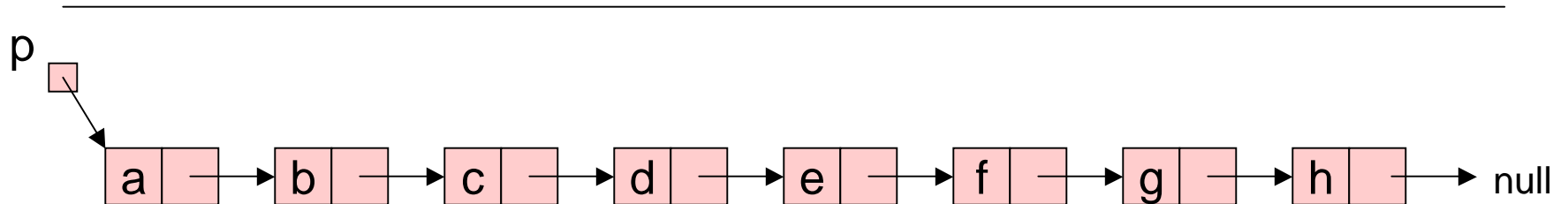
duo



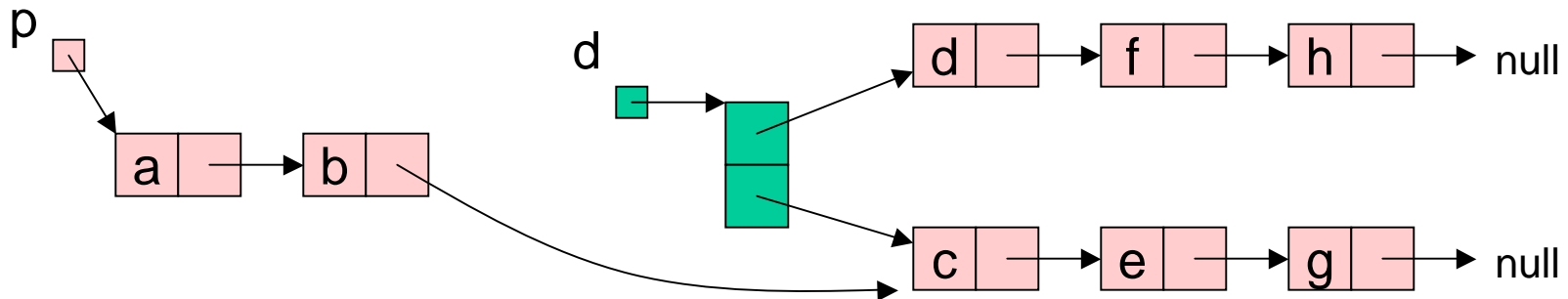
Split

```
Split(p : node pointer) : duo pointer {
d : duo pointer;
Case {
  p = null : d := new duo; return d
  p.next = null : d := new duo; d.first := p ; return d
  else :
    d := Split(p.next.next);
    p.next.next := d.first;
    d.first := p.next;
    p.next := d.second;
    d.second := p;
    return d;
}
}
```

