Tablas de Símbolos

Programación de Sistemas de Telecomunicación
Informática II

Departamento de Sistemas Telemáticos y Computación
(GSyC)

Universidad Rey Juan Carlos

Noviembre 2019

Contenidos

1. Tablas de Símbolos
2. Implementación de TS mediante un array no ordenado
3. Implementación de TS mediante una lista enlazada no ordenada
4. Ejemplo de ejecución (TS mediante lista enlazada no ordenada)
5. Iteración sobre todos los elementos de una colección
6. Implementación de TS mediante un Array ordenado
7. Implementación de TS mediante una lista enlazada ordenada
8. Implementación de TS mediante un árbol de búsqueda binaria (ABB)
9. Ejemplo de ejecución: Get en un ABB
10. Ejemplo de ejecución: Put en un ABB vacío
11. Ejemplo de ejecución: Put en un ABB
12. Borrado de un nodo en un ABB

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Tablas de símbolos

- La tabla de símbolos es una estructura de datos también conocida por los siguientes nombres: mapa, array asociativo, diccionario.
- La tabla de símbolos es una estructura de datos que almacena elementos compuestos por parejas (`Clave`, `Valor`).
- `Clave` y `Valor` pueden ser tipos de datos cualesquiera.

Usos de las tablas de símbolos (I)

- Lista de usuarios en Mini-Chat:
  (`Clave =>` EP, `Valor =>` Nickname)
- Listado de teléfonos:
  (`Clave =>` Nombre, `Valor =>` Nº de teléfono)
- Diccionario:
  (`Clave =>` Palabra, `Valor =>` Definición)
- DNS:
  (`Clave =>` Nombre de máquina, `Valor =>` Dirección IP)
- DNS inverso:
  (`Clave =>` Dirección IP, `Valor =>` Nombre de máquina)

Usos de las tablas de símbolos (II)

- Valoración bursátil:
  (`Clave =>` Valor bursátil, `Valor =>` Cotización)
- Intercambio de ficheros P2P:
  (`Clave =>` Fichero, `Valor =>` Máquina)
- Índice inverso de un libro:
  (`Clave =>` Vocablo, `Value =>` Lista de números de página)
- Catálogo de buscador Web:
  (`Clave =>` Palabra, `Value =>` Sitios web)

Operaciones permitidas

- Las tablas de símbolos se caracterizan porque disponen de las siguientes operaciones básicas:
    - `Put`: Dado un nuevo elemento (`Clave, Valor`) como parámetro, se añade éste a la tabla. Si ya existía un elemento con la misma `Clave`, se sustituye su `Valor` asociado por el especificado en la llamada a `Put`
    - `Get`: Dada una `Clave` como parámetro, devuelve el `Valor` asociado a la misma en la tabla en caso de que exista un elemento (`Clave`, `Valor`)
    - `Delete`: Dada un `Clave` como parámetro, se borra de la tabla, si existe, el elemento (`Clave`, `Valor`)
- Todas las tablas de símbolos tienen al menos esas 3 operaciones, independientemente del tipo de datos que almacenen.

Especificación de la tabla de símbolos

```
with Ada.Strings.Unbounded;
package Maps is
   type Map is limited private;

   procedure Get (M       : Map;
                  Key     : in  ASU.Unbounded_String;
                  Value   : out ASU.Unbounded_String;
                  Success : out Boolean);
   procedure Put (M     : in out Map;
                  Key   : ASU.Unbounded_String;
                  Value : ASU.Unbounded_String);
   procedure Delete (M       : in out Map;
                     Key     : in  Asu.Unbounded_String;
                     Success : out Boolean);
   function Map_Length (M : Map) return Natural;

   --
   -- Cursor Interface for iterating over Map elements
   --
...
private
  ...
end Maps;
```

Implementaciones de tablas de símbolos

- Mediante un Array no ordenado
- Mediante una Lista enlazada no ordenada
- Mediante un Array ordenado con búsqueda binaria
- Mediante una Lista enlazada ordenada
- Mediante un Árbol de búsqueda binaria (ABB)

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Implementación de TS mediante un array no ordenado

- `Put`, `Get` y `Delete` requieren una búsqueda lineal en el Array: en el peor caso hay que recorrer todos los elementos
- El Array tiene un tamaño máximo fijado de antemano

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Tipos de datos

```
package Maps is
   package ASU renames Ada.Strings.Unbounded;

   type Map is limited private;

   procedure Get (M       : Map;
                  Key     : in  ASU.Unbounded_String;
                  Value   : out ASU.Unbounded_String;
                  Success : out Boolean);

private
   type Cell;
   type Cell_A is access Cell;
   type Cell is record
      Key   : ASU.Unbounded_String := ASU.Null_Unbounded_String;
      Value : ASU.Unbounded_String := ASU.Null_Unbounded_String;
      Next  : Cell_A;
   end record;
   type Map is record
      P_First : Cell_A;
      Length  : Natural := 0;
   end record;
end Maps;
```

Comparación con la implementación mediante un Array no ordenado

- La lista enlazada puede crecer / contraerse
- La búsqueda de un elemento (`Get`) no mejora respecto a la implementación con un Array no ordenado: hay que buscar linealmente la `Clave`
- La inserción de un elemento (`Put`) tampoco mejora, pues requiere buscar la `Clave`, ya que si existe hay que sustituir el valor almacenado por el nuevo
- El borrado de un elemento (`Delete`) tampoco mejora, pues, de nuevo, hay que buscar la `Clave`

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Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

1

```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
          ASU.To_Unbounded_String("69.63.189.16"));
```

2

```
Maps.Get (A_Map, ASU.To_Unbounded_String(“www.urjc.es"),
          Value, Success);
```

3

```
Maps.Put (A_Map, ASU.To_Unbounded_String(“google.com"),
          ASU.To_Unbounded_String(“66.249.92.104"));
```

4

```
Maps.Put (A_Map, ASU.To_Unbounded_String(“www.urjc.es"),
          ASU.To_Unbounded_String(“212.128.240.25"));
```

5

```
Maps.Put (A_Map, ASU.To_Unbounded_String(“facebook.com"),
          ASU.To_Unbounded_String(“69.63.189.11"));
```

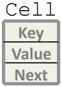
6

```
Maps.Delete (A_Map, ASU.To_Unbounded_String(“google.com"),Success);
```

7

```
Maps.Delete (A_Map, ASU.To_Unbounded_String(“www.urjc.es"),Success);
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



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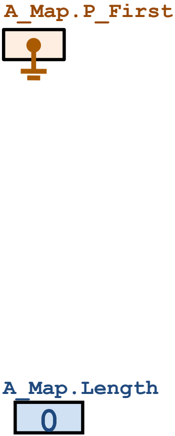

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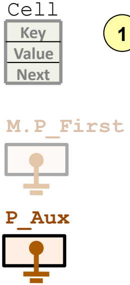

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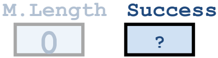
```

```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```



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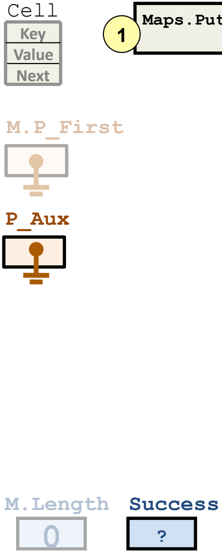

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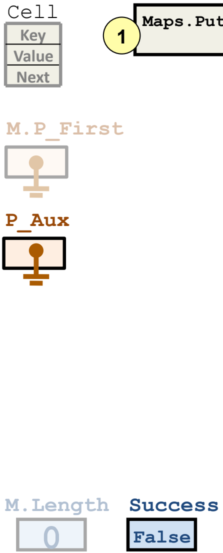

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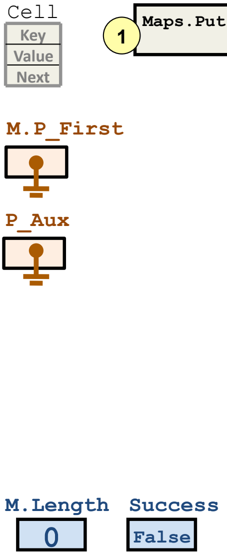

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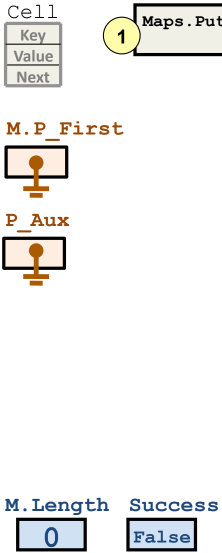

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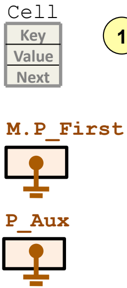

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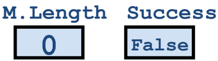

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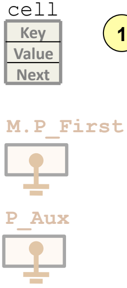

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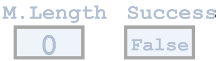

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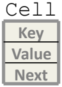

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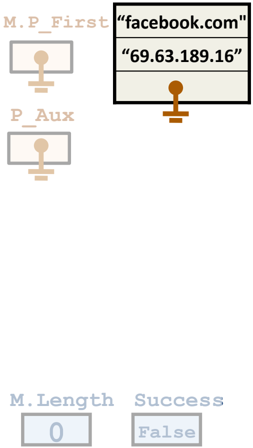

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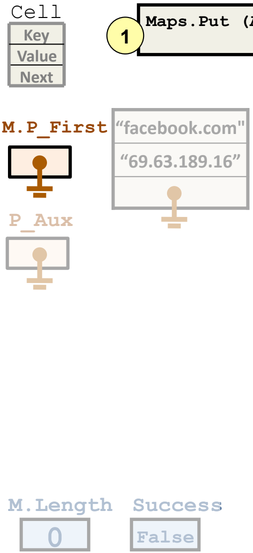

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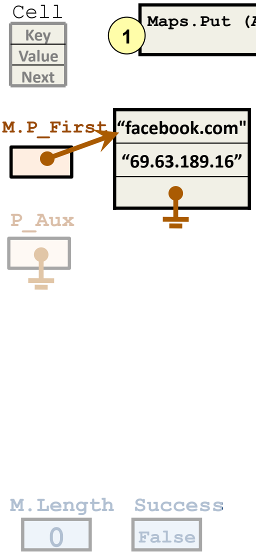

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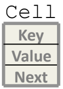

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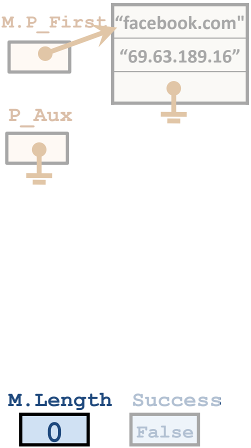

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   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```
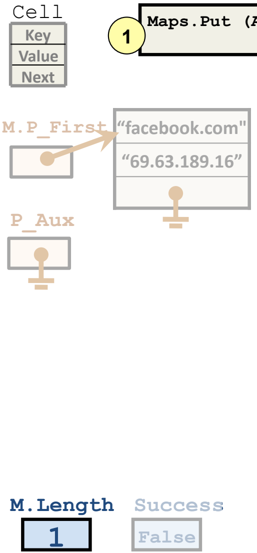
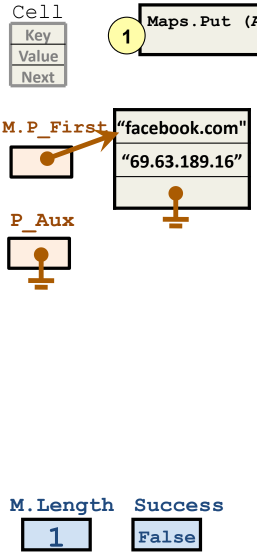



1

```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
                 ASU.To_Unbounded_String("69.63.189.16"));
```

```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



1

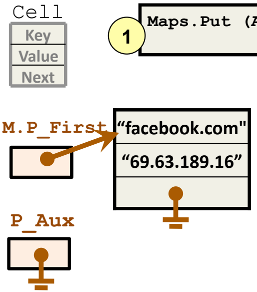
```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
                 ASU.To_Unbounded_String("69.63.189.16"));
```

```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

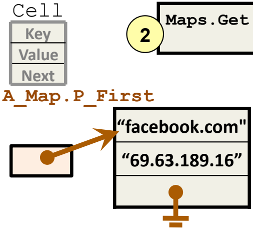
1

```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
                 ASU.To_Unbounded_String("69.63.189.16"));
```



```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

M.Length	Success
1	False



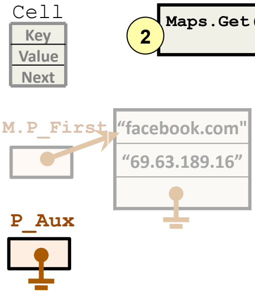
2

```
Maps.Get(A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 Value, Success);
```

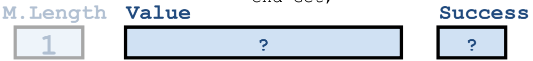
Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

2

```
Maps.Get(A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                Value, Success);
```



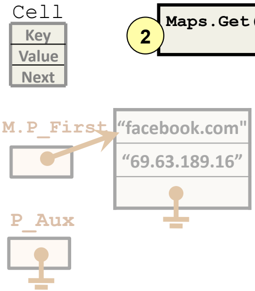
```
procedure Get (M       : in out Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success: out Boolean) is
   P_Aux : Cell_A;
begin
   Value := ASU.Null_Unbounded_String;

   P_Aux := M.P_First;
   Success := False;
   while not Success and P_Aux /= null Loop
      if P_Aux.Key = Key then
         Value := P_Aux.Value;
         Success := True;
      end if;
      P_Aux := P_Aux.Next;
   end loop;
end Get;
```



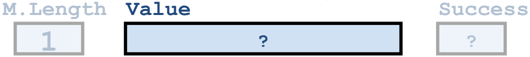
Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

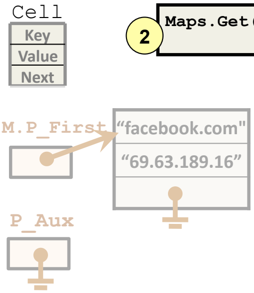
2

```
Maps.Get(A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                Value, Success);
```



```
procedure Get (M       : in out Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success: out Boolean) is
   P_Aux : Cell_A;
begin
   Value  := ASU.Null_Unbounded_String;

   P_Aux := M.P_First;
   Success := False;
   while not Success and P_Aux /= null Loop
      if P_Aux.Key = Key then
         Value := P_Aux.Value;
         Success := True;
      end if;
      P_Aux := P_Aux.Next;
   end loop;
end Get;
```





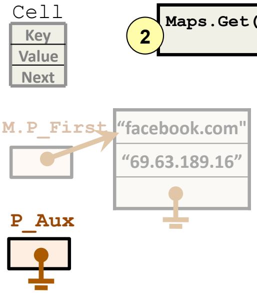
2

```
Maps.Get(A_Map, ASU.To_Unbounded_String("www.urjc.es"),
         Value, Success);
```

```
procedure Get (M       : in out Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success: out Boolean) is
   P_Aux : Cell_A;
begin
   Value := ASU.Null_Unbounded_String;

   P_Aux := M.P_First;
   Success := False;
   while not Success and P_Aux /= null Loop
      if P_Aux.Key = Key then
         Value := P_Aux.Value;
         Success := True;
      end if;
      P_Aux := P_Aux.Next;
   end loop;
end Get;
```

M.Length	Value	Success
1	Null_Unbounded_String	?

