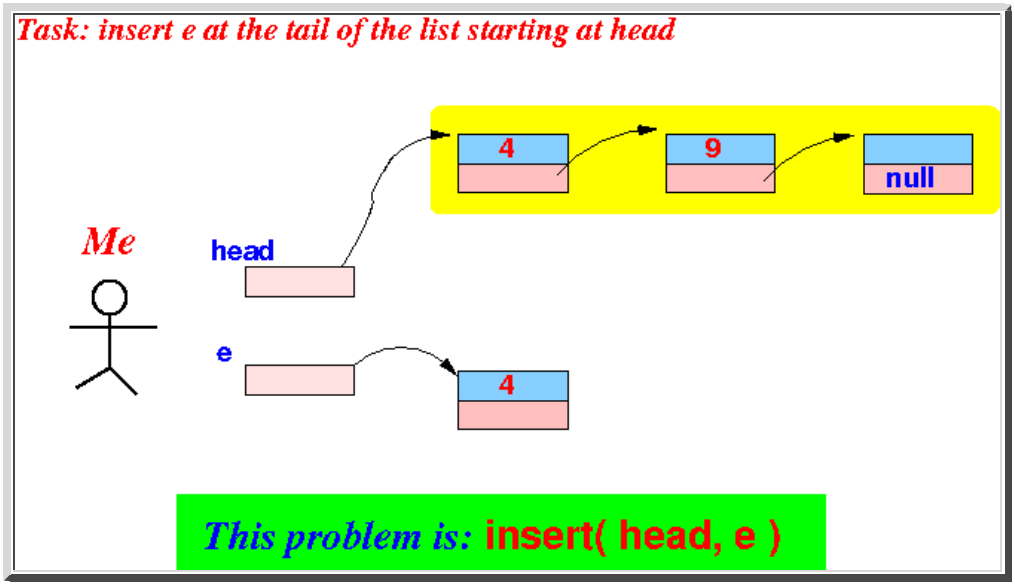
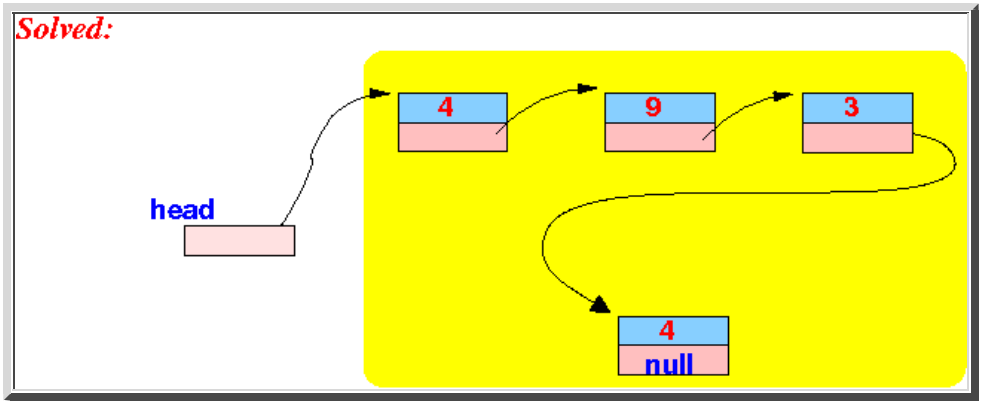
Using *recursion* to insert node at the *tail* of a list

- **Pay attention to this when you study *recursion***
  - The **key** to ***understanding* recursion** is:
    - Figure out ***how*** to **solve** the ***original* problem using** the **solution** of a **smaller version of the problem**
  - **After** you have **figure out** the **key problem** above, you can **then**:
    - Find the **base case(s)** (easy to solve problems)
    - Find out **how to *detect*** the **base case(s)**
      - The **recursive method** must use an ***if*-statement** to **detect** each **base case** and ***return*** the **solution** !!!
- **Insert a node at the *tail* of a list using *recursion***
  - **How to** solve the **problem** of
    - Insert a **node** at the **end** of a linked list

    using the **solution** of a **smaller version** of the **problem**
  - **Example:**
    - I want to **change** this **state**