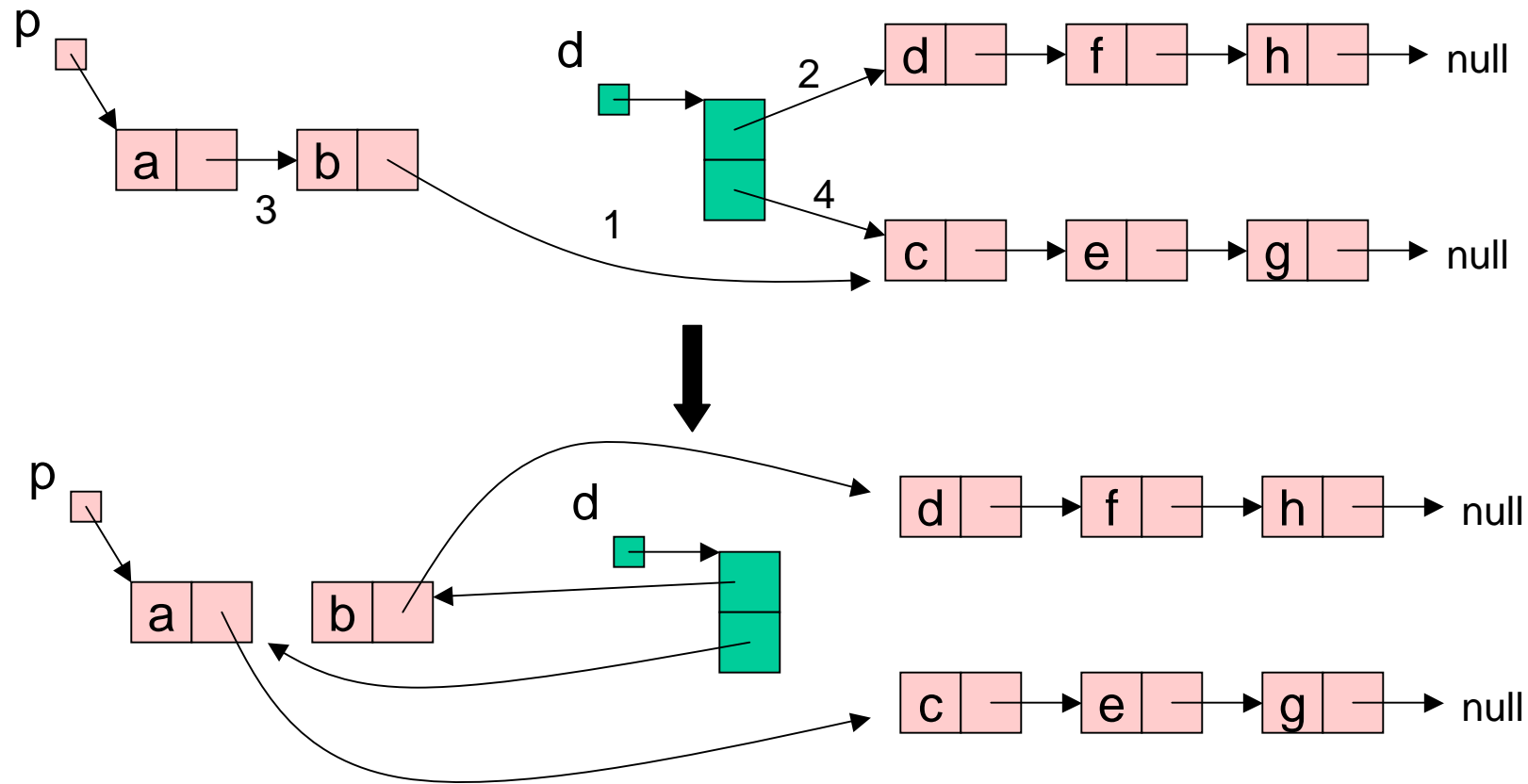
Split Example



After recursive call to Split



Split Example

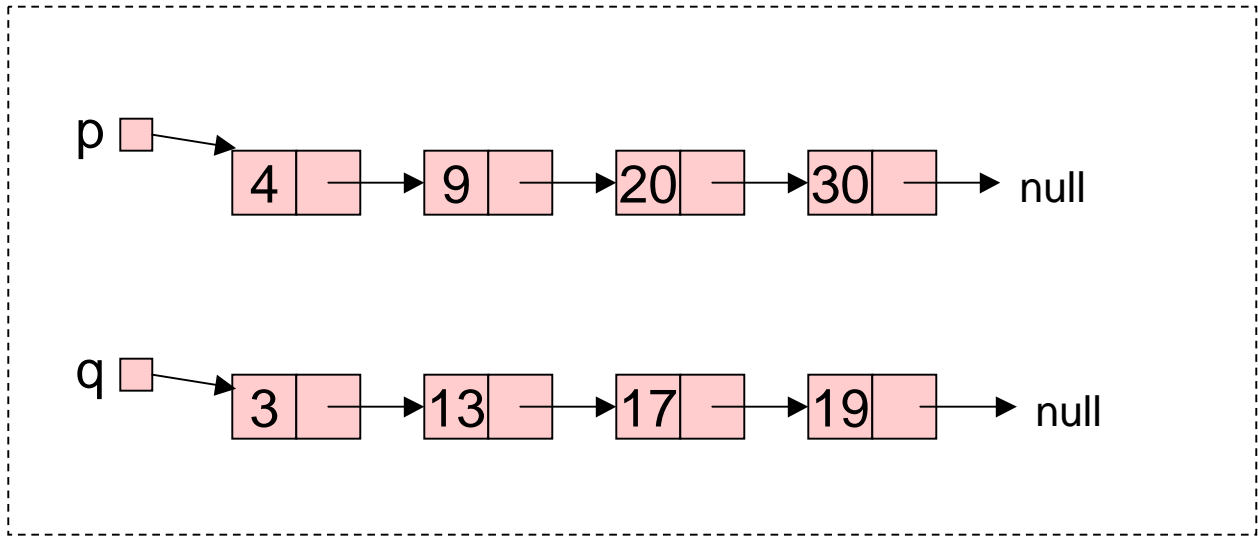


Merge

```
Merge(p,q : node pointer): node pointer{
case {
  p = null : return q;
  q = null : return p;
  LessThan(p.value,q.value) :
    p.next := Merge(p.next,q);
    return p;
  else :
    q.next := Merge(p,q.next);
    return q;
}
}
```