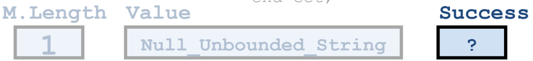
Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



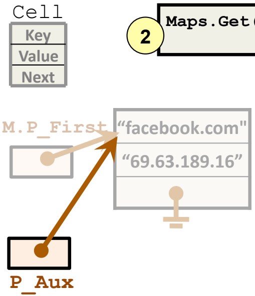
2

```
Maps.Get(A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                Value, Success);
```

```
procedure Get (M       : in out Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success: out Boolean) is
   P_Aux : Cell_A;
begin
   Value := ASU.Null_Unbounded_String;

   P_Aux := M.P_First;
   Success := False;
   while not Success and P_Aux /= null Loop
      if P_Aux.Key = Key then
         Value := P_Aux.Value;
         Success := True;
      end if;
      P_Aux := P_Aux.Next;
   end loop;
end Get;
```



Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



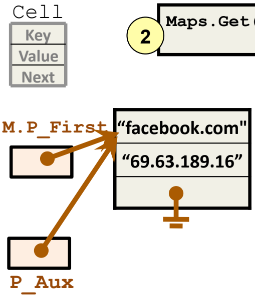
2

```
Maps.Get(A_Map, ASU.To_Unbounded_String(“www.urjc.es"),
                  Value, Success);
```

```
procedure Get (M       : in out Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success: out Boolean) is
   P_Aux : Cell_A;
begin
   Value := ASU.Null_Unbounded_String;

   P_Aux := M.P_First;
   Success := False;
   while not Success and P_Aux /= null Loop
      if P_Aux.Key = Key then
         Value := P_Aux.Value;
         Success := True;
      end if;
      P_Aux := P_Aux.Next;
   end loop;
end Get;
```

M.Length	Value	Success
1	Null_Unbounded_String	False

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



2

```
Maps.Get(A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                Value, Success);
```

```
procedure Get (M       : in out Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success: out Boolean) is
   P_Aux : Cell_A;
begin
   Value := ASU.Null_Unbounded_String;

   P_Aux := M.P_First;
   Success := False;
   while not Success and P_Aux /= null Loop
      if P_Aux.Key = Key then
         Value := P_Aux.Value;
         Success := True;
      end if;
      P_Aux := P_Aux.Next;
   end loop;
end Get;
```

M.Length

1

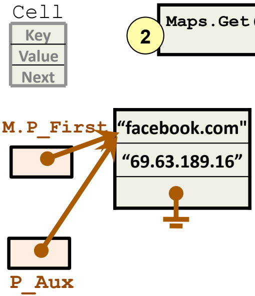
Value

Null_Unbounded_String

Success

False

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



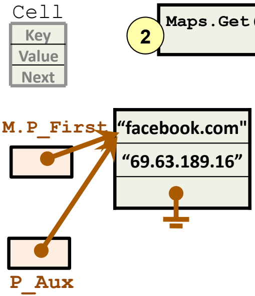
2

```
Maps.Get(A_Map, ASU.To_Unbounded_String(“www.urjc.es"),
               Value, Success);
```

```
procedure Get (M       : in out Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success: out Boolean) is
   P_Aux : Cell_A;
begin
   Value := ASU.Null_Unbounded_String;

   P_Aux := M.P_First;
   Success := False;
   while not Success and P_Aux /= null Loop
      if P_Aux.Key = Key then
         Value := P_Aux.Value;
         Success := True;
      end if;
      P_Aux := P_Aux.Next;
   end loop;
end Get;
```

M.Length	Value	Success
1	Null_Unbounded_String	False

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



2

```
Maps.Get(A_Map, ASU.To_Unbounded_String(“www.urjc.es"),
                Value, Success);
```

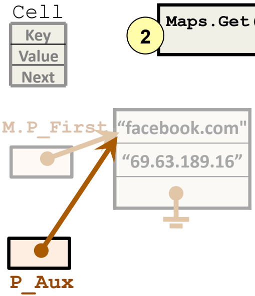
```
procedure Get (M       : in out Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success: out Boolean) is
   P_Aux : Cell_A;
begin
   Value := ASU.Null_Unbounded_String;

   P_Aux := M.P_First;
   Success := False;
   while not Success and P_Aux /= null Loop
      if P_Aux.Key = Key then
         Value := P_Aux.Value;
         Success := True;
      end if;
      P_Aux := P_Aux.Next;
   end loop;
end Get;
```

M.Length	Value	Success
1	Null_Unbounded_String	False

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

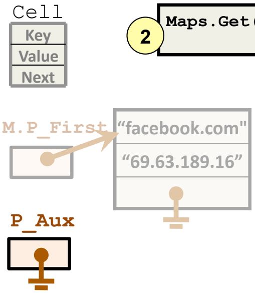
2

```
Maps.Get(A_Map, ASU.To_Unbounded_String("www.urjc.es"),
               Value, Success);
```



```
procedure Get (M       : in out Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success: out Boolean) is
   P_Aux : Cell_A;
begin
   Value := ASU.Null_Unbounded_String;

   P_Aux := M.P_First;
   Success := False;
   while not Success and P_Aux /= null Loop
      if P_Aux.Key = Key then
         Value := P_Aux.Value;
         Success := True;
      end if;
      P_Aux := P_Aux.Next;
   end loop;
end Get;
```

M.Length	Value	Success
1	Null_Unbounded_String	False



2

```
Maps.Get(A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                Value, Success);
```

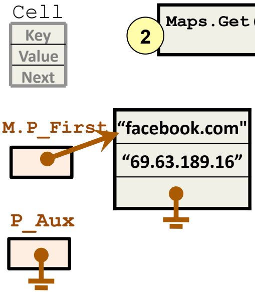
```
procedure Get (M       : in out Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success: out Boolean) is
   P_Aux : Cell_A;
begin
   Value := ASU.Null_Unbounded_String;

   P_Aux := M.P_First;
   Success := False;
   while not Success and P_Aux /= null Loop
      if P_Aux.Key = Key then
         Value := P_Aux.Value;
         Success := True;
      end if;
      P_Aux := P_Aux.Next;
   end loop;
end Get;
```

M.Length	Value	Success
1	Null_Unbounded_String	False

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

2

```
Maps.Get(A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                    Value, Success);
```



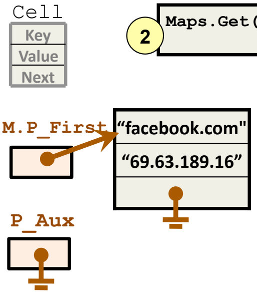
```
procedure Get (M       : in out Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success: out Boolean) is
   P_Aux : Cell_A;
begin
   Value := ASU.Null_Unbounded_String;

   P_Aux := M.P_First;
   Success := False;
   while not Success and P_Aux /= null Loop
      if P_Aux.Key = Key then
         Value := P_Aux.Value;
         Success := True;
      end if;
      P_Aux := P_Aux.Next;
   end loop;
end Get;
```

M.Length	Value	Success
1	Null_Unbounded_String	False

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

2

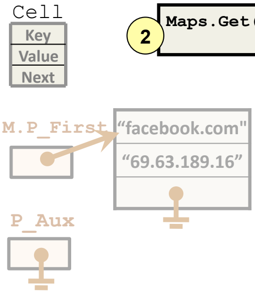
```
Maps.Get(A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                Value, Success);
```



```
procedure Get (M       : in out Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success: out Boolean) is
   P_Aux : Cell_A;
begin
   Value := ASU.Null_Unbounded_String;

   P_Aux := M.P_First;
   Success := False;
   while not Success and P_Aux /= null Loop
      if P_Aux.Key = Key then
         Value := P_Aux.Value;
         Success := True;
      end if;
      P_Aux := P_Aux.Next;
   end loop;
end Get;
```

M.Length	Value	Success
1	Null_Unbounded_String	False

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



2

```
Maps.Get(A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                Value, Success);
```

```
procedure Get (M       : in out Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success: out Boolean) is
   P_Aux : Cell_A;
begin
   Value := ASU.Null_Unbounded_String;

   P_Aux := M.P_First;
   Success := False;
   while not Success and P_Aux /= null Loop
      if P_Aux.Key = Key then
         Value := P_Aux.Value;
         Success := True;
      end if;
      P_Aux := P_Aux.Next;
   end loop;
end Get;
```

M.Length

1

Value

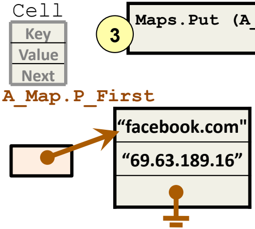
Null_Unbounded_String

Success

False

3

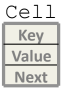
```
Maps.Put (A_Map, ASU.To_Unbounded_String("google.com"),
                 ASU.To_Unbounded_String("66.249.92.104"));
```



A_Map.Length

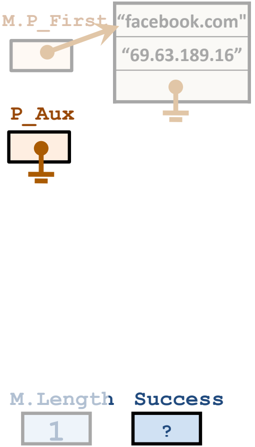
1

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



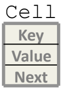
3

```
Maps.Put (A_Map, ASU.To_Unbounded_String(“google.com"),
                 ASU.To_Unbounded_String(“66.249.92.104"));
```



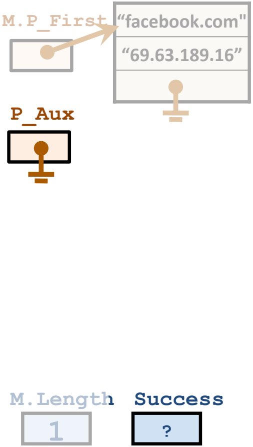
```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



3

```
Maps.Put (A_Map, ASU.To_Unbounded_String("google.com"),
                 ASU.To_Unbounded_String("66.249.92.104"));
```

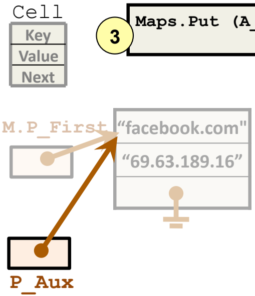


```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

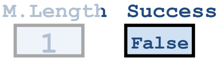
Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

3

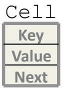
```
Maps.Put (A_Map, ASU.To_Unbounded_String("google.com"),
                 ASU.To_Unbounded_String("66.249.92.104"));
```



```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

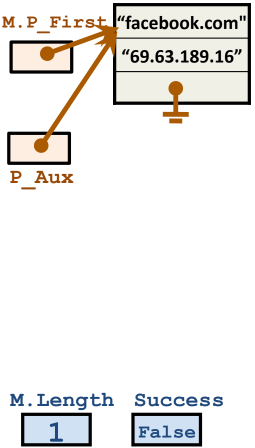


Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

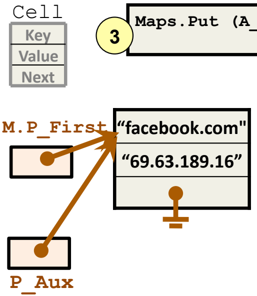


3

```
Maps.Put (A_Map, ASU.To_Unbounded_String("google.com"),
                 ASU.To_Unbounded_String("66.249.92.104"));
```



```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```



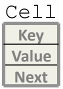
3

```
Maps.Put (A_Map, ASU.To_Unbounded_String("google.com"),
                 ASU.To_Unbounded_String("66.249.92.104"));
```

```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

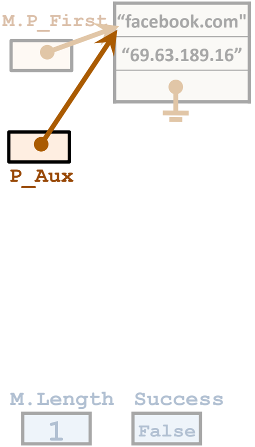
M.Length	Success
1	False

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



3

```
Maps.Put (A_Map, ASU.To_Unbounded_String("google.com"),
                 ASU.To_Unbounded_String("66.249.92.104"));
```

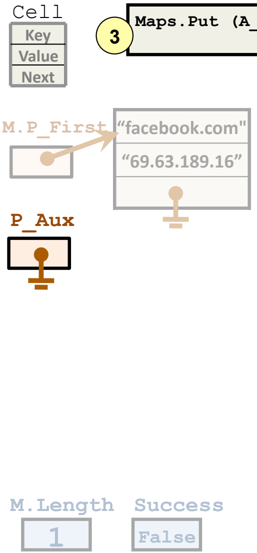


```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

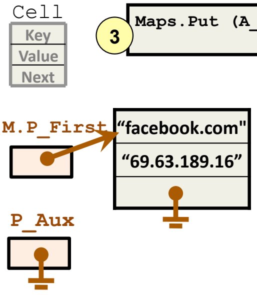
Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

3

```
Maps.Put (A_Map, ASU.To_Unbounded_String("google.com"),
                 ASU.To_Unbounded_String("66.249.92.104"));
```



```
procedure Put (M      : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```



```
3 Maps.Put (A_Map, ASU.To_Unbounded_String("google.com"),
                   ASU.To_Unbounded_String("66.249.92.104"));
```

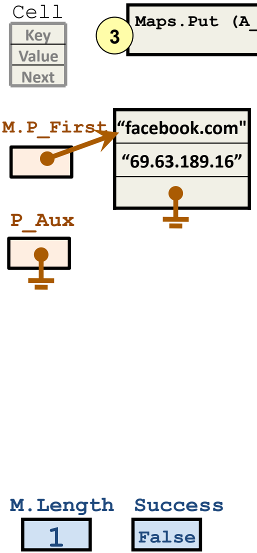
```
procedure Put (M      : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

M.Length	Success
1	False

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

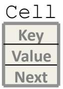
3

```
Maps.Put (A_Map, ASU.To_Unbounded_String(“google.com"),
                 ASU.To_Unbounded_String(“66.249.92.104"));
```



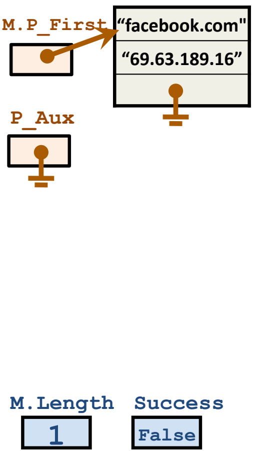
```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



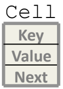
3

```
Maps.Put (A_Map, ASU.To_Unbounded_String(“google.com"),
                 ASU.To_Unbounded_String(“66.249.92.104"));
```



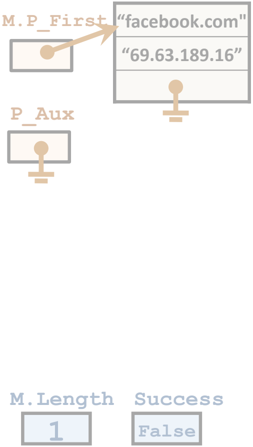
```
procedure Put (M      : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

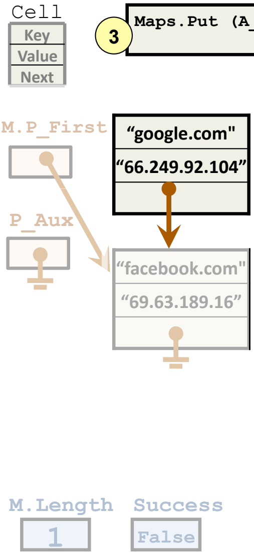


3

```
Maps.Put (A_Map, ASU.To_Unbounded_String(“google.com"),
                 ASU.To_Unbounded_String(“66.249.92.104"));
```



```
procedure Put (M      : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

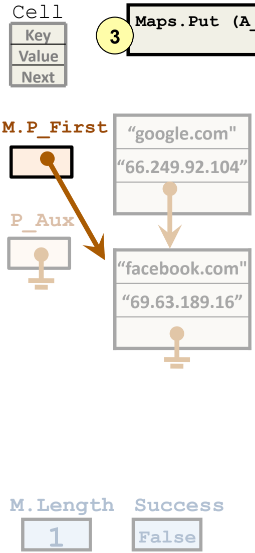


3

```
Maps.Put (A_Map, ASU.To_Unbounded_String("google.com"),
                 ASU.To_Unbounded_String("66.249.92.104"));
```

```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

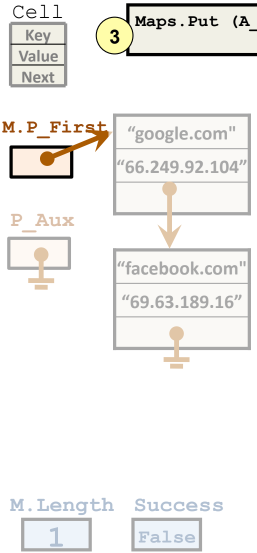


3

```
Maps.Put (A_Map, ASU.To_Unbounded_String("google.com"),
                 ASU.To_Unbounded_String("66.249.92.104"));
```

```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



3

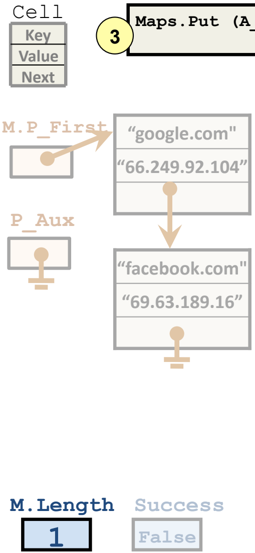
```
Maps.Put (A_Map, ASU.To_Unbounded_String("google.com"),
                 ASU.To_Unbounded_String("66.249.92.104"));
```

```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

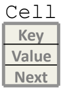
3

```
Maps.Put (A_Map, ASU.To_Unbounded_String("google.com"),
                 ASU.To_Unbounded_String("66.249.92.104"));
```



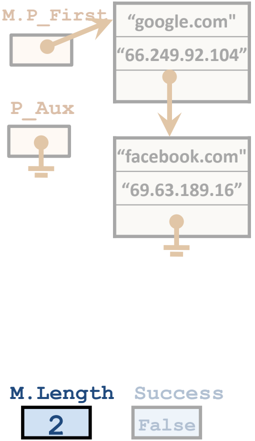
```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



3

```
Maps.Put (A_Map, ASU.To_Unbounded_String("google.com"),
                 ASU.To_Unbounded_String("66.249.92.104"));
```



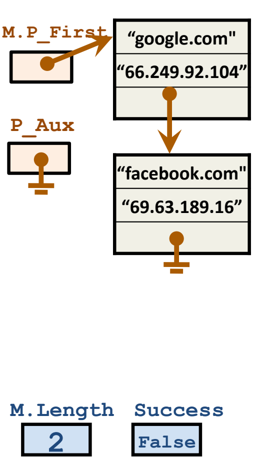
```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

