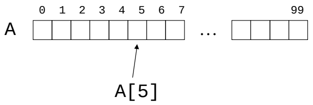
Pointers and Lists

CSE 326
Data Structures
Lecture 5

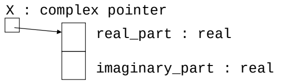
Basic Types and Arrays

- Basic Types
  - › integer, real (floating point), boolean (0,1), character
- Arrays
  - › A[0..99] : integer array



Records and Pointers

- Record (also called a struct or data object)
  - › Group data together that are related



  - › To access the fields we use “dot” notation.

```
X.real_part
X.imaginary_part
```

Record Definition

- Record definition creates a new type

Definition

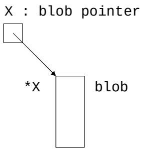
```
record complex : (
  real_part : real,
  imaginary_part : real
)
```

Use in a declaration

```
X : complex
```

Pointer

- A pointer is a reference to a variable or record (or object in Java world).

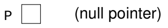


- In C, if X is of type pointer to Y then *X is of type Y

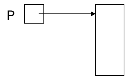
Creating a Record

- We use the “new” operator to create a record.

P : pointer to blob;

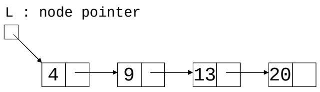


P := new blob;



Simple Linked List

- A linked list
  - Group data together in a flexible, dynamic way.
  - We'll describe several list ADTs later.



```
record node : (
  data : integer
  next : node pointer
)
```

Memory Management – Global Allocator

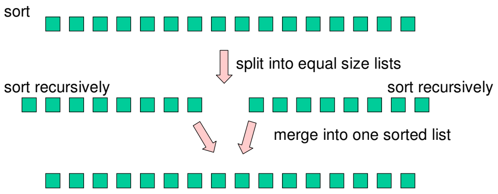
- Global Allocator's store – always get and return blocks to global allocator
  - \+ Necessary for dynamic memory.
  - \+ Blocks of various sizes can be merged if they reside in contiguous memory.
  - \- Allocator may not handle blocks of different sizes well.
  - \- Allocator may be slower than a private store.

Memory Management – Garbage Collection

- Garbage collection – run time system recovers inaccessible blocks from time-to-time. Used in Lisp, Smalltalk, Java.
  - \+ No need to return blocks to an allocator or keep them in a private store.
  - \- Care must be taken to make unneeded blocks inaccessible.
  - \- When garbage collection kicks in there may be undesirable response time.

List Mergesort

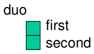
- Overall sorting plan



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));
}
}
```

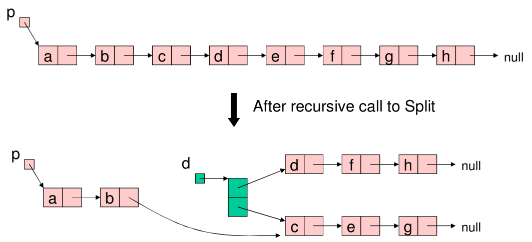
Note: Mergesort is destructive.



Split

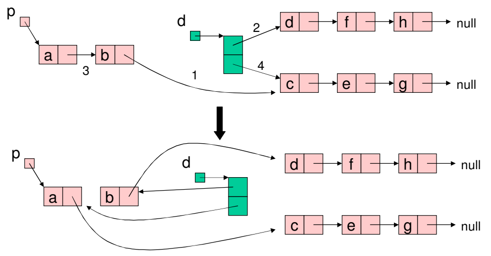
```
Split(p : node pointer) : duo pointer {
d : duo pointer;
Case {
  p = null : d := new duo; return d
  p.next = null : d := new duo; d.first := p ; return d
  else :
    d := Split(p.next.next);
    p.next.next := d.first;
    d.first := p.next;
    p.next := d.second;
    d.second := p;
    return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

Split Example

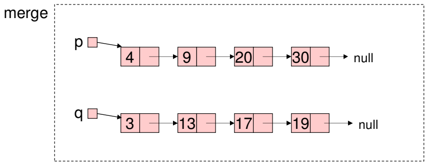


After recursive call to Split

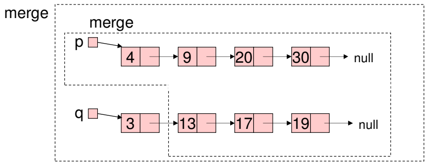
Split Example



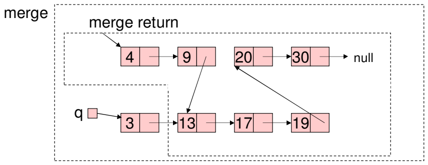
Merge Example



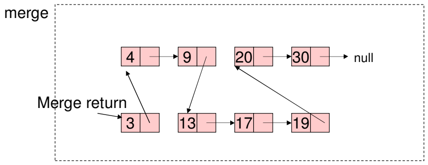
Merge Example



Merge Example



Merge Example



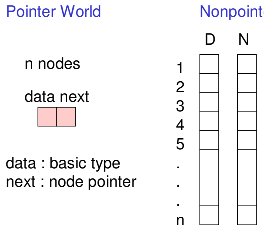
Merge Pseudocode Exercise

```
Merge(p,q : node pointer): node pointer{
\\precondition p and q point to sorted lists
if p = null return q;
if q = null return p;
if p.data < q.data then
    p.next := merge(p.next,q);
    return p;
else
    q.next := merge(p,q.next);
    return q
}
```

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.

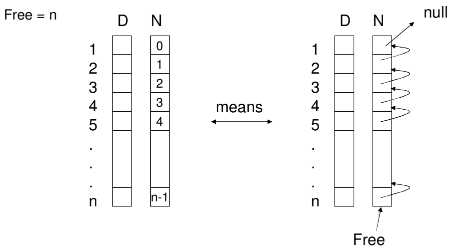
Idea



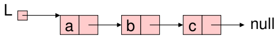
data : basic type
next : node pointer

- 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

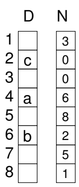
Initialization



Example of Use



n = 8
L = 4
Free = 7



```
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

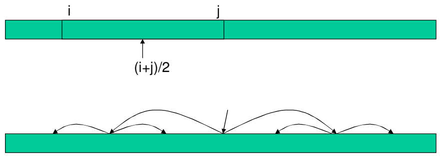
- Class Participation
- Define the cursor implementation of DeleteFront which removes the first member of the list when there is one.
  - › Remember to add garbage to free list.

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

Pointer Summary

- Pointers can be implemented in several ways
  - Explicit using “dot” notation in most high level languages
  - Explicit using arrays of indices in all high level languages. (Cursor implementation)
  - Implicit using calculation instead of storage. (Commonly used in nice structures like trees)

Implicit Pointers in Binary Search



Implicit pointers

DeleteFront Solution

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