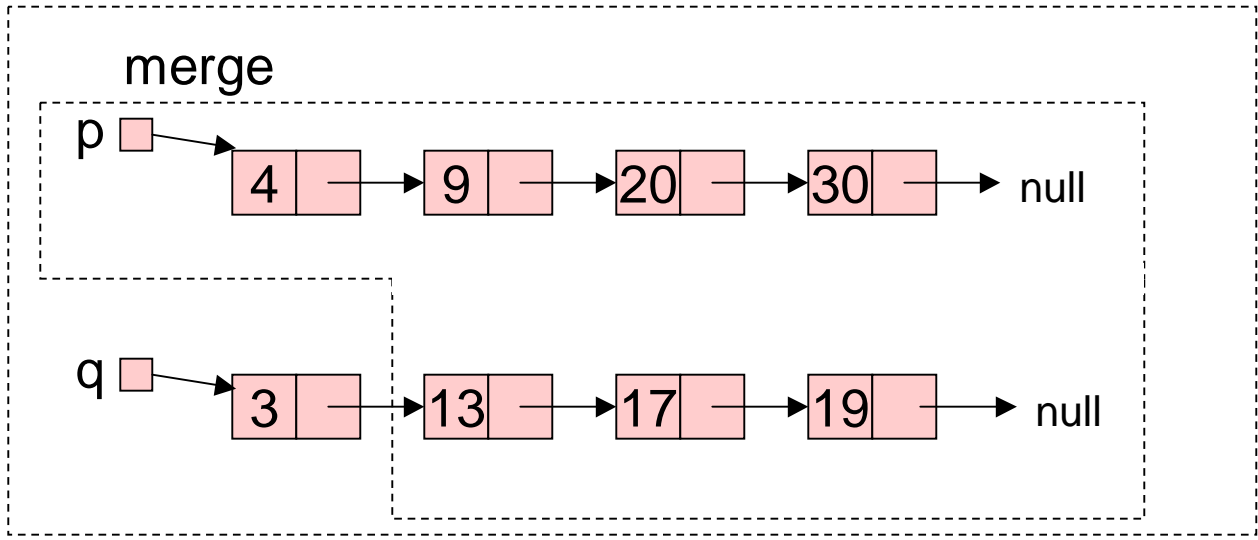
Merge Example

merge



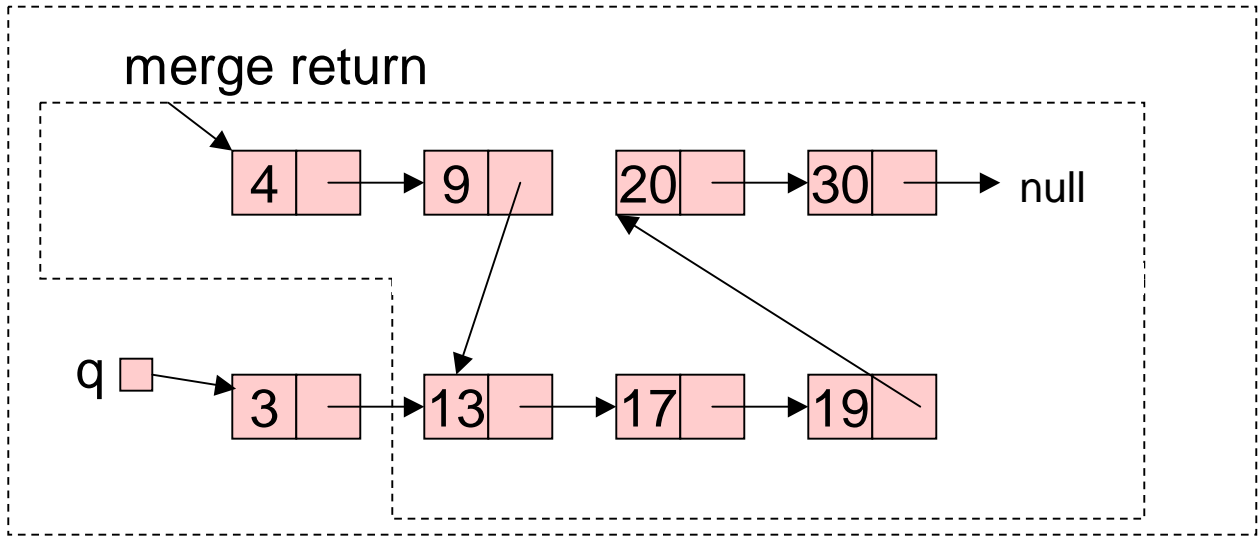
Merge Example

merge



Merge Example

merge



Implementing Pointers in Arrays

– “Cursor Implementation”

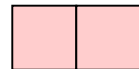
- This is needed in languages like Fortran, Basic, and assembly language
- Easiest when number of records is known ahead of time.
- Each record field of a basic type is associated with an array.
- A pointer field is an unsigned integer indicating an array index.