Cell
Key
Value
Next

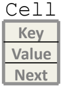
3

```
Maps.Put (A_Map, ASU.To_Unbounded_String(“google.com"),
                 ASU.To_Unbounded_String(“66.249.92.104"));
```



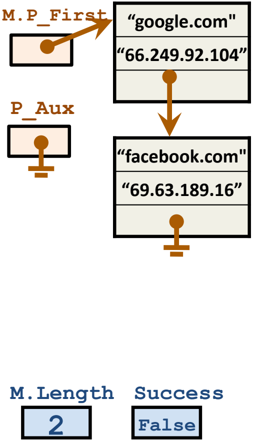
```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



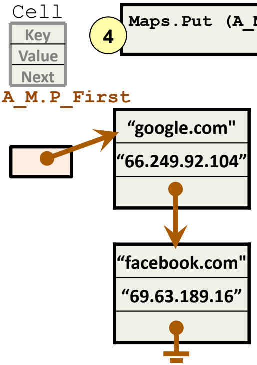
3

```
Maps.Put (A_Map, ASU.To_Unbounded_String("google.com"),
                 ASU.To_Unbounded_String("66.249.92.104"));
```



```
procedure Put (M      : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

```
Maps.Put (A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 ASU.To_Unbounded_String("212.128.240.25"));
```



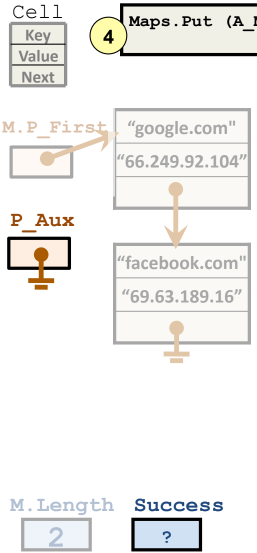
A_Map.Length

2

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

4

```
Maps.Put (A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 ASU.To_Unbounded_String("212.128.240.25"));
```

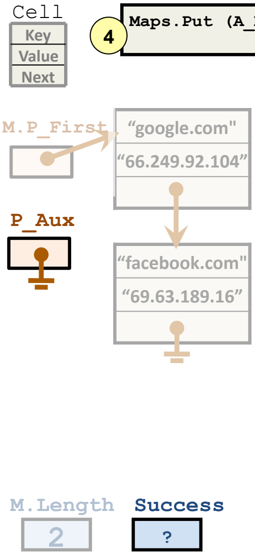


```
procedure Put (M      : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

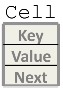
4

```
Maps.Put (A_Map, ASU.To_Unbounded_String(“www.urjc.es"),
                 ASU.To_Unbounded_String(“212.128.240.25"));
```



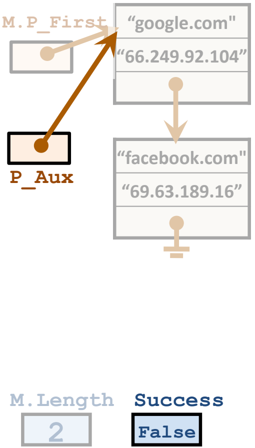
```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux  := M.P_First;
  Success  := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



4

```
Maps.Put (A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 ASU.To_Unbounded_String("212.128.240.25"));
```

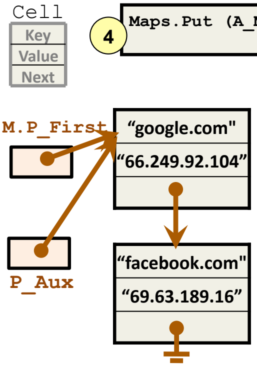


```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

4

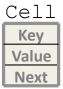
```
Maps.Put (A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 ASU.To_Unbounded_String("212.128.240.25"));
```



```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

   P_Aux := M.P_First;
   Success := False;
   while not Success and P_Aux /= null loop
      if P_Aux.Key = Key then
         P_Aux.Value := Value;
         Success := True;
      end if;
      P_Aux := P_Aux.Next;
   end loop;

   if not Success then
      M.P_First:=new Cell'(Key, Value, M.P_First);
      M.Length := M.Length + 1;
   end if;
end Put;
```

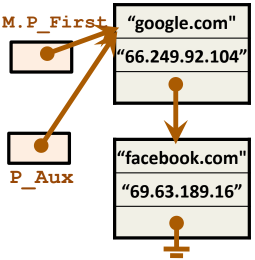
M.Length	Success
2	False

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



4

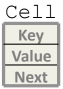
```
Maps.Put (A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 ASU.To_Unbounded_String("212.128.240.25"));
```



```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

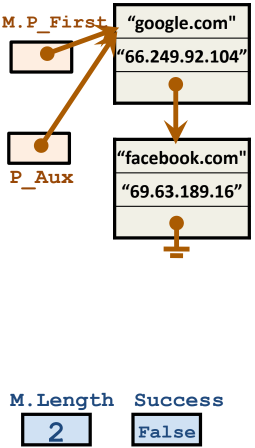
M.Length	Success
2	False

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

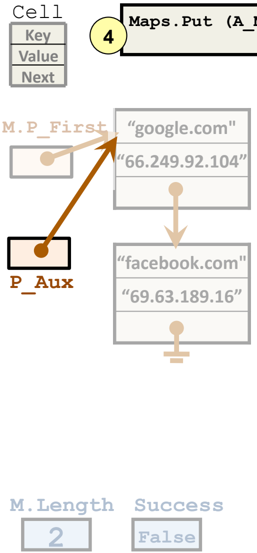


4

```
Maps.Put (A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 ASU.To_Unbounded_String("212.128.240.25"));
```



```
procedure Put (M      : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

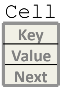


4

```
Maps.Put (A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 ASU.To_Unbounded_String("212.128.240.25"));
```

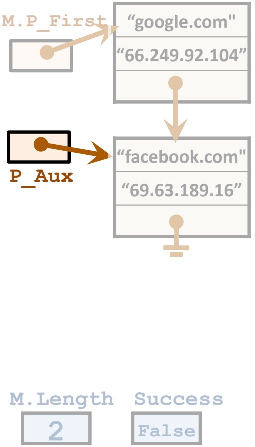
```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



4

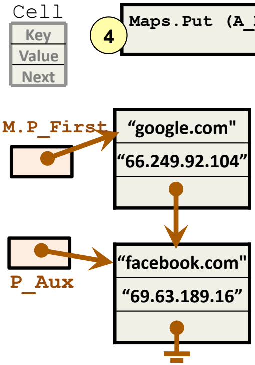
```
Maps.Put (A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 ASU.To_Unbounded_String("212.128.240.25"));
```



```
procedure Put (M      : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

4

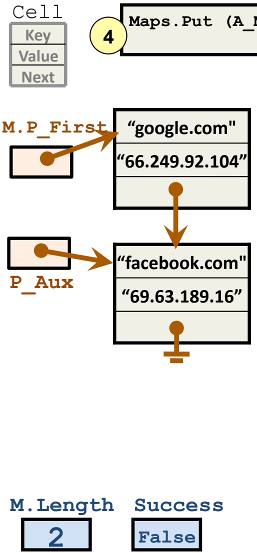
```
Maps.Put (A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 ASU.To_Unbounded_String("212.128.240.25"));
```



```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

M.Length	Success
2	False

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

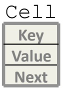


4

```
Maps.Put (A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 ASU.To_Unbounded_String("212.128.240.25"));
```

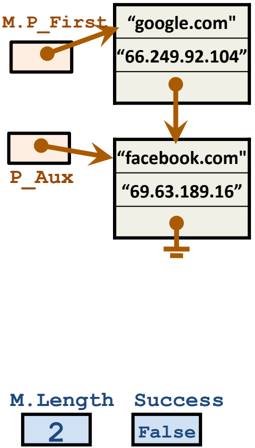
```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



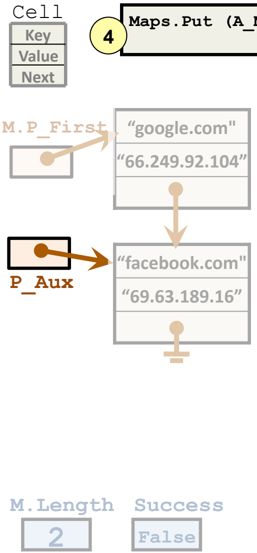
4

```
Maps.Put (A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 ASU.To_Unbounded_String("212.128.240.25"));
```



```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



4

```
Maps.Put (A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 ASU.To_Unbounded_String("212.128.240.25"));
```

```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
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     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
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  end if;
end Put;
```
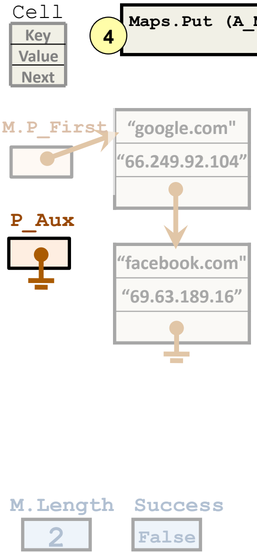

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

4

```
Maps.Put (A_Map, ASU.To_Unbounded_String(“www.urjc.es"),
                 ASU.To_Unbounded_String(“212.128.240.25"));
```



```
procedure Put (M      : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String) is
   P_Aux : Cell_A;
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begin

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```
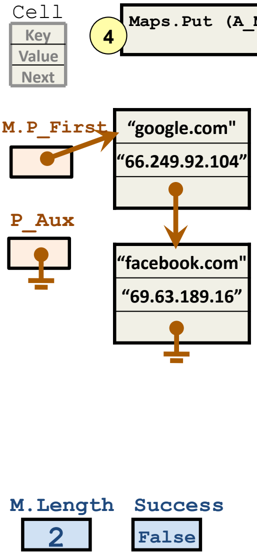

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



4

```
Maps.Put (A_Map, ASU.To_Unbounded_String(“www.urjc.es"),
                 ASU.To_Unbounded_String(“212.128.240.25"));
```

```
procedure Put (M      : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String) is
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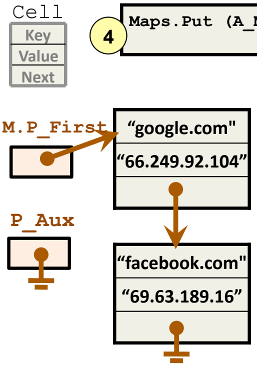
Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

4

```
Maps.Put (A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 ASU.To_Unbounded_String("212.128.240.25"));
```



```
procedure Put (M     : in out Map;
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               Value : ASU.Unbounded_String) is
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begin

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        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

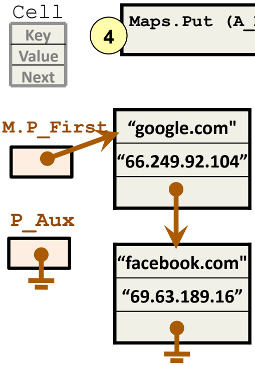
  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

M.Length	Success
2	False

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

4

```
Maps.Put (A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 ASU.To_Unbounded_String("212.128.240.25"));
```



```
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               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String) is
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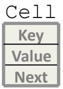
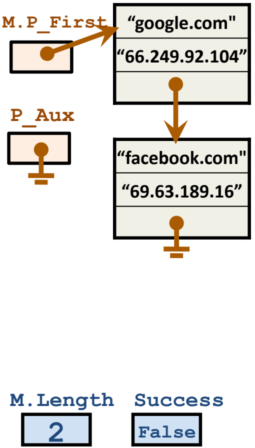
M.Length	Success
2	False

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



4

```
Maps.Put (A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 ASU.To_Unbounded_String("212.128.240.25"));
```



```
procedure Put (M     : in out Map;
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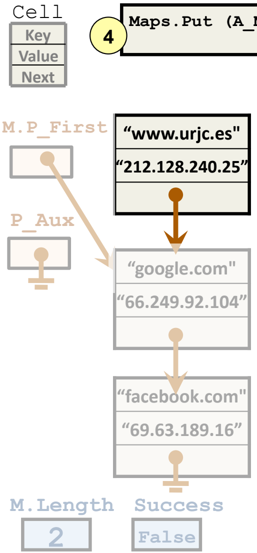

```
Maps.Put (A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 ASU.To_Unbounded_String("212.128.240.25"));
```

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Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

4

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                 ASU.To_Unbounded_String("212.128.240.25"));
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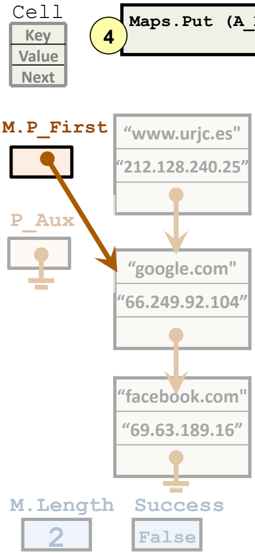

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        Success := True;
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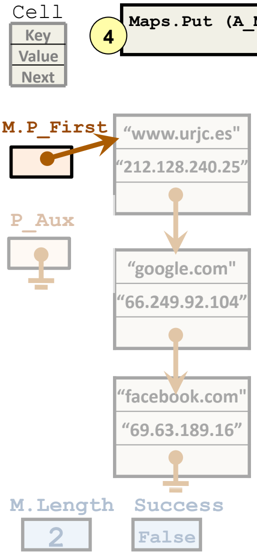

```
Maps.Put (A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 ASU.To_Unbounded_String("212.128.240.25"));
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        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

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     M.P_First:=new Cell'(Key, Value, M.P_First);
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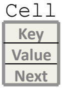
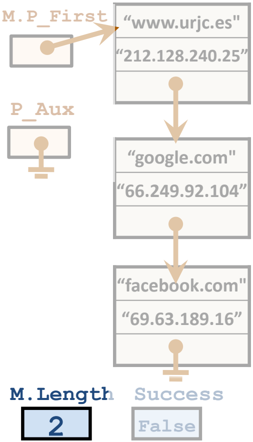
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



4

```
Maps.Put (A_Map, ASU.To_Unbounded_String(“www.urjc.es"),
                 ASU.To_Unbounded_String(“212.128.240.25"));
```



```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
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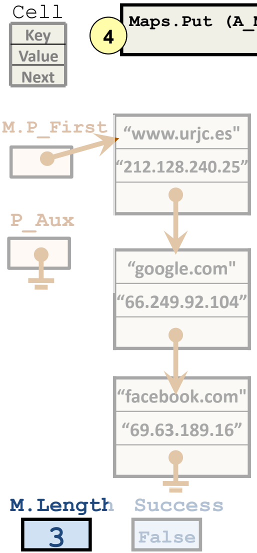
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```



4

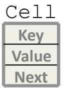
```
Maps.Put (A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 ASU.To_Unbounded_String("212.128.240.25"));
```

```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

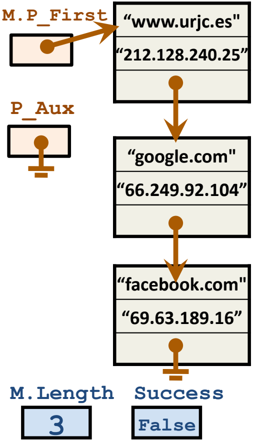
  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



4

```
Maps.Put (A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 ASU.To_Unbounded_String("212.128.240.25"));
```

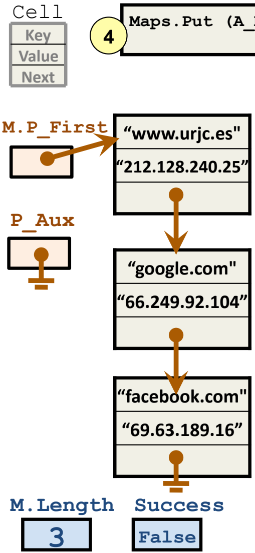


```
procedure Put (M      : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

   P_Aux := M.P_First;
   Success := False;
   while not Success and P_Aux /= null loop
      if P_Aux.Key = Key then
         P_Aux.Value := Value;
         Success := True;
      end if;
      P_Aux := P_Aux.Next;
   end loop;

   if not Success then
      M.P_First:=new Cell'(Key, Value, M.P_First);
      M.Length := M.Length + 1;
   end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



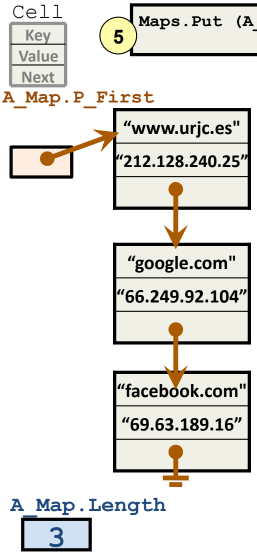
```
Maps.Put (A_Map, ASU.To_Unbounded_String("www.urjc.es"),
                 ASU.To_Unbounded_String("212.128.240.25"));
```

