More on Lists

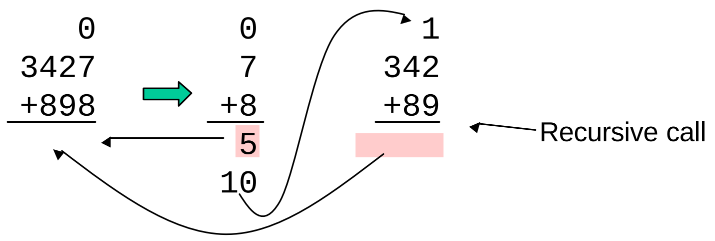
CSE 373
Data Structures

Alternative Addition

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

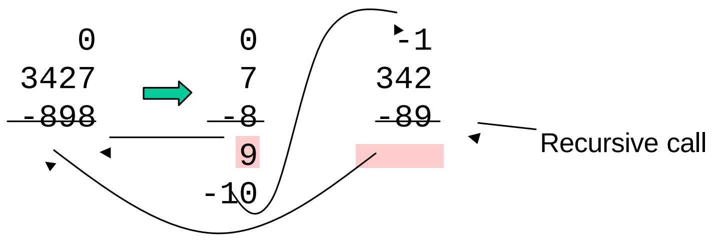
Auxiliary Addition

- Positive numbers (or negative numbers)



Auxiliary Addition

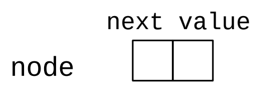
- Mixed numbers



Copy

- Design a recursive algorithm to make a copy of a linked list (like the one used for long integers)

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

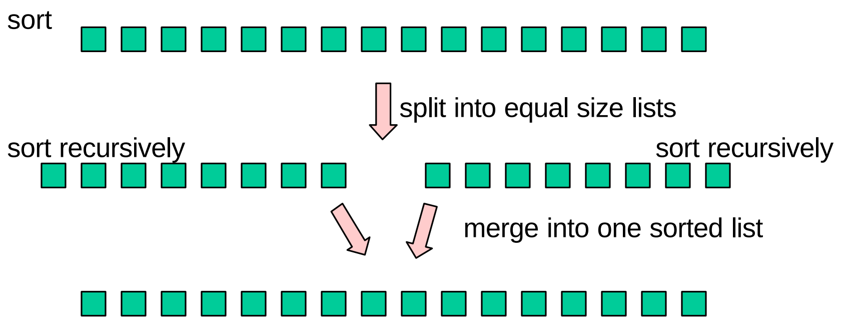


Comparing Long Integers

```
IsZero(p : node pointer) : boolean { //p points to the sign node
return p.next = null;
}
IsPositive(p: node pointer) : boolean {//p points to the sign node
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 { // non destructive
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

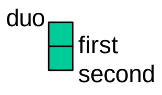
- Overall sorting plan



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));
}
}
```

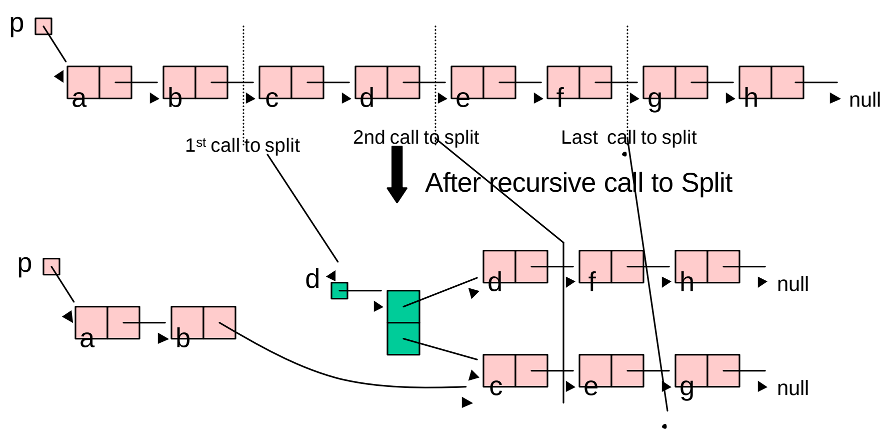
Note: Mergesort is destructive.