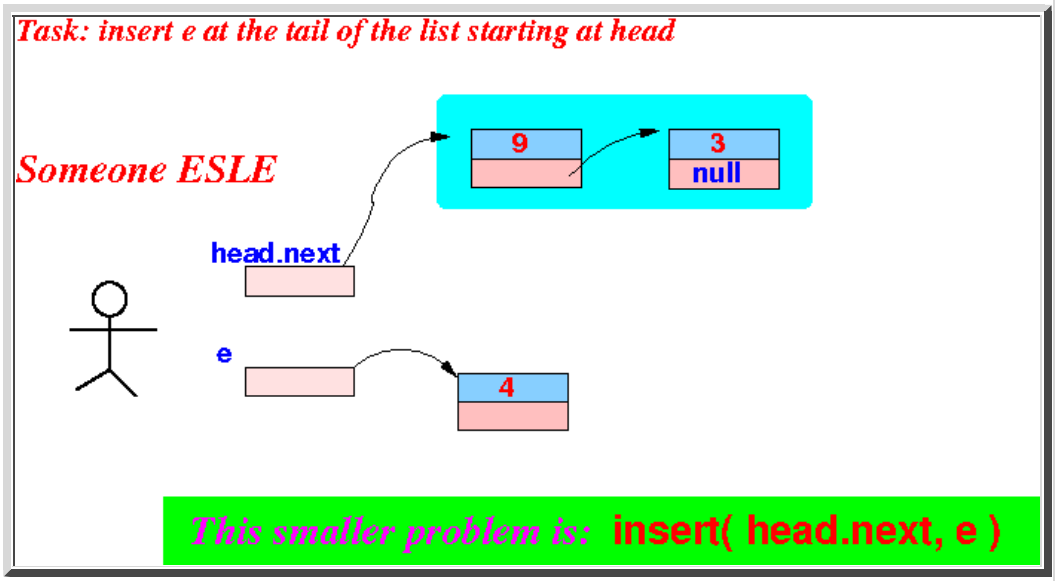


into the **following state** (i.e., what the **list** would look like ***after*** the node ***e*** has been **inserted**)



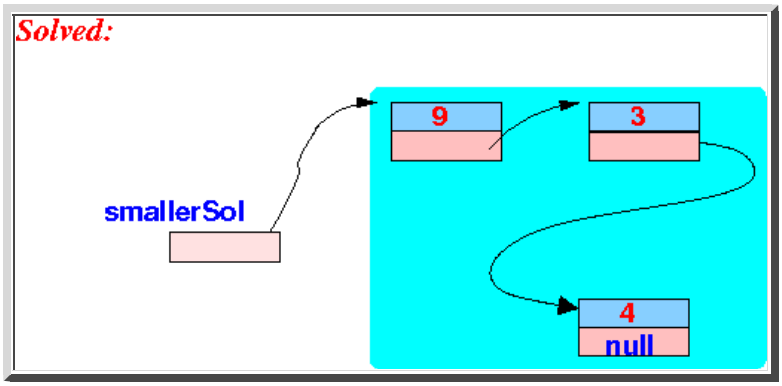
by *using* the ***solution*** of a ***smaller* version** of the ***same* problem**

- Here is a ***smaller* version** of the ***same* problem**:

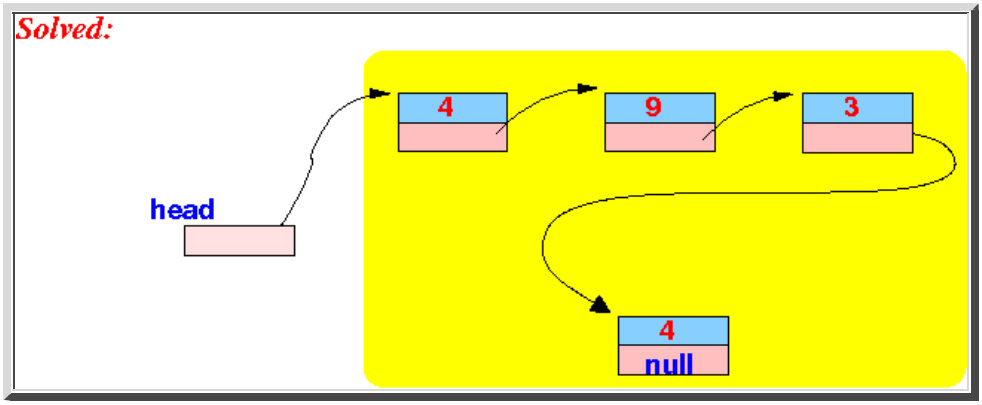


(**Notice** the **list** is ***smaller*** because the ***first* node** is missing