```
procedure Put (M      : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

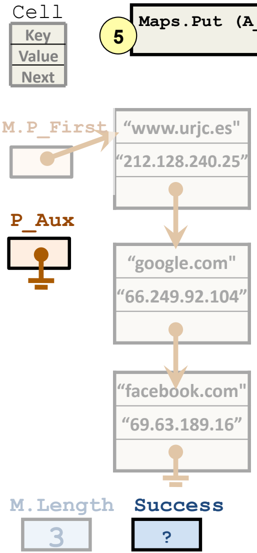
```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
                 ASU.To_Unbounded_String("69.63.189.11"));
```



Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

5

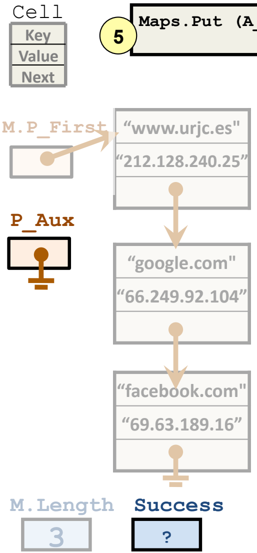
```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
                 ASU.To_Unbounded_String("69.63.189.11"));
```



```
procedure Put (M      : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```



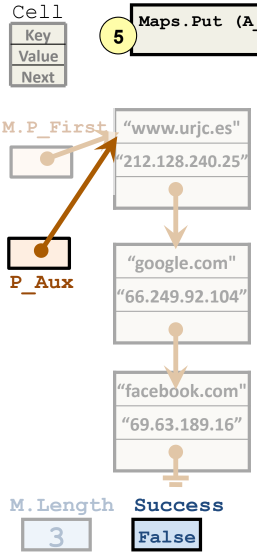
5

```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
                 ASU.To_Unbounded_String("69.63.189.11"));
```

```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

   P_Aux := M.P_First;
   Success := False;
   while not Success and P_Aux /= null loop
      if P_Aux.Key = Key then
         P_Aux.Value := Value;
         Success := True;
      end if;
      P_Aux := P_Aux.Next;
   end loop;

   if not Success then
      M.P_First:=new Cell'(Key, Value, M.P_First);
      M.Length := M.Length + 1;
   end if;
end Put;
```



5

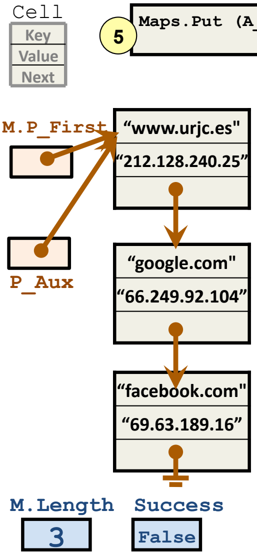
```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
                 ASU.To_Unbounded_String("69.63.189.11"));
```

```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



5

```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
                 ASU.To_Unbounded_String("69.63.189.11"));
```

```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

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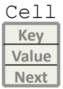
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

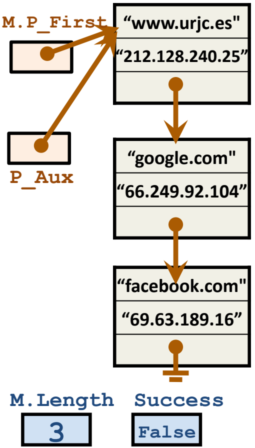
  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



5

```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
                 ASU.To_Unbounded_String("69.63.189.11"));
```



```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

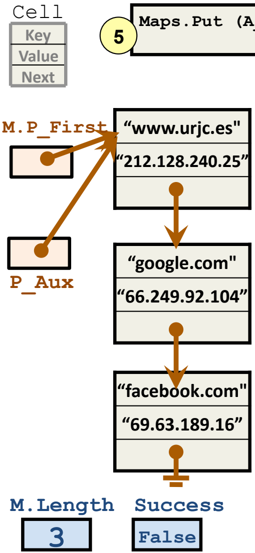
  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

5

```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
                 ASU.To_Unbounded_String("69.63.189.11"));
```



```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
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   Success : Boolean;
begin

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     if P_Aux.Key = Key then
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        Success := True;
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     P_Aux := P_Aux.Next;
  end loop;

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```

5

```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
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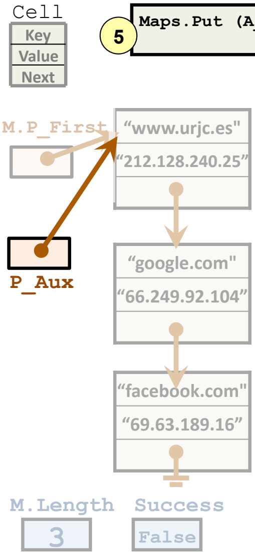
```



```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
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     if P_Aux.Key = Key then
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     P_Aux := P_Aux.Next;
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```

5

```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
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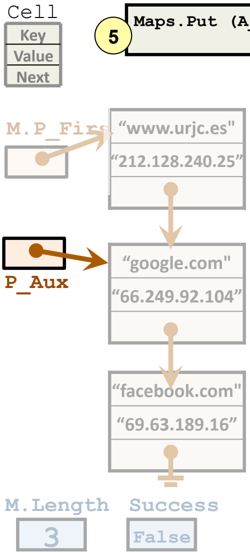
```



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     P_Aux := P_Aux.Next;
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     M.P_First:=new Cell'(Key, Value, M.P_First);
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```
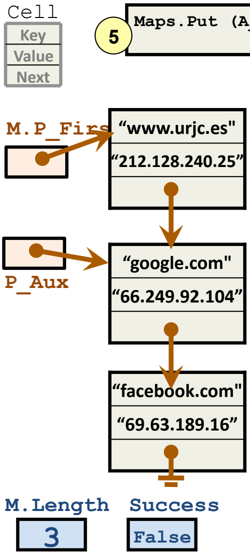

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

5

```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
                 ASU.To_Unbounded_String("69.63.189.11"));
```



```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
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  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
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```
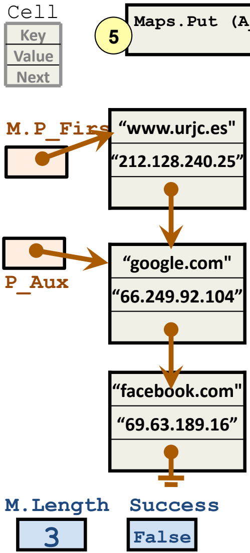

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

5

```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
                 ASU.To_Unbounded_String("69.63.189.11"));
```



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               Value : ASU.Unbounded_String) is
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     P_Aux := P_Aux.Next;
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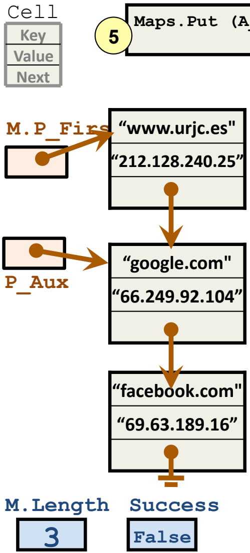
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

5

```
Maps.Put (A_Map, ASU.To_Unbounded_String(“facebook.com"),
                 ASU.To_Unbounded_String(“69.63.189.11"));
```



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```
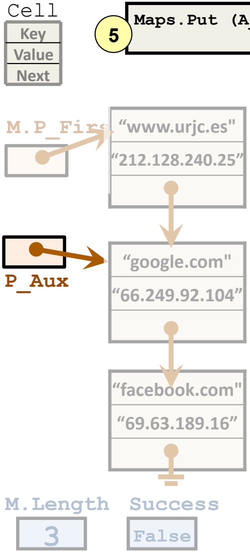

5

```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
                 ASU.To_Unbounded_String("69.63.189.11"));
```



```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
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     end if;
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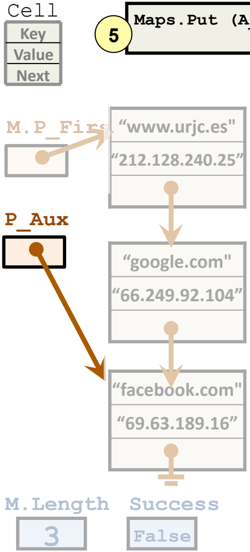
Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



5

```
Maps.Put (A_Map, ASU.To_Unbounded_String(“facebook.com"),
                 ASU.To_Unbounded_String(“69.63.189.11"));
```

```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

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     if P_Aux.Key = Key then
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Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

5

```
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                 ASU.To_Unbounded_String("69.63.189.11"));
```

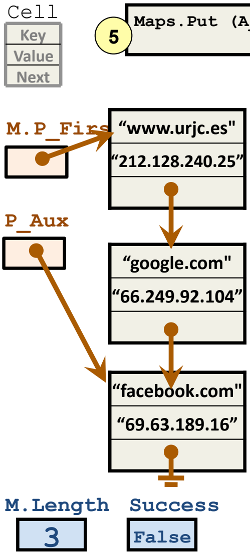

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               Key   : ASU.Unbounded_String;
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                 ASU.To_Unbounded_String("69.63.189.11"));
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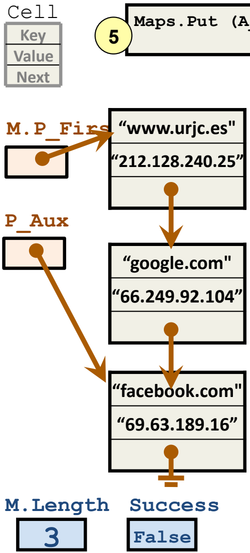

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               Value  : ASU.Unbounded_String) is
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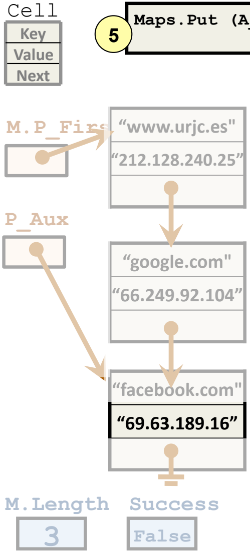
Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



5

```
Maps.Put (A_Map, ASU.To_Unbounded_String(“facebook.com"),
                 ASU.To_Unbounded_String(“69.63.189.11"));
```

```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
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   Success : Boolean;
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```
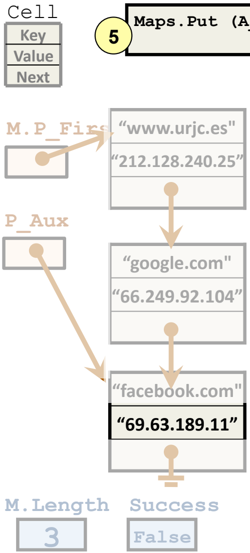

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



5

```
Maps.Put (A_Map, ASU.To_Unbounded_String(“facebook.com"),
                 ASU.To_Unbounded_String(“69.63.189.11"));
```

```
procedure Put (M     : in out Map;
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               Value : ASU.Unbounded_String) is
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   Success : Boolean;
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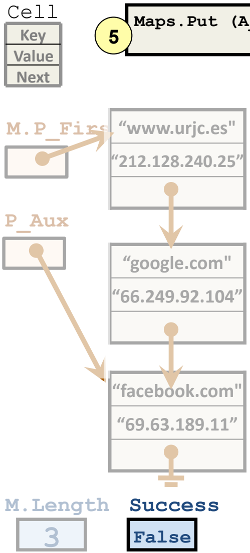
Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

5

```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
                 ASU.To_Unbounded_String("69.63.189.11"));
```



```
procedure Put (M      : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

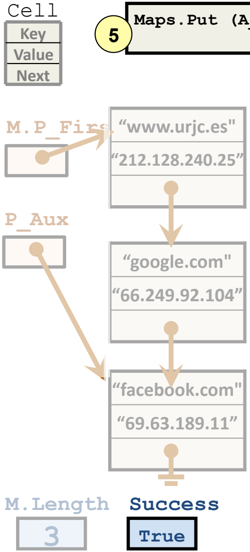
  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

5

```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
                 ASU.To_Unbounded_String("69.63.189.11"));
```



```
procedure Put (M      : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

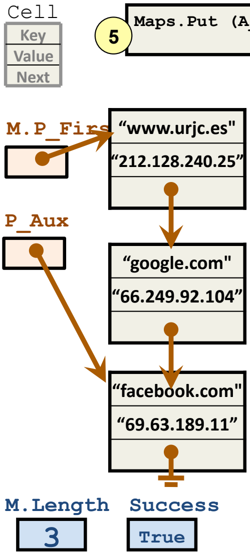
  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

5

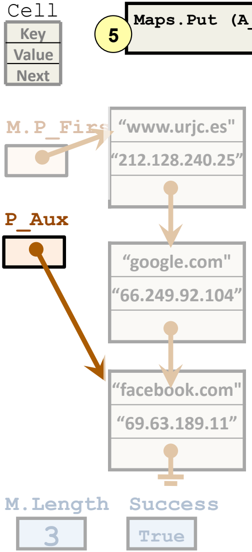
```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
                 ASU.To_Unbounded_String("69.63.189.11"));
```



```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

   P_Aux := M.P_First;
   Success := False;
   while not Success and P_Aux /= null loop
      if P_Aux.Key = Key then
         P_Aux.Value := Value;
         Success := True;
      end if;
      P_Aux := P_Aux.Next;
   end loop;

   if not Success then
      M.P_First:=new Cell'(Key, Value, M.P_First);
      M.Length := M.Length + 1;
   end if;
end Put;
```



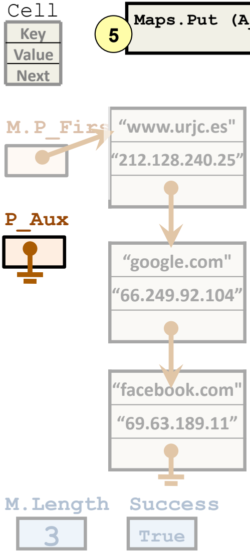
5

```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
                 ASU.To_Unbounded_String("69.63.189.11"));
```

```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

   P_Aux := M.P_First;
   Success := False;
   while not Success and P_Aux /= null loop
      if P_Aux.Key = Key then
         P_Aux.Value := Value;
         Success := True;
      end if;
      P_Aux := P_Aux.Next;
   end loop;

   if not Success then
      M.P_First:=new Cell'(Key, Value, M.P_First);
      M.Length := M.Length + 1;
   end if;
end Put;
```



5

```
Maps.Put (A_Map, ASU.To_Unbounded_String(“facebook.com"),
                 ASU.To_Unbounded_String(“69.63.189.11"));
```

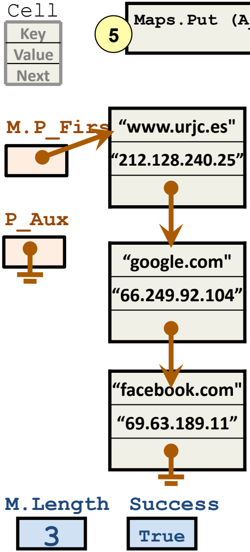
```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

5

```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
                 ASU.To_Unbounded_String("69.63.189.11"));
```

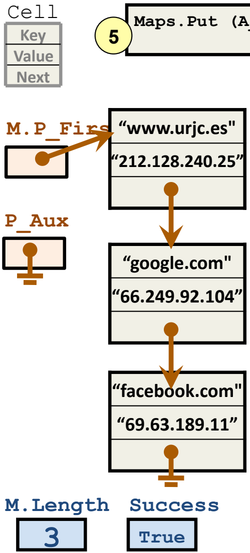


```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



5

```
Maps.Put (A_Map, ASU.To_Unbounded_String(“facebook.com"),
                 ASU.To_Unbounded_String(“69.63.189.11"));
```

```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

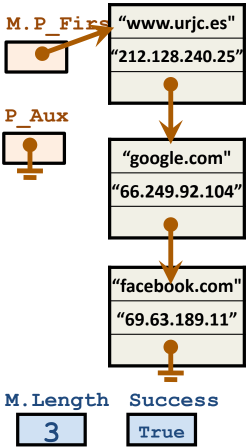
  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

Cell
Key
Value
Next

5

```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
                 ASU.To_Unbounded_String("69.63.189.11"));
```

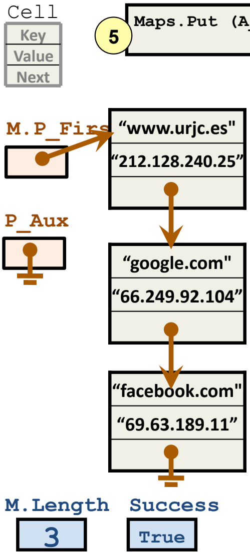


```
procedure Put (M      : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

  P_Aux := M.P_First;
  Success := False;
  while not Success and P_Aux /= null loop
     if P_Aux.Key = Key then
        P_Aux.Value := Value;
        Success := True;
     end if;
     P_Aux := P_Aux.Next;
  end loop;

  if not Success then
     M.P_First:=new Cell'(Key, Value, M.P_First);
     M.Length := M.Length + 1;
  end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)



```
Maps.Put (A_Map, ASU.To_Unbounded_String("facebook.com"),
                 ASU.To_Unbounded_String("69.63.189.11"));
```