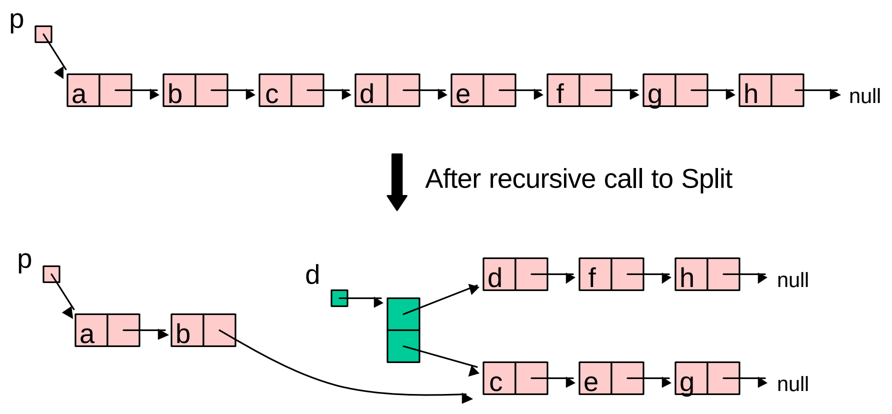
Split

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

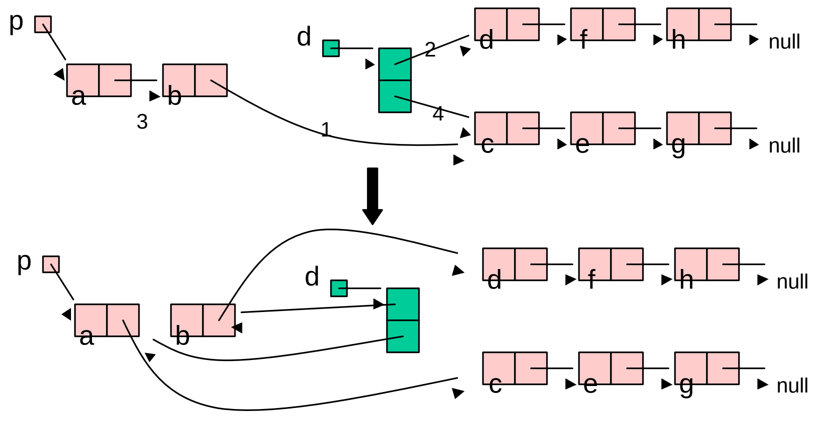
Split Example



Split Example



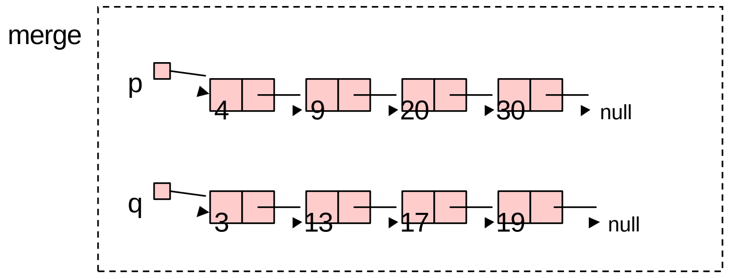
Split Example



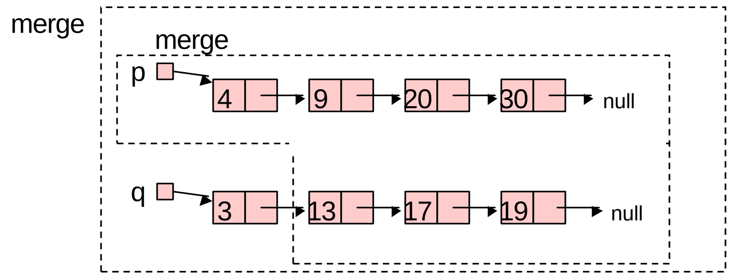
Merge

```
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;
}
}
```