Idea

Pointer World

n nodes

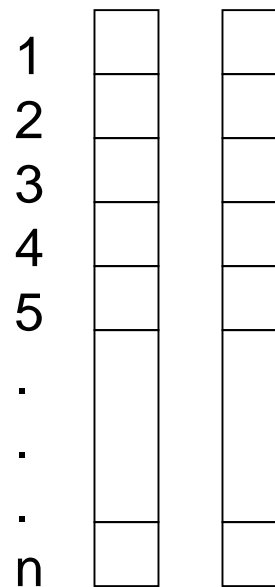
data next



data : basic type
next : node pointer

Nonpointer World

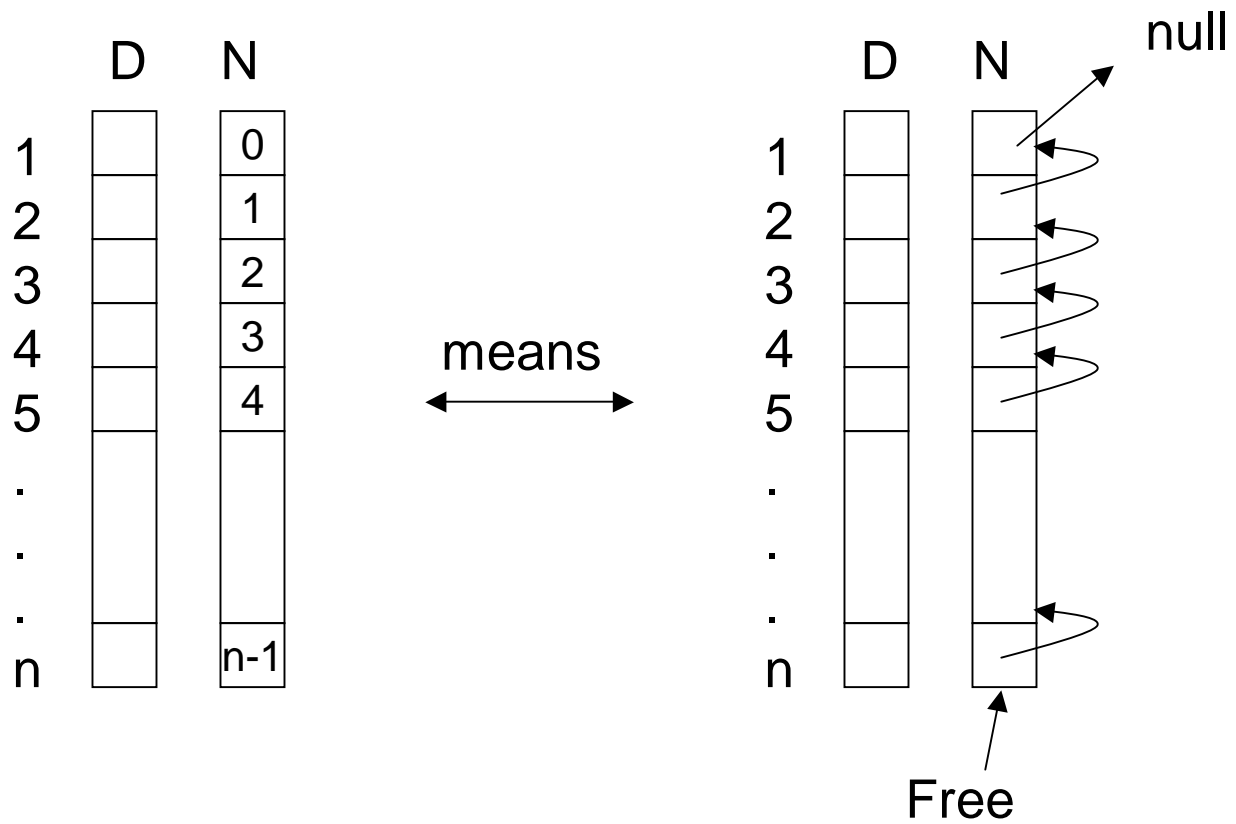
D N



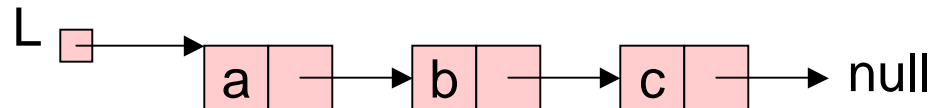
- $D[]$: basic type array
- $N[]$: integer array
- Pointer is an integer
- null is 0
- $p.data$ is $D[p]$
- $p.next$ is $N[p]$
- Free list needed for node allocation

Initialization

Free = n



Example of Use



$n = 8$

$L = 4$

$Free = 7$

	D	N
1		3
2	c	0
3		0
4	a	6
5		8
6	b	2
7		5
8		1

```
InsertFront(L : integer, x : basic type) {  
  q : integer;  
  if not(Free = 0) then q := Free  
    else return "overflow";  
  Free := N[Free];  
  D[q] := x;  
  N[q] := L;  
  L := q;  
}
```

Try DeleteFront

- Class Participation
- Define the cursor implementation of DeleteFront which removes the first member of the list when there is one.
 - › Remember to add garbage to free list.

```
DeleteFront(L : integer) {  
  ???  
}
```

Copy Solution

```
Copy(p : node pointer) : node pointer {
  if p = null then return null
  else {
    q : node pointer;
    q := new node;
    q.value := p.value;
    q.next := Copy(p.next);
    return q;
  }
}
```

DeleteFront Solution

```
DeleteFront(L : integer) {  
  q : integer;  
  if L = 0 then return "underflow"  
  else {  
    q := L;  
    L := N[L];  
    N[q] := Free;  
    Free := q;  
  }  
}
```