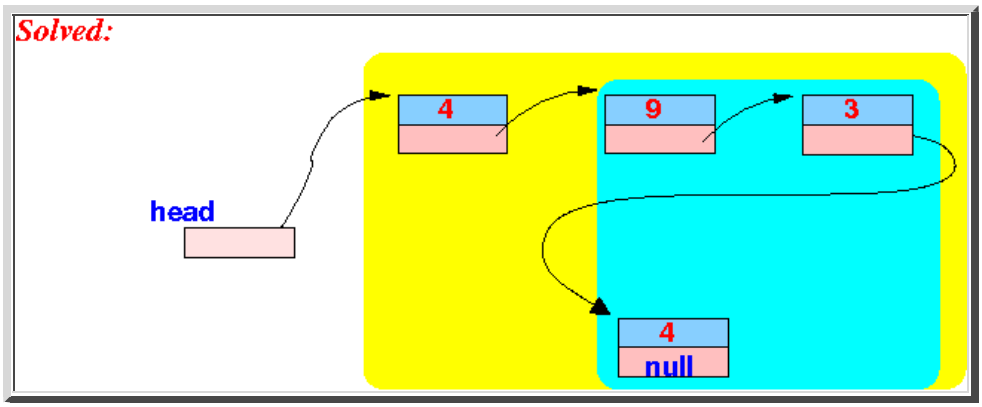
Here is the **solution** for the ***smaller* problem**:



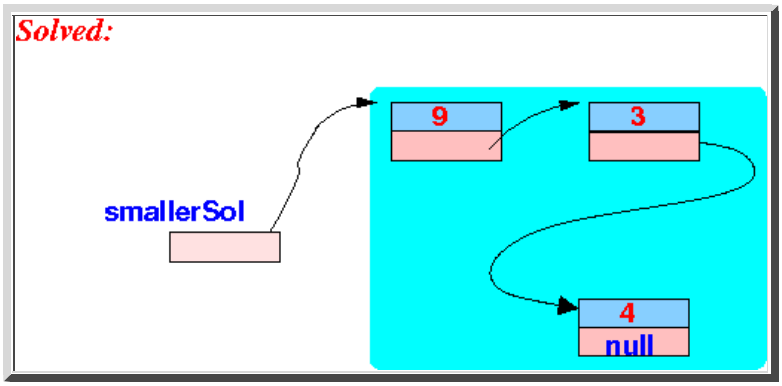
- **How** I obtain the **solution** of ***original* problem**:



let me draw it **differently** and ***highlight*** the **smaller solution**:



using the **solution** for the ***smaller* problem**:



- **Answer:** with ***this* statement**

```
head.next = smallerSol;
```

This is the **basis** for the ***recusive* algorithm** !!!

- **Pseudo code** for the ***recursive* algorithm** to **insert** a node ***e*** at the **tail** of a list starting at ***head***:

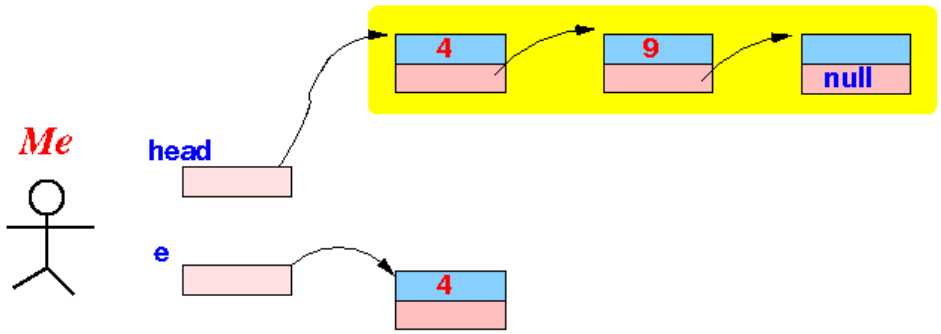
```
Node insert( Node head, Node e)
{
    /* ========================================
       Recursive algorithm WITHOUT
       handling of the base case(s)
```

```
   ======================================== */

Node smallerSol;

// Suppose head and e are as follows:
```