```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

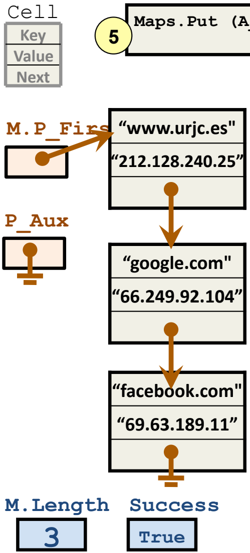
   P_Aux := M.P_First;
   Success := False;
   while not Success and P_Aux /= null loop
      if P_Aux.Key = Key then
         P_Aux.Value := Value;
         Success := True;
      end if;
      P_Aux := P_Aux.Next;
   end loop;

   if not Success then
      M.P_First:=new Cell'(Key, Value, M.P_First);
      M.Length := M.Length + 1;
   end if;
end Put;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

5

```
Maps.Put (A_Map, ASU.To_Unbounded_String(“facebook.com"),
                 ASU.To_Unbounded_String(“69.63.189.11"));
```



Cell

Key

Value

Next

M.P_First

“www.urjc.es"

“212.128.240.25”

P_Aux

“google.com"

“66.249.92.104”

“facebook.com"

“69.63.189.11”

M.Length

3

Success

True

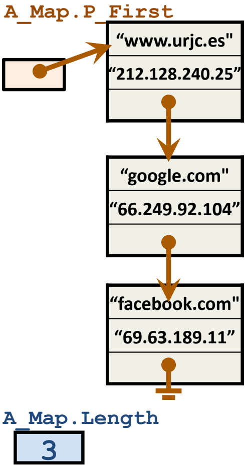
```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
   P_Aux : Cell_A;
   Success : Boolean;
begin

   P_Aux := M.P_First;
   Success := False;
   while not Success and P_Aux /= null loop
      if P_Aux.Key = Key then
         P_Aux.Value := Value;
         Success := True;
      end if;
      P_Aux := P_Aux.Next;
   end loop;

   if not Success then
      M.P_First:=new Cell'(Key, Value, M.P_First);
      M.Length := M.Length + 1;
   end if;
end Put;
```

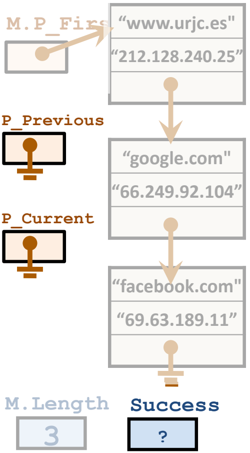
6

```
Maps.Delete(A_Map,ASU.To_Unbounded_String(“google.com"),Success);
```



6

```
Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);
```

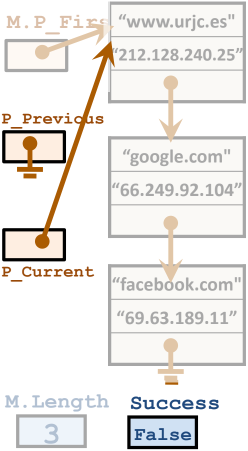


```
procedure Delete (M       : in out Map;
                  Key     : in Asu.Unbounded_String;
                  Success : out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
begin
      Success := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

6

Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);

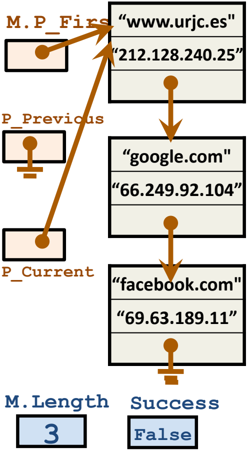


```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success  := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

6

```
Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);
```



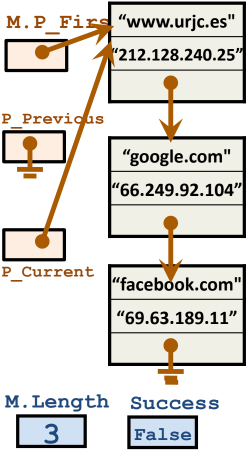
```
procedure Delete (M    :  in out Map;
                  Key  :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success  := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

6

```
Maps.Delete(A_Map,ASU.To_Unbounded_String(“google.com"),Success);
```



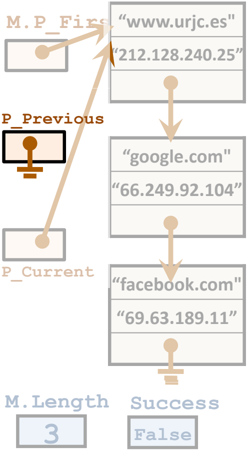
```
procedure Delete (M    : in out Map;
                  Key  : in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

6

Maps.Delete(A_Map,ASU.To_Unbounded_String(“google.com"),Success);



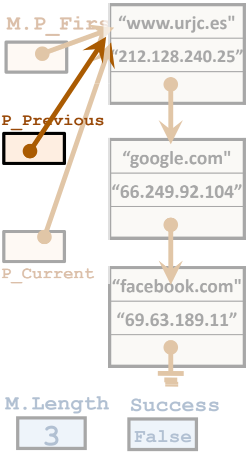
```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

6

```
Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);
```

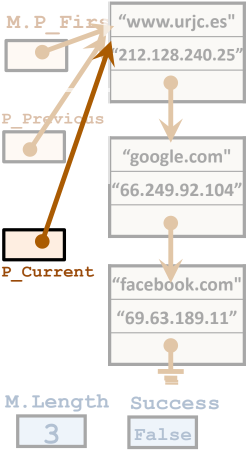


```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

6 **Maps.Delete(A_Map,ASU.To_Unbounded_String(“google.com"),Success);**



```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success  := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

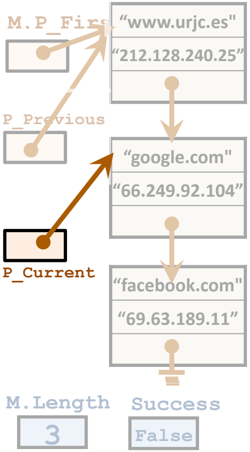
end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

6 **Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);**

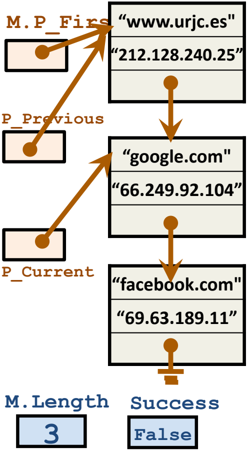
```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success  := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current  := P_Current.Next;
         end if;
      end loop;

   end Delete;
```



Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

6 `Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);`

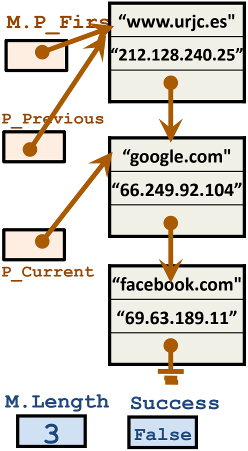


```
procedure Delete (M    :  in out Map;
                  Key  :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current   : Cell_A;
      P_Previous  : Cell_A;
   begin
      Success  := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

6

```
Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);
```



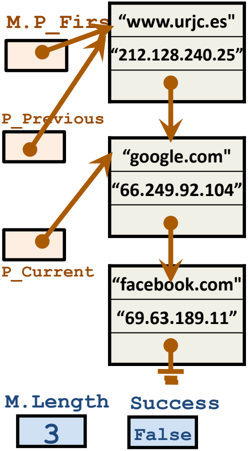
```
procedure Delete (M      :  in out Map;
                  Key    :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

6

```
Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);
```



```
procedure Delete (M      : in out Map;
                  Key    : in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

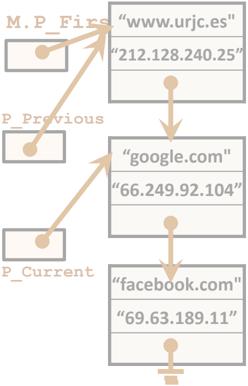
   end Delete;
```

6

```
Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);
```

```
procedure Delete (M      :  in out Map;
                  Key    :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

   end Delete;
```



M.Length

3

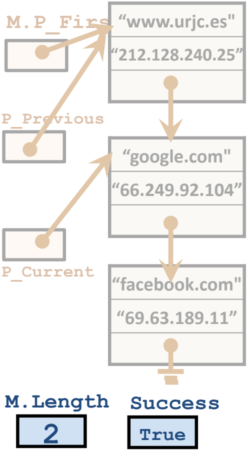
Success

False

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

6

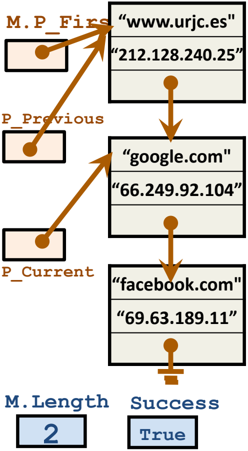
```
Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);
```



```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success  := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success  := True;
            M.Length  := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

6 `Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);`



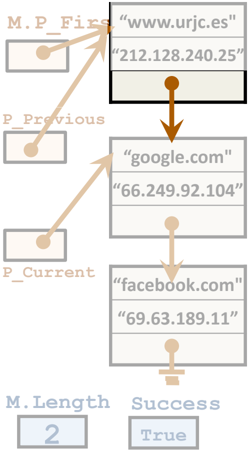
```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

6

Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);



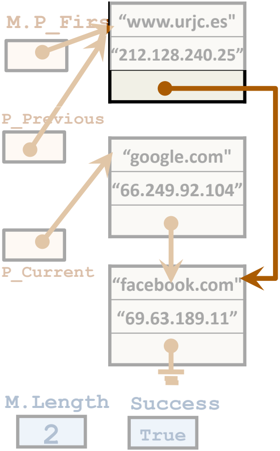
```
procedure Delete (M      :  in out Map;
                  Key    :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

6

```
Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);
```



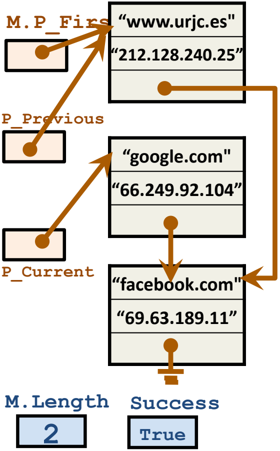
```
procedure Delete (M    :  in out Map;
                  Key  :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current  := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

6

```
Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);
```



```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current  := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

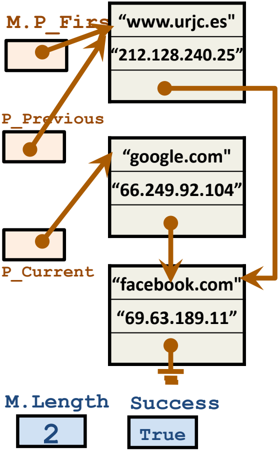
Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

6

Maps.Delete(A_Map,ASU.To_Unbounded_String(“google.com"),Success);

```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

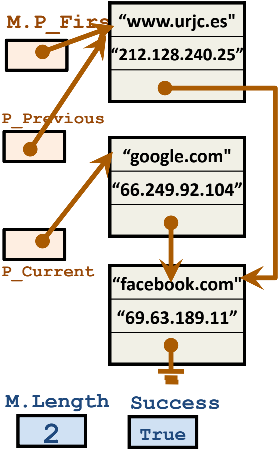
   end Delete;
```



Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

6

```
Maps.Delete(A_Map,ASU.To_Unbounded_String(“google.com"),Success);
```

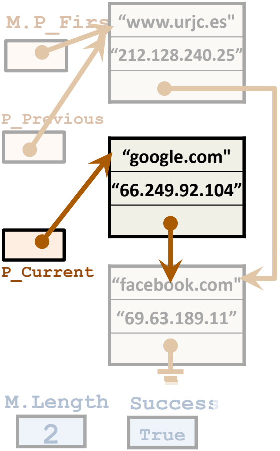


```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success  := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

6

```
Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);
```

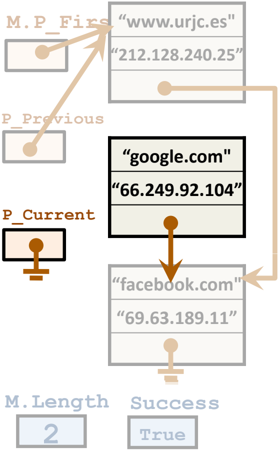


```
procedure Delete (M      :  in out Map;
                  Key    :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success  := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

6

```
Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);
```

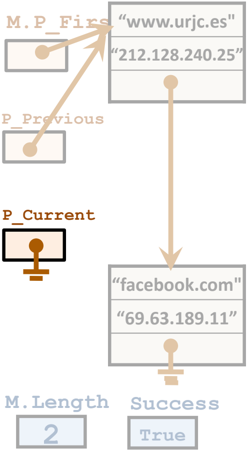


```
procedure Delete (M      :  in out Map;
                  Key    :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

6

```
Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);
```

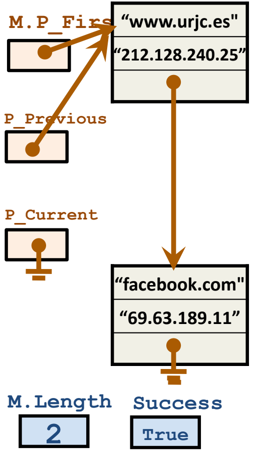


```
procedure Delete (M      :  in out Map;
                  Key    :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success  := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

6 `Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);`

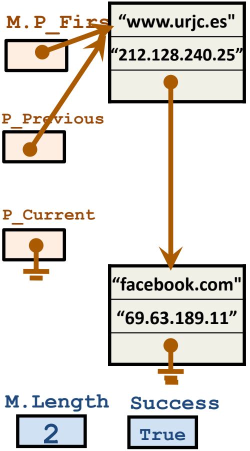


```
procedure Delete (M      :  in out Map;
                  Key    :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success  := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

6

```
Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);
```

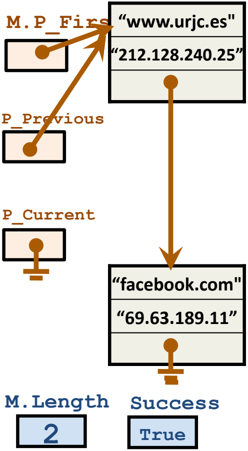


```
procedure Delete (M      :  in out Map;
                  Key    :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

6 `Maps.Delete(A_Map,ASU.To_Unbounded_String(“google.com"),Success);`

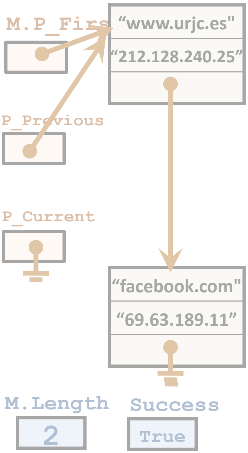


```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success  := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

6

```
Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);
```



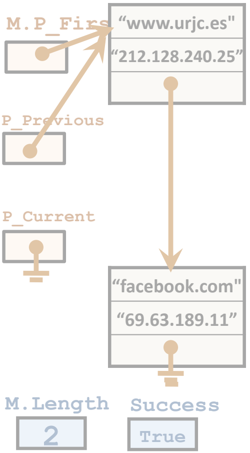
```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

6

```
Maps.Delete(A_Map,ASU.To_Unbounded_String("google.com"),Success);
```

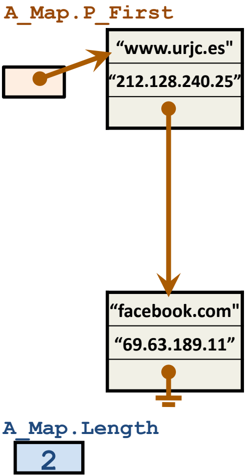


```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

7

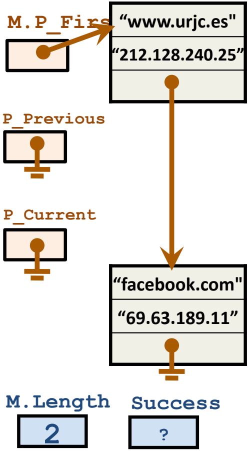
```
Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);
```



Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

7

```
Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);
```

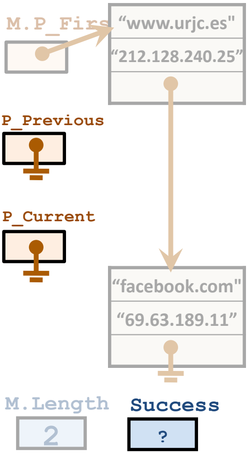


```
procedure Delete (M    :  in out Map;
                  Key  :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

7

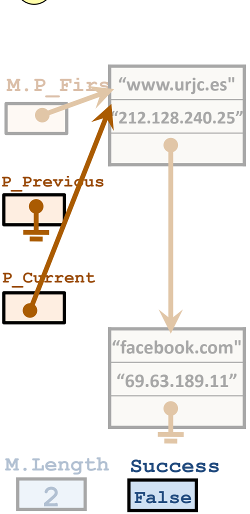
```
Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);
```



```
procedure Delete (M      :  in out Map;
                  Key    :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success  := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

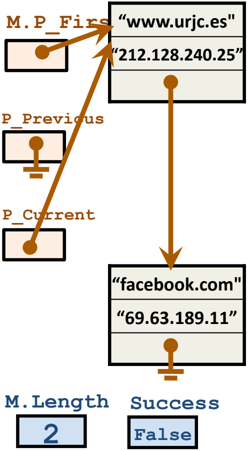
```
Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);
```



