Data is Often Related

- A point in the plane has an x coordinate and y coordinate
- If a program manipulates lots of points, there will be lots of x's and y's
  - Anticipate clutter
- Is there a way to "package" the two coordinate values?

Packaging Affects Thinking

- Our Reasoning Level:
  - P and Q are points
  - Compute the midpoint M of the connecting line segment
- Behind the scenes we do this:

$M_x = (P_x + Q_x)/2$
$M_y = (P_y + Q_y)/2$

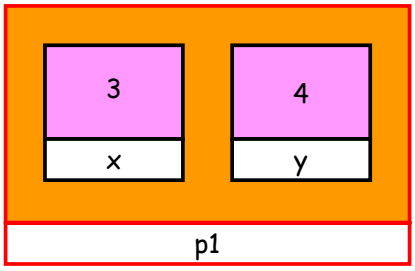
- We've seen this before
  - Functions are used to "package" calculations
- This kind of packaging (a type of abstraction) elevates the level of our reasoning
- Critical for problem solving!

Initialization

```
p1 = struct('x', 3, 'y', 4);
```

- p1 is a structure
- The structure has two fields
- Their names are x and y
- They are assigned the values 3 and 4

Assigning to a Field




```
p1.x = p.y^2
```

Assigns the value 16 to p1.x

Legal/Illegal Maneuvers

```
Q = struct('x', 5, 'y', 6);

R = Q;                  % Legal: R is a copy of Q

S = (Q+R)/2;            % Illegal: Cannot add structures

P=struct('x', 3, 'y');  % Illegal: Args must be in pairs
P.y = 4;

P = struct('x',3,'y',[]);  % Legal: Empty array as a "place holder"
P.y = 4;
```

Sample "Make" Function

```
function P = MakePoint(x,y)
% P is a point.
% P.x and P.y are assigned the values x and y.

P = struct('x',x,'y',y);
```

- Good style
- Highlights the structure's definition

Functions and Structures

```
function DrawLS (P, Q, c)
% Draws a line segment connecting points
% P and Q; color is specified by c.
% Assumes hold is on.

plot([P.x  Q.x], [P.y  Q.y], c)
```

Function Returning An Array of Points

```
function P = CirclePoints(n)
% P is a structure array holding n points around a circle.

theta = 2*pi/n;
for k=1:n
   c = cos(theta*k);
   s = sin(theta*k);
   P(k) = MakePoint(c,s);
end
```

Avoiding Duplicates: i < j < k

```
for i=1:n
  for j=i+1:n
    for k=j+1:n
       disp([i j k])
    end
  end
end
```

Triangle Solution!

```
for i=1:n
 for j=i+1:n
   for k=j+1:n
     DrawTriangle( P(i),P(j),P(k),'m')
     DrawPoints(P)
     pause
     DrawTriangle(P(i),P(j),P(k),'k')
   end
 end
end
```

Structures with Array Fields

- Let's develop a structure that can be use to represent a colored disk
- Four fields:
  - xc: x-coordinate of center
  - yc: y-coordinate of center
  - r: radius
  - c: rgb color vector
- Example:

```
D1 = struct('xc',1,'yc',2,'r',3,'c',[1 0 1])
D2 = struct('xc',4,'yc',0,'r',1,'c',[.2 .5 .3])
```

A Structure's Field Can Hold a Structure

```
A = MakePoint(2,3)
B = MakePoint(4,5)
L = struct('P',A,'Q',B)
```

- This could be used to represent a line segment with endpoints P and Q, for instance

```
x = L.P.y       % Assigns 3 to x
```