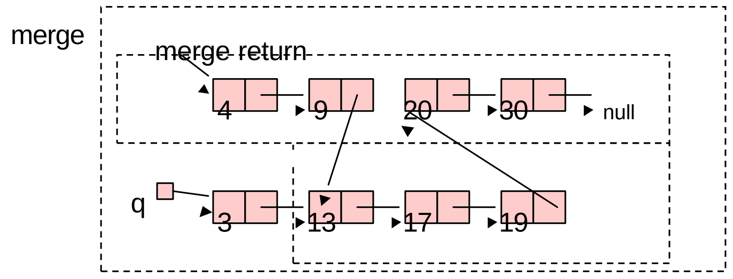
Merge Example



Merge Example



Merge Example



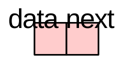
Implementing Pointers in Arrays – “Cursor Implementation”

- 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

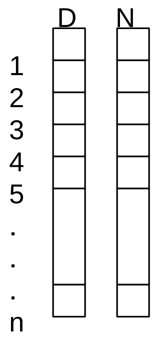
Pointer World

n nodes



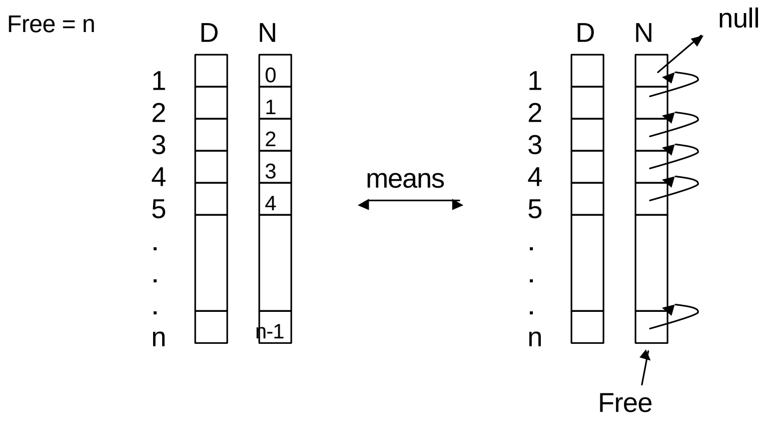
data : basic type
next : node pointer

Nonpointer World

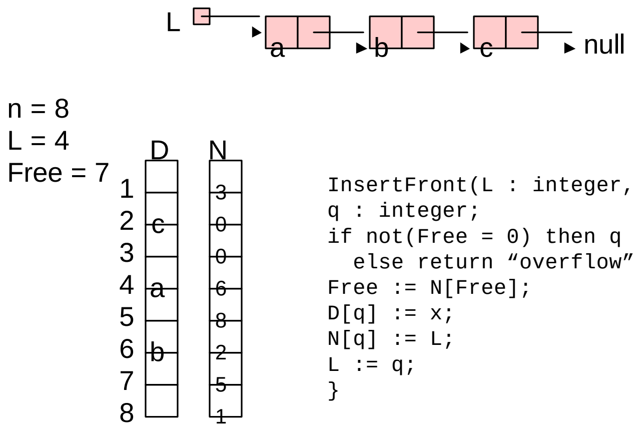


- D[ ] : basic type array
- N[ ] : integer array
- Pointer is an integer
- null is 0
- p.data is D[p]
- p.next is N[p]
- Free list needed for node allocation

Initialization



Example of Use



```
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

- 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; //by convention the value
                 //field is 0 and the
                 //pointer field is null
  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;
}
}
```