```
procedure Delete (M      :  in out Map;
                  Key    :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success  := False;
      P_Previous  := null;
      P_Current   := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

```
Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);
```



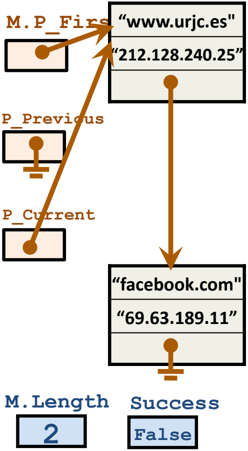
```
procedure Delete (M      :  in out Map;
                  Key    :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

7

```
Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);
```

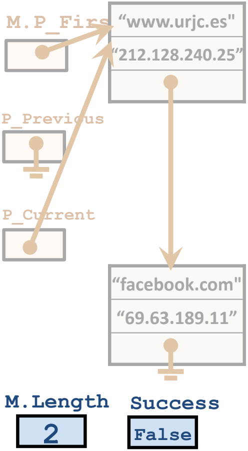


```
procedure Delete (M      :  in out Map;
                  Key    :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

7

```
Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);
```



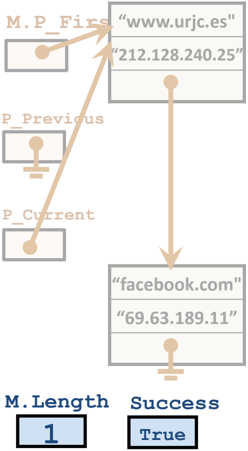
```
procedure Delete (M      :  in out Map;
                  Key    :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

7

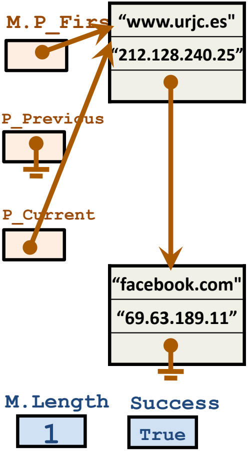
```
Maps.Delete(A_Map, ASU.To_Unbounded_String(“www.urjc.es"), Success);
```



```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

```
Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);
```



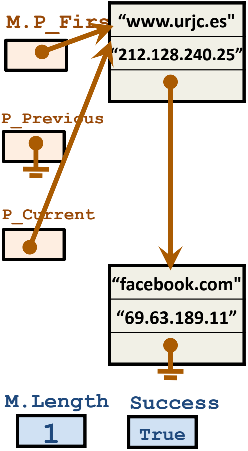
```
procedure Delete (M      :  in out Map;
                  Key    :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success  := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

7

```
Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);
```

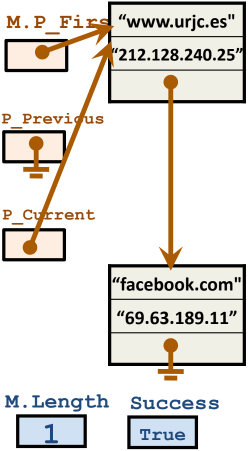


```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success  := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

7

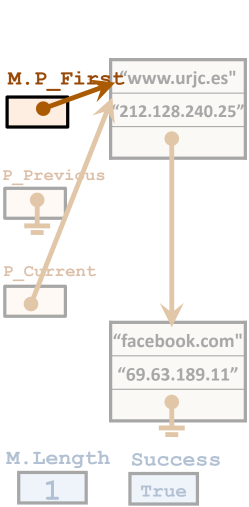
```
Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);
```



```
procedure Delete (M      :  in out Map;
                  Key    :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success  := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

```
Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);
```



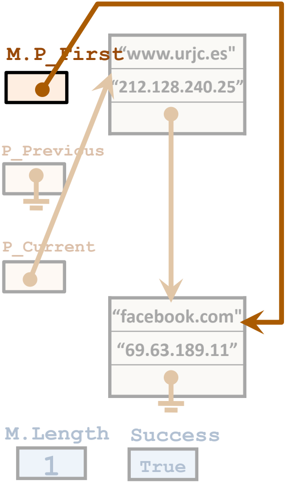
```
procedure Delete (M      : in out Map;
                  Key    : in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success  := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

7

```
Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);
```

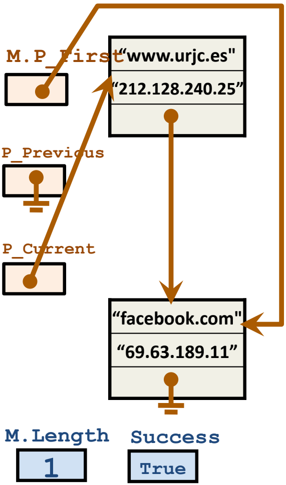


```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

7

```
Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);
```



```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success  := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
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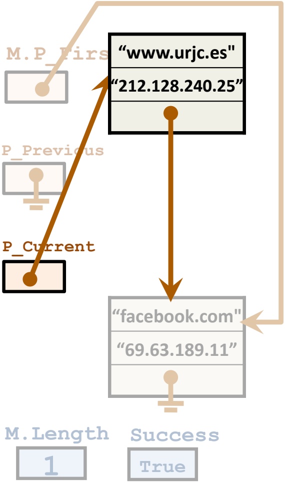
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

7

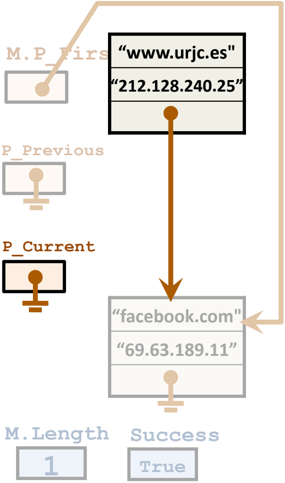
`Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);`



```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success  := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

7 `Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);`



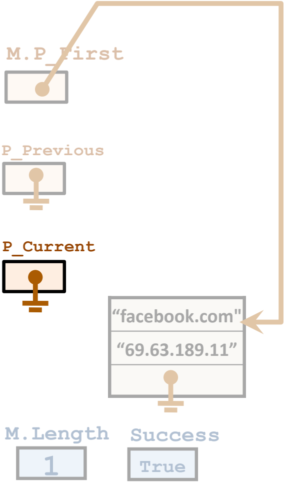
```
procedure Delete (M      :  in out Map;
                  Key    :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

7

```
Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);
```



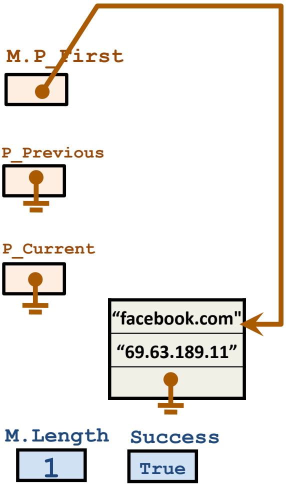
```
procedure Delete (M      :  in out Map;
                  Key    :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

7

```
Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);
```



M.P_First

P_Previous

P_Current

"facebook.com"

"69.63.189.11"

M.Length

1

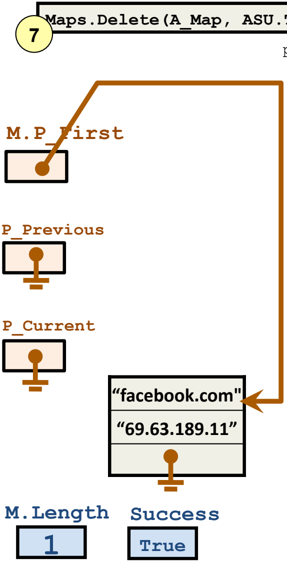
Success

True

```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

```
Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);
```



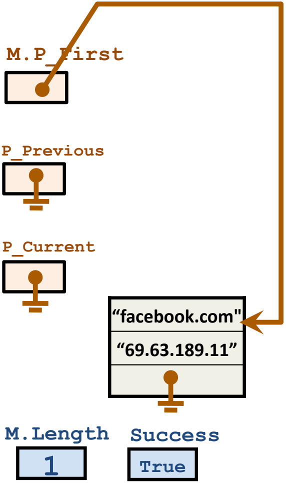
```
procedure Delete (M      :  in out Map;
                  Key    :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success  := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

7

```
Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);
```



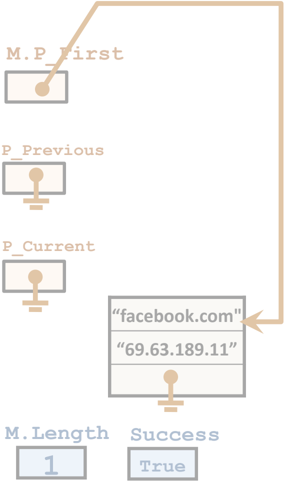
```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current  : Cell_A;
      P_Previous : Cell_A;
   begin
      Success := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

Ejemplo de ejecución (TS mediante lista enlazada no ordenada)

7

```
Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);
```

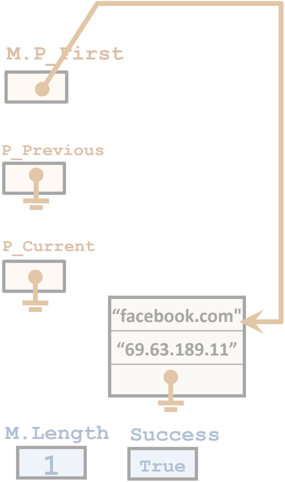


```
procedure Delete (M     :  in out Map;
                  Key   :  in Asu.Unbounded_String;
                  Success: out Boolean) is
      P_Current   : Cell_A;
      P_Previous : Cell_A;
   begin
      Success := False;
      P_Previous := null;
      P_Current  := M.P_First;
      while not Success and P_Current /= null loop
         if P_Current.Key = Key then
            Success := True;
            M.Length := M.Length - 1;
            if P_Previous /= null then
               P_Previous.Next := P_Current.Next;
            end if;
            if M.P_First = P_Current then
               M.P_First := M.P_First.Next;
            end if;
            -- Liberar si no hay Garbage Collector
            P_Current:=null;
         else
            P_Previous := P_Current;
            P_Current := P_Current.Next;
         end if;
      end loop;

   end Delete;
```

7

```
Maps.Delete(A_Map, ASU.To_Unbounded_String("www.urjc.es"), Success);
```



```
procedure Delete (M      :  in out Map;
                  Key    :  in Asu.Unbounded_String;
                  Success: out Boolean) is
   P_Current  : Cell_A;
   P_Previous : Cell_A;
begin
   Success := False;
   P_Previous := null;
   P_Current  := M.P_First;
   while not Success and P_Current /= null loop
      if P_Current.Key = Key then
         Success := True;
         M.Length := M.Length - 1;
         if P_Previous /= null then
            P_Previous.Next := P_Current.Next;
         end if;
         if M.P_First = P_Current then
            M.P_First := M.P_First.Next;
         end if;
         -- Liberar si no hay Garbage Collector
         P_Current:=null;
      else
         P_Previous := P_Current;
         P_Current := P_Current.Next;
      end if;
   end loop;

end Delete;
```

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12. Borrado de un nodo en un ABB

Especificación de iteradores para la tabla de símbolos

```
with Ada.Strings.Unbounded;
package Maps is
...
   --
   -- Cursor Interface for iterating over Map elements
   --
   type Cursor is limited private;
   function First (M: Map) return Cursor;
   procedure Next (C: in out Cursor);
   function Has_Element (C: Cursor) return Boolean;
   type Element_Type is record
      Key:   ASU.Unbounded_String;
      Value: ASU.Unbounded_String;
   end record;
   No_Element: exception;
   -- Raises No_Element if Has_Element(C) = False;
   function Element (C: Cursor) return Element_Type;
private
... // Suponiendo una implementación mediante lista enlazada
   type Cursor is record
      M         : Map;
      Element_A : Cell_A;
   end record;
```

Ejemplo de uso del iterador

```
with Maps;
procedure Map_Test is

   procedure Print_Map (M : Maps.Map) is
      C: Maps.Cursor
   begin
      Ada.Text_IO.Put_Line ("Map");
      Ada.Text_IO.Put_Line ("===");

      C := Maps.First(M);
      while Maps.Has_Element(C) loop
         Ada.Text_IO.Put_Line (ASU.To_String(Maps.Element(C).Key) &
                               " " &
                               ASU.To_String(Maps.Element(C).Value));
         Maps.Next(C);
      end loop;
   end Print_Map;
...

begin
  ...
end Map_Test;
```

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Tabla de símbolos implementada mediante un Array ordenado

- Se utiliza también un Array, por lo que tenemos un tamaño máximo fijado de antemano
- Los elementos de la tabla se mantienen ordenados y contiguos en el array
- La ventaja ahora es que la búsqueda de un elemento NO requiere recorrer todos los elementos del Array hasta encontrar el que se busca. En su lugar, se realiza una búsqueda binaria.
- La inserción de un nuevo elemento se realiza usando la búsqueda binaria para encontrar la posición que le corresponde al elemento que se inserta
    - Si la clave del elemento a insertar no está ya en el Array, hay que mover todos los elementos que le suceden una posición hacia adelante para hacer hueco para el que se inserta
        - Esta operación es costosa porque implica no sólo recorrer todos los elementos mayores sino también copiar cada uno de ellos.

Búsqueda binaria en un Array ordenado

- La búsqueda binaria es menos costosa que la búsqueda lineal en un Array ordenado ya que, comparado con la implementación que usa un Array no ordenado, requiere menos accesos al Array para localizar el elemento
- Se compara el elemento a buscar con el elemento que está en el medio del Array:
  - si es menor, se busca con el mismo procedimiento en el subArray a la izquierda
  - en caso contrario, se busca en el subArray a la derecha

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Implementación de TS mediante una lista enlazada ordenada

- Al igual que con un Array ordenado, mantenemos ordenados los elementos según su clave
- Ventaja: la operación de inserción no requiere mover los elementos que le suceden
- Inconveniente: la operación de búsqueda sin embargo no se puede implementar tan eficientemente como en el Array ordenado: no podemos ir al elemento que está en la mitad de la lista por lo que la búsqueda ha de ser lineal y no binaria

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Tabla de símbolos implementada mediante un ABB

- En lugar de utilizar un Array o una Lista enlazada utilizaremos ahora un árbol de búsqueda binaria (ABB) para implementar la misma estructura de datos: una tabla de símbolos
- Recordatorio:
  - La tabla de símbolos es una estructura de datos que almacena elementos compuestos por parejas (`Clave`, `Valor`)
  - `Clave` y `Valor` pueden ser tipos de datos cualesquiera
  - Tiene tres operaciones básicas:
    - `Put`: Dado un nuevo elemento (`Clave, Valor`) como parámetro, se añade éste a la tabla. Si ya existía un elemento con la misma `Clave`, se sustituye su `Valor` asociado por el especificado en la llamada a `Put`
    - `Get`: Dada una `Clave` como parámetro, devuelve el `Valor` asociado a la misma en la tabla en caso de que exista un elemento (`Clave`, `Valor`)
    - `Delete`: Dada un `Clave` como parámetro, se borra de la tabla, si existe, el elemento (`Clave`, `Valor`)

Especificación de la tabla de símbolos

La especificación no cambia, salvo por la parte privada:

```
with Ada.Strings.Unbounded;
package Maps is
   package ASU renames Ada.Strings.Unbounded;

   type Map is limited private;
   procedure Get (M       : Map;
                  Key     : in  ASU.Unbounded_String;
                  Value   : out ASU.Unbounded_String;
                  Success : out Boolean);
   ...
private
   type Tree_Node;
   type Map is access Tree_Node;
   type Tree_Node is record
      Key   : ASU.Unbounded_String := ASU.Null_Unbounded_String;
      Value : ASU.Unbounded_String := ASU.Null_Unbounded_String;
      Left  : Map;
      Right : Map;
   end record;
end Maps;
```

Árbol de búsqueda binaria (ABB)

Principal característica de un ABB

- La información que está almacenada en el árbol está ordenada
- Gracias a ello la búsqueda de un elemento en la tabla implementada con un ABB a partir de su clave NO requiere recorrer todos los nodos: búsqueda binaria

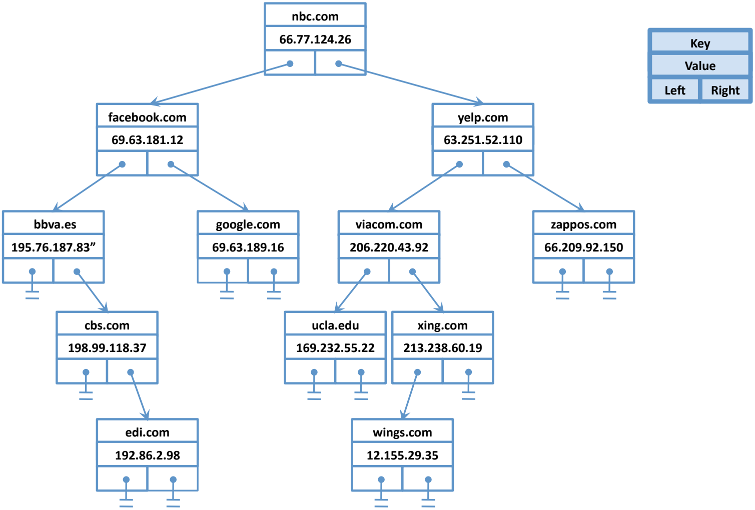
- Cada nodo de un árbol de búsqueda binaria almacena una clave con su valor asociado: (`Key`, `Value`)
- Los nodos del árbol están ordenados por su clave ⇒
    - las claves tienen que ser de tipos que tengan definidos los operadores de comparación $<, >, =, / =$
- El valor de cada nodo puede ser de cualquier tipo
    - Incluyendo tipos compuestos (arrays, listas,...)