Task: insert e at the tail of the list starting at head

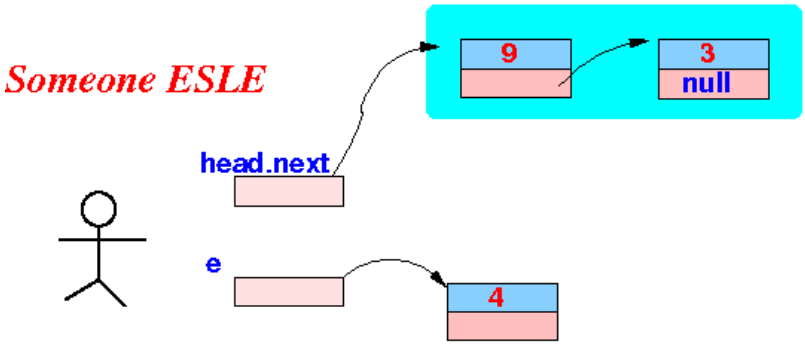


This problem is: **insert(head, e)**

```
smallerSol = insert( head.next, e );

// insert( head.next, e ) is this smaller problem:
```

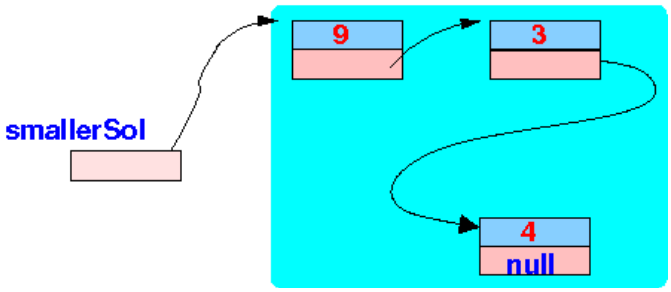
Task: insert e at the tail of the list starting at head



This smaller problem is: **insert(head.next, e)**

```
// smallerSol will contains this list:
```

Solved:

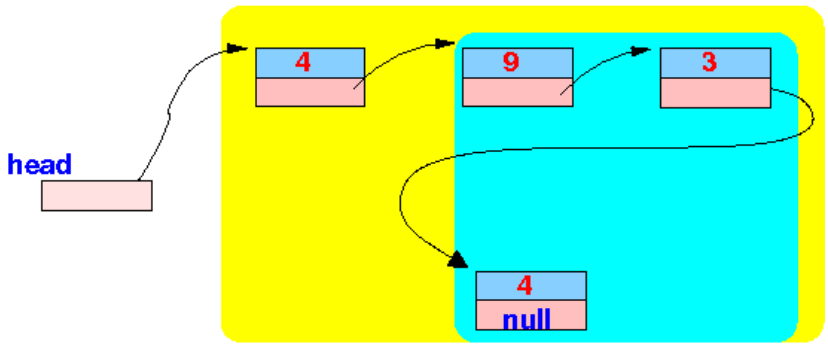



```
// Solve the original problem:

head.next = smallerSol;
```

```
    // Now we have:
```

Solved:




```
    solution = head;      // The solution is the list starting at head

    // Return the solution list

    return( solution );

}
```

- **The *other* important part of recursion: the *base case(s)***
  - **Fact:**
    - To **complete** the **recursive algorithm**, we must **find** ***easy*** **to solve** cases (**base cases**) and **handle** the **base cases** ***separately***
      - ***Otherwise***, the **recursive method** will **not terminate** --- it will keep calling itself **forever**

  - **Hint:**
    - **Base cases** are **usually** problems where the ***input*** **data** is ***small*** **in size**

      Characteristic of **base cases**:
      - **Every base case** has the **property** that you can ***solve*** the **problem** using **a *few* simple statements**

    Base cases for **list** problems are ***often***:
    - When the **input list** is ***empty***, ***and/or***
    - When the **input list** contains ***one*** **node**

- **The base case for "insert node at the tail of a list"**
  - **Question:**
    - ***When*** is it ***extremely*** **easy** to **insert** a **node** at the **tail** of a **list** ???

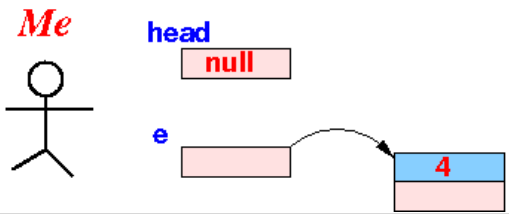
    Answer:

- When the **list** has ***no*** **nodes** !!!

- **Example:**

  - **Base case:**

    Task: insert e at the tail of the list starting at head

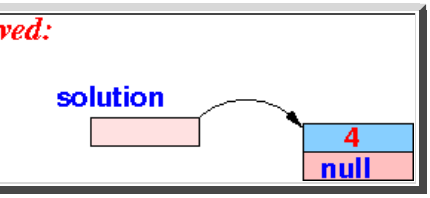
    How do you ***detect*** the **base case** ?

    Answer:

```
if ( head == null )
```

  - **Solution:**

    Solved:

- **Java code** to **detect** and ***handle*** the **base case** in "insert node at the tail of a list":

```
if ( head == null )
{
   e.next = null;

   solution = e;

   return solution;
}
```

- **The *complete* recursive algorithm...**

  - The **complete** ***recursive*** **algorithm** in **general** is as follows:

```
static SolveProblem(  n  )
{
   variables: solution, smallerSol;

   if ( base case detected )
   {
      solution = solve base case;
```

```
        return solution;
    }
    else
    {
        smallerSol = SolveProb( n-1 );   // Recursion !!!

        solution = find solution using smallerSol;

        return solution;
    }
}
```

Note:

- ***Recursive* methods** are ***almost always*** a **class method** (i.e.: `static`)

- **The *recursive* insert node at tail of list algorithm**
  - **Put** the **code** that we have **develop** above into the ***general* recursive algorithm** form and we obtain:

```
private static Node insert( Node head, Node e )
{
   Node solution, smallerSol;

   /* ------------------------------------------
      Base case: insert at the tail of an empty
      ------------------------------------------ */
   if ( head == null )
   {
      e.next = null;     // Mark e as the last node

      solution = e;      //

      return(solution);  // return the simple solution !
   }
   else
   {
      /* ============================================================
         Solve the problem USING the solution of a smaller problem

         I know the list is not empty...
         And "head.next" is a SHORTER list !
         ============================================================ */

      smallerSol = insert( head.next, e ); // Have "someone else" solve
                                           // in smaller problem

      head.next = smallerSol;  // Find solution using smallerSol

      solution = head;

      return solution;        // Return the solution
   }
}
```

  - **How to** use this **method**:

```
public static void main( String[] args )
{
   Node head = null;
   Node e;

   e = new Node(4);
   head = RecursiveList.insert(head, e);  // Pass head and e as parameter
                                          // Method returns a new list
   RecursiveList.printList( head );

   e = new Node(1);
   head = RecursiveList.insert(head, e);
   RecursiveList.printList( head );
```

```
        e = new Node(3);
        head = RecursiveList.insert(head, e);
        RecursiveList.printList( head );

        e = new Node(7);
        head = RecursiveList.insert(head, e);
        RecursiveList.printList( head );
    }
```

Output:

```
[4.0]
[4.0 , 1.0]
[4.0 , 1.0 , 3.0]
[4.0 , 1.0 , 3.0 , 7.0]
```

- **Example Program:** (Demo above code) *Example*
  - The **Recursive List** Prog file: click here
  - The **test** Prog file: click here

How to run the program:

- **Right click** on link(s) and **save** in a scratch directory
- To compile: `javac testProg.java`
- To run: `java testProg`