Definición recursiva del árbol de búsqueda binaria (ABB)

Un árbol de búsqueda binaria (ABB):

- o está vacío
- o está formado por:
  - Una pareja (`Key`, `Value`)
  - Un ABB izquierdo con claves menores que `Key` (subárbol izquierdo)
  - Un ABB derecho con claves mayores que `Key` (subárbol derecho)

Definición recursiva del ABB: ejemplo



nbc.com
66.77.124.26

facebook.com
69.63.181.12

yelp.com
63.251.52.110

bbva.es
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google.com
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viacom.com
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zappos.com
66.209.92.150

cbs.com
198.99.118.37

ucla.edu
169.232.55.22

xing.com
213.238.60.19

edi.com
192.86.2.98

wings.com
12.155.29.35

Key
Value
Left Right

Definición recursiva del árbol de búsqueda binaria (ABB): código

```
type Tree_Node;
type Map is access Tree_Node;
type Tree_Node is record
   Key   : ASU.Unbounded_String := ASU.Null_Unbounded_String;
   Value : ASU.Unbounded_String := ASU.Null_Unbounded_String;
   Left  : Map;
   Right : Map;
end record;
```

Definición recursiva del árbol de búsqueda binaria (ABB)

- Para identificar el árbol utilizamos la dirección en la que está su nodo raíz
- Llamamos subárbol izquierdo de un nodo i al árbol cuya raíz está apuntada por $i.Left$
    - Llamamos subárbol derecho de un nodo i al árbol cuya raíz está apuntada por $i.Right$
- Un nodo j es hijo de un nodo padre i si j es la raíz de uno de los dos subárboles de i
- La definición recursiva del árbol permite definir operaciones recursivas de manera elegante.
    - También una lista enlazada se puede definir recursivamente (o vacía, o formada por un primer nodo y una lista con el resto de los elementos)
    - Se pueden también definir las operaciones de la lista enlazada recursivamente

Búsqueda de un nodo

Para buscar un nodo con determinada clave `Key` en un árbol del que conocemos su nodo raíz (`Root`):

- Si el árbol está vacío ⇒ no existe el elemento
- Si el árbol no está vació ⇒
  - Si $Key = Root.Key$ ⇒ el nodo raíz es el nodo buscado
  - Si $Key < Root.Key$ ⇒ buscar el nodo en el subárbol izquierdo
  - Si $Key > Root.Key$ ⇒ buscar el nodo en el subárbol derecho

Búsqueda de un nodo: código

En el primer parámetro, M, se le pasa al procedimiento Get un puntero al nodo raíz del árbol:

```
procedure Get (M  : Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success : out Boolean) is
begin
   Value := ASU.Null_Unbounded_String;

   If M = null then
      Success := False;
   elsif M.Key = Key then
      Value := M.Value;
      Success := True;
   elsif Key > M.Key then
      Get (M.Right, Key, Value, Success);
   else
      Get (M.Left, Key, Value, Success);
   end if;
end Get;
```

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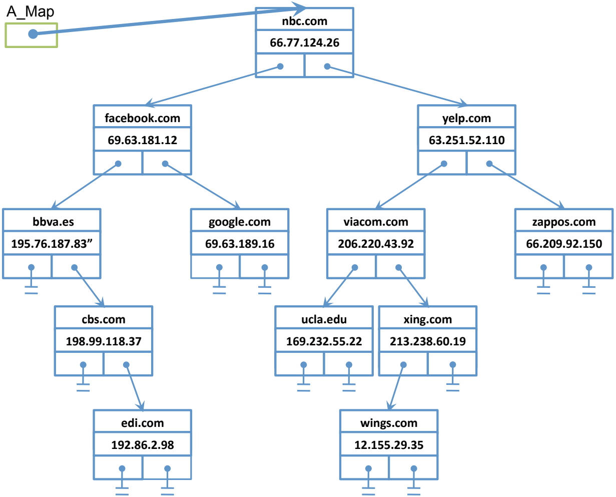
A_Map
nbc.com
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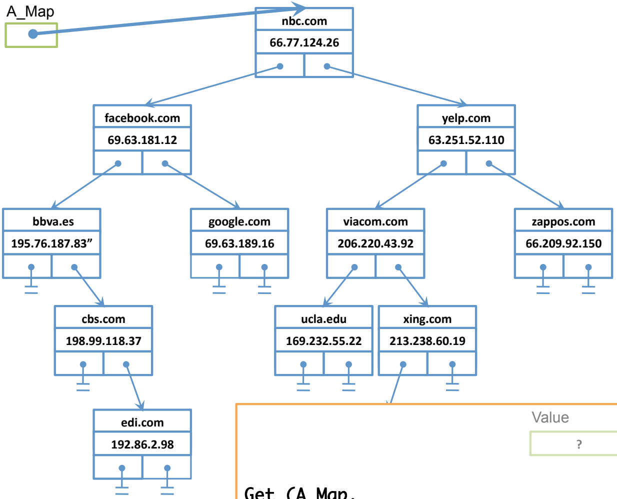
ucla.edu
169.232.55.22
xing.com
213.238.60.19
edi.com
192.86.2.98
wings.com
12.155.29.35

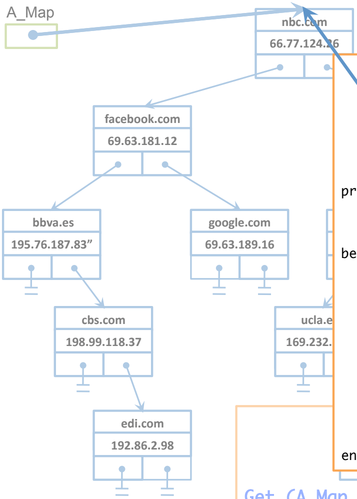
Ejemplo de ejecución: Get en un ABB



Value	Success
?	?

```
Get (A_Map,
     ASU.To_Unbounded_String ("google.com"),
     Value,
     Success);
```

Ejemplo de ejecución: Get en un ABB



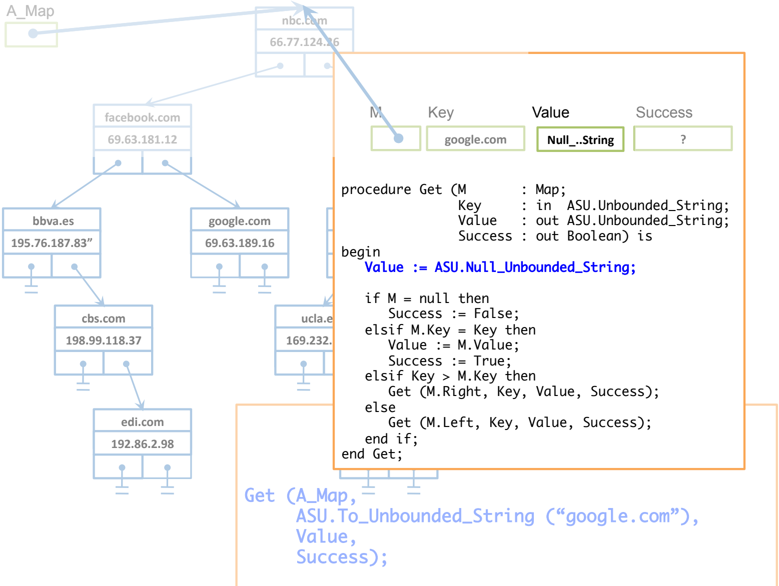
M	Key	Value	Success
	google.com	?	?

```
procedure Get (M       : Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success : out Boolean) is
begin
   Value := ASU.Null_Unbounded_String;

   if M = null then
      Success := False;
   elsif M.Key = Key then
      Value := M.Value;
      Success := True;
   elsif Key > M.Key then
      Get (M.Right, Key, Value, Success);
   else
      Get (M.Left, Key, Value, Success);
   end if;
end Get;
```

```
Get (A_Map,
     ASU.To_Unbounded_String (“google.com”),
     Value,
     Success);
```

Ejemplo de ejecución: Get en un ABB



A_Map

nbc.com
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ucla.e
169.232.

edi.com
192.86.2.98

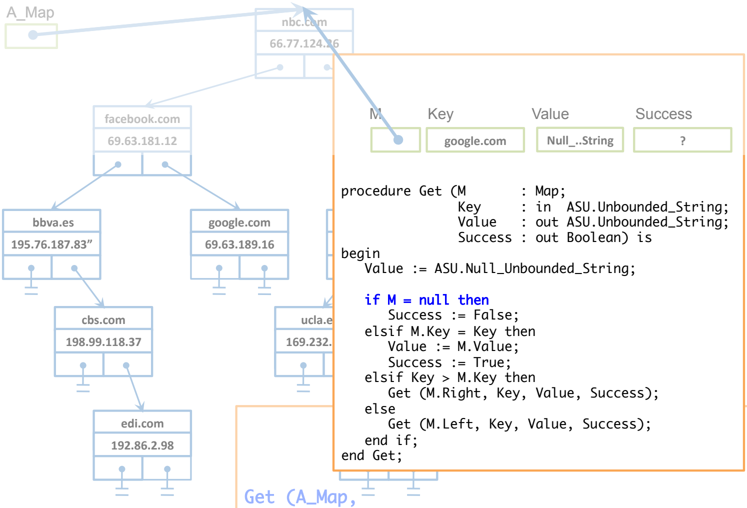
M	Key	Value	Success
	google.com	Null_..String	?

```
procedure Get (M       : Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success : out Boolean) is
begin
   Value := ASU.Null_Unbounded_String;

   if M = null then
      Success := False;
   elsif M.Key = Key then
      Value := M.Value;
      Success := True;
   elsif Key > M.Key then
      Get (M.Right, Key, Value, Success);
   else
      Get (M.Left, Key, Value, Success);
   end if;
end Get;
```

```
Get (A_Map,
     ASU.To_Unbounded_String (“google.com”),
     Value,
     Success);
```

Ejemplo de ejecución: Get en un ABB



```
procedure Get (M       : Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success : out Boolean) is
begin
   Value := ASU.Null_Unbounded_String;

   if M = null then
      Success := False;
   elsif M.Key = Key then
      Value  := M.Value;
      Success := True;
   elsif Key > M.Key then
      Get (M.Right, Key, Value, Success);
   else
      Get (M.Left, Key, Value, Success);
   end if;
end Get;
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```

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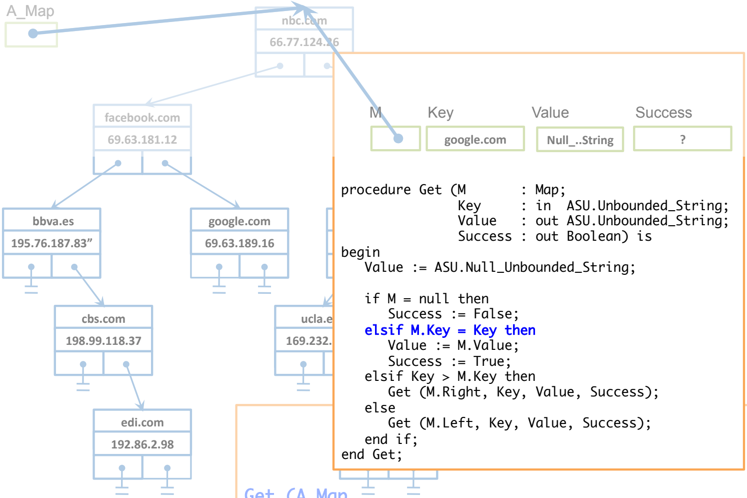
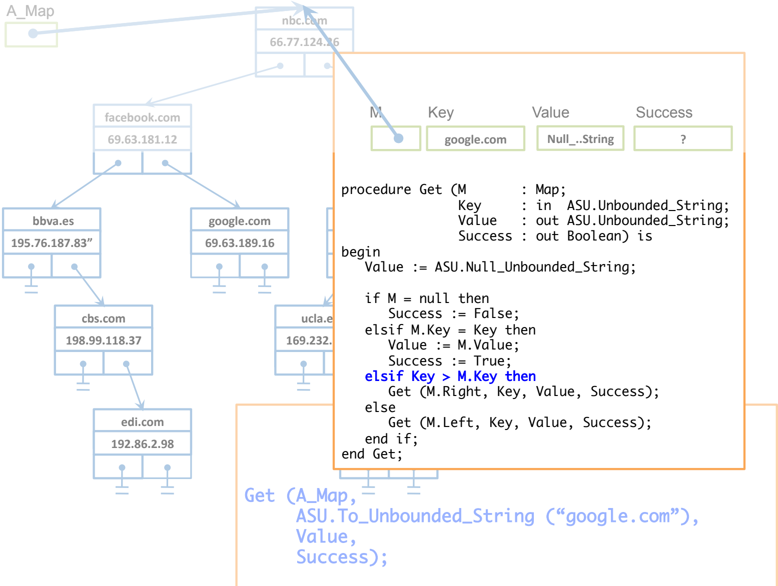


```
procedure Get (M       : Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success : out Boolean) is
begin
   Value := ASU.Null_Unbounded_String;

   if M = null then
      Success := False;
   elsif M.Key = Key then
      Value := M.Value;
      Success := True;
   elsif Key > M.Key then
      Get (M.Right, Key, Value, Success);
   else
      Get (M.Left, Key, Value, Success);
   end if;
end Get;
```

```
Get (A_Map,
     ASU.To_Unbounded_String (“google.com”),
     Value,
     Success);
```

Ejemplo de ejecución: Get en un ABB



```
procedure Get (M       : Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success : out Boolean) is
begin
   Value := ASU.Null_Unbounded_String;

   if M = null then
      Success := False;
   elsif M.Key = Key then
      Value := M.Value;
      Success := True;
   elsif Key > M.Key then
      Get (M.Right, Key, Value, Success);
   else
      Get (M.Left, Key, Value, Success);
   end if;
end Get;
```

```
Get (A_Map,
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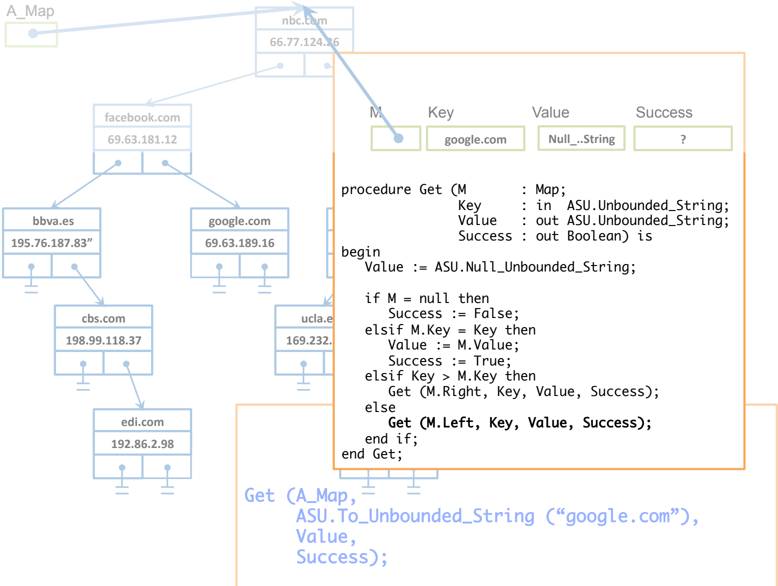
Ejemplo de ejecución: Get en un ABB



```
procedure Get (M       : Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
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begin
   Value := ASU.Null_Unbounded_String;

   if M = null then
      Success := False;
   elsif M.Key = Key then
      Value  := M.Value;
      Success := True;
   elsif Key > M.Key then
      Get (M.Right, Key, Value, Success);
   else
      Get (M.Left, Key, Value, Success);
   end if;
end Get;
```
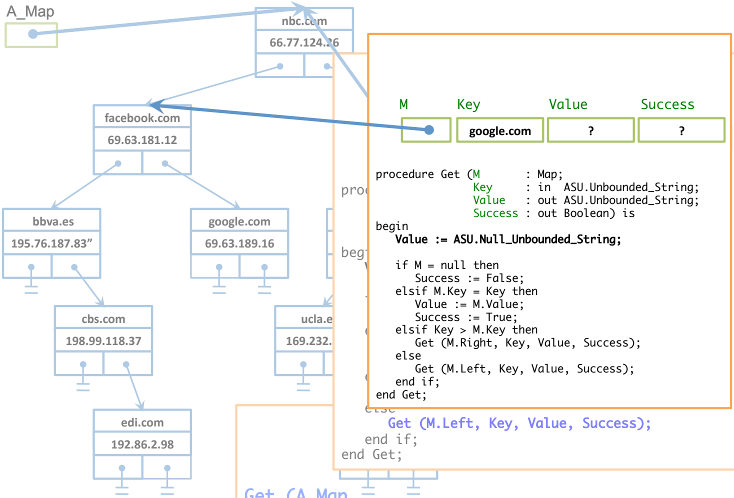

```
Get (A_Map,
     ASU.To_Unbounded_String (“google.com”),
     Value,
     Success);
```

Ejemplo de ejecución: Get en un ABB

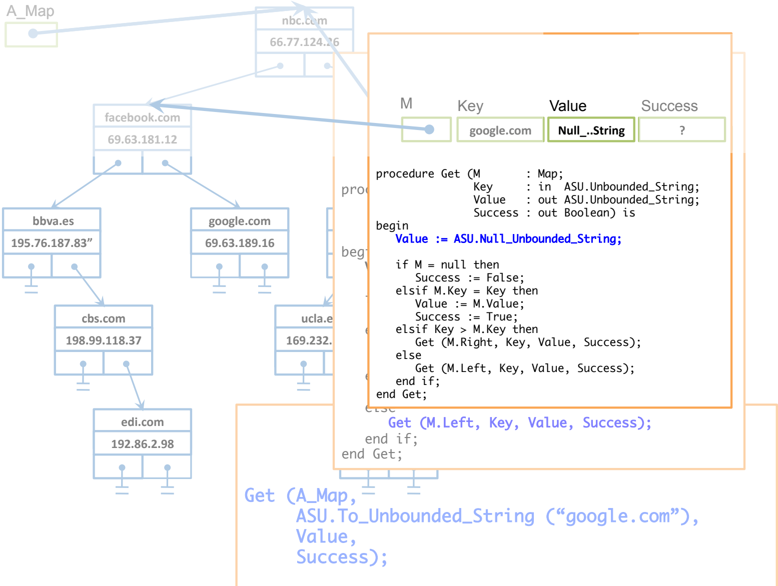


```
procedure Get (M       : Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success : out Boolean) is
begin
   Value := ASU.Null_Unbounded_String;

   if M = null then
      Success := False;
   elsif M.Key = Key then
      Value := M.Value;
      Success := True;
   elsif Key > M.Key then
      Get (M.Right, Key, Value, Success);
   else
      Get (M.Left, Key, Value, Success);
   end if;
end Get;
```

```
proc

beg

   else
      Get (M.Left, Key, Value, Success);
   end if;
end Get;
```

```
Get (A_Map,
     ASU.To_Unbounded_String (“google.com”),
     Value,
     Success);
```

Ejemplo de ejecución: Get en un ABB



```
procedure Get (M       : Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success : out Boolean) is
begin
   Value := ASU.Null_Unbounded_String;

   if M = null then
      Success := False;
   elsif M.Key = Key then
      Value := M.Value;
      Success := True;
   elsif Key > M.Key then
      Get (M.Right, Key, Value, Success);
   else
      Get (M.Left, Key, Value, Success);
   end if;
end Get;
```

```
proc

beg

    else
      Get (M.Left, Key, Value, Success);
    end if;
end Get;
```

```
Get (A_Map,
     ASU.To_Unbounded_String (“google.com”),
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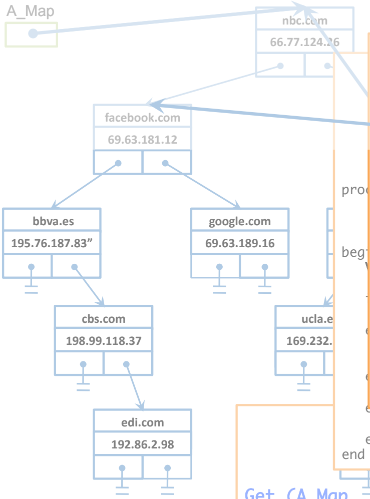
Ejemplo de ejecución: Get en un ABB



M	Key	Value	Success
●	google.com	**Null_..String**	?

```
procedure Get (M       : Map;
               Key     : in  ASU.Unbounded_String;
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   else
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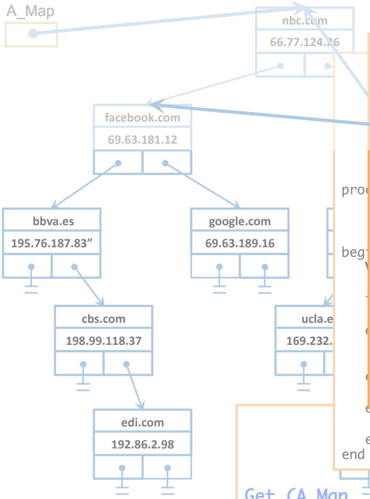

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●	google.com	Null_..String	?

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      Get (M.Left, Key, Value, Success);
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   else
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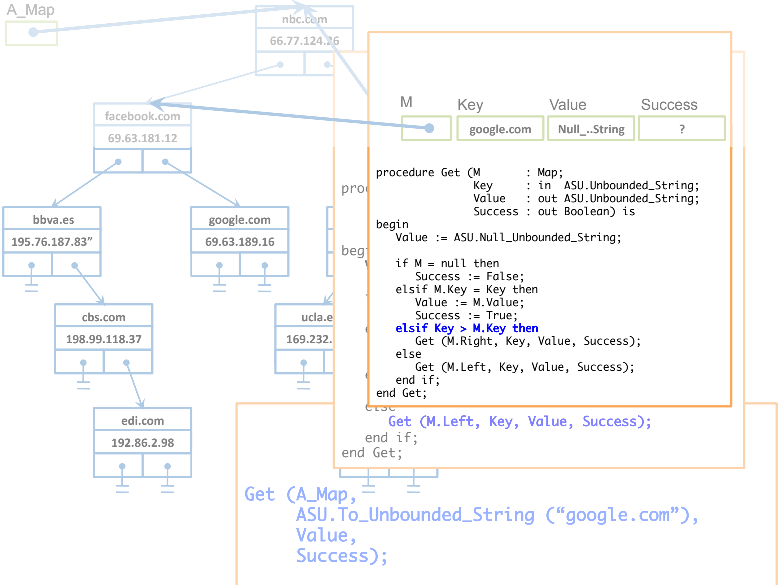

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   else
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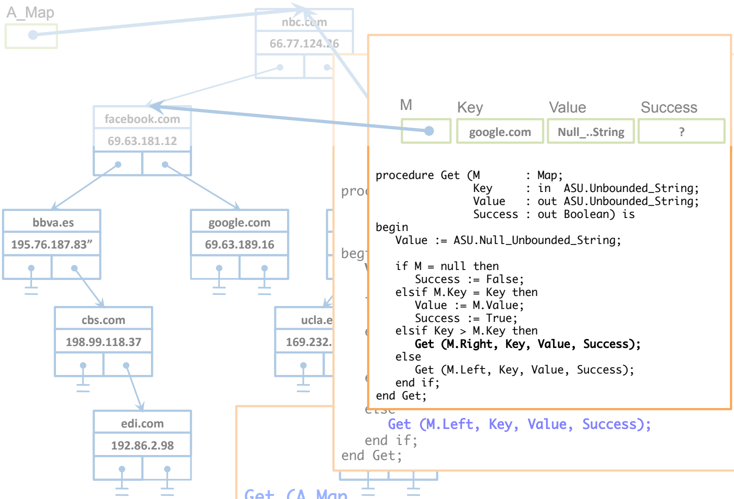

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               Value   : out ASU.Unbounded_String;
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      Get (M.Left, Key, Value, Success);
   end if;
end Get;
```

```
proc

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    else
      Get (M.Left, Key, Value, Success);
    end if;
end Get;
```

```
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     ASU.To_Unbounded_String (“google.com”),
     Value,
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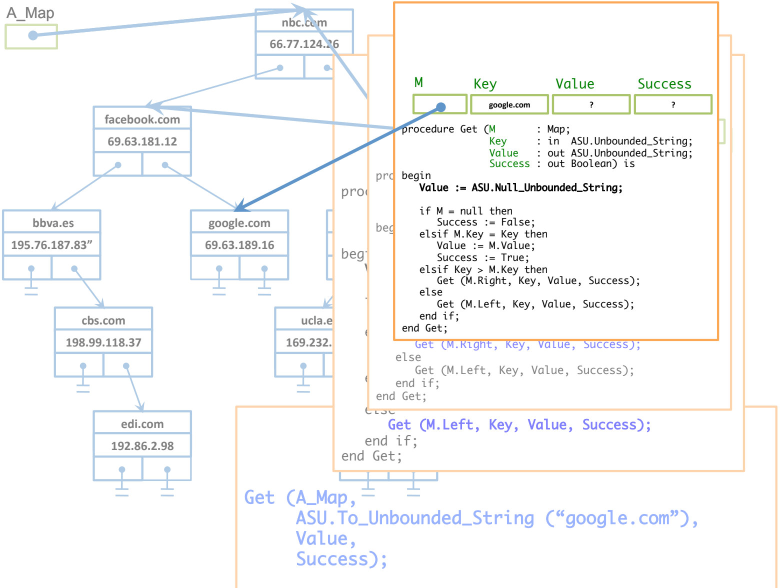
```

Ejemplo de ejecución: Get en un ABB



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procedure Get (M       : Map;
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   else
      Get (M.Left, Key, Value, Success);
   end if;
end Get;
```

```
      Get (M.Right, Key, Value, Success);
   else
      Get (M.Left, Key, Value, Success);
   end if;
end Get;
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      Get (M.Left, Key, Value, Success);
   end if;
end Get;
```
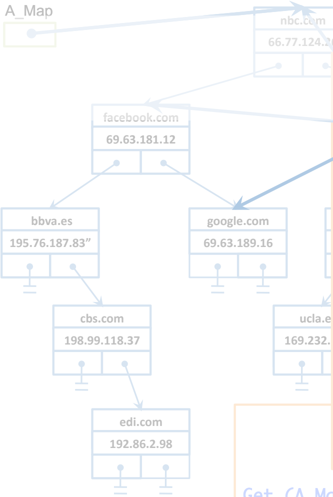

```
Get (A_Map,
     ASU.To_Unbounded_String (“google.com”),
     Value,
     Success);
```



M	Key	Value	Success
	google.com	Null_..String	?

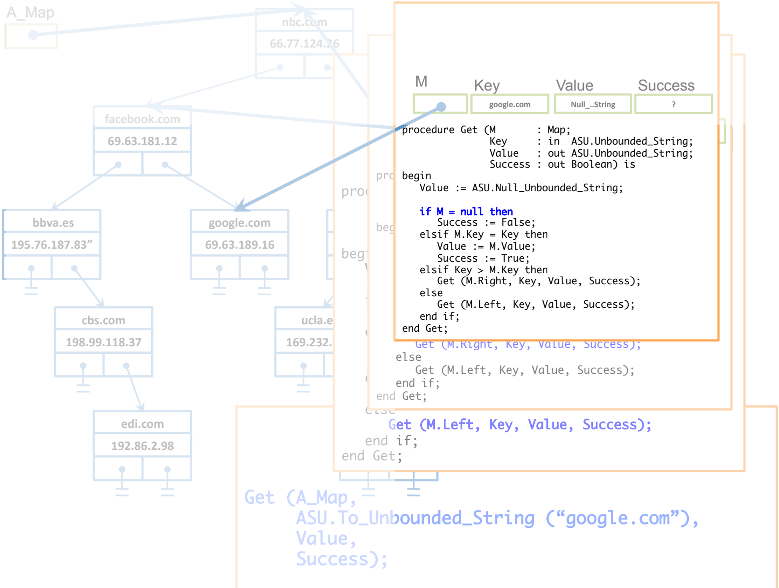
```
procedure Get (M       : Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success : out Boolean) is
begin
   Value := ASU.Null_Unbounded_String;

   if M = null then
      Success := False;
   elsif M.Key = Key then
      Value := M.Value;
      Success := True;
   elsif Key > M.Key then
      Get (M.Right, Key, Value, Success);
   else
      Get (M.Left, Key, Value, Success);
   end if;
end Get;
```

```
      Get (M.Right, Key, Value, Success);
   else
      Get (M.Left, Key, Value, Success);
   end if;
end Get;
```

```
   else
      Get (M.Left, Key, Value, Success);
   end if;
end Get;
```

```
Get (A_Map,
     ASU.To_Unbounded_String (“google.com”),
     Value,
     Success);
```

Ejemplo de ejecución: Get en un ABB



```
procedure Get (M       : Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success : out Boolean) is
begin
   Value := ASU.Null_Unbounded_String;

   if M = null then
      Success := False;
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   else
      Get (M.Left, Key, Value, Success);
   end if;
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```
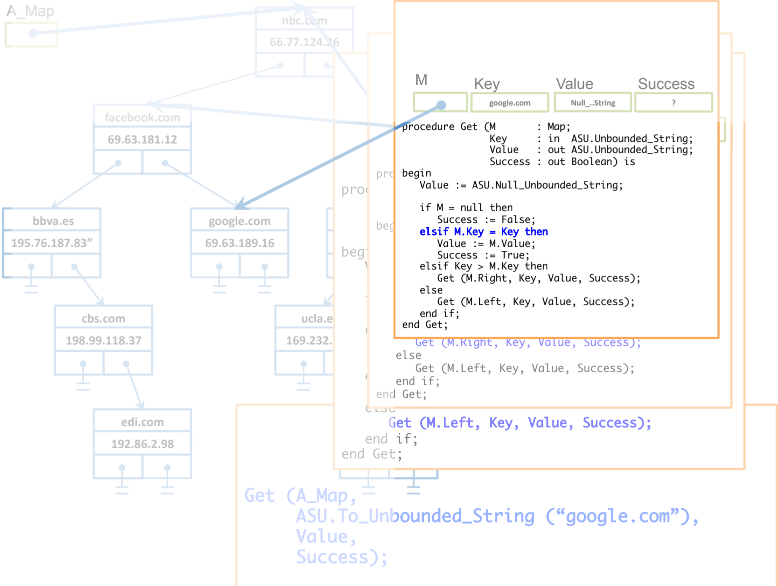

```
      Get (M.Right, Key, Value, Success);
   else
      Get (M.Left, Key, Value, Success);
   end if;
end Get;
```

```
      Get (M.Left, Key, Value, Success);
   end if;
end Get;
```

```
Get (A_Map,
     ASU.To_Unbounded_String (“google.com”),
     Value,
     Success);
```



```
procedure Get (M       : Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
               Success : out Boolean) is
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   Value := ASU.Null_Unbounded_String;

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      Success := False;
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   end if;
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```
      Get (M.Right, Key, Value, Success);
   else
      Get (M.Left, Key, Value, Success);
   end if;
end Get;
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      Get (M.Left, Key, Value, Success);
   end if;
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Get (A_Map,
     ASU.To_Unbounded_String ("google.com"),
     Value,
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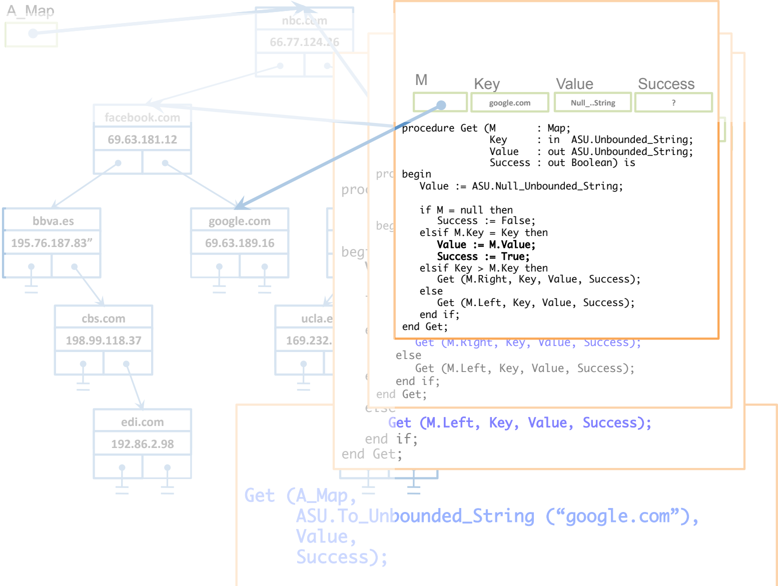
```



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               Key     : in  ASU.Unbounded_String;
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      Get (M.Left, Key, Value, Success);
   end if;
end Get;
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```
      Get (M.Right, Key, Value, Success);
   else
      Get (M.Left, Key, Value, Success);
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end Get;
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      Get (M.Left, Key, Value, Success);
   end if;
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Get (A_Map,
     ASU.To_Unbounded_String (“google.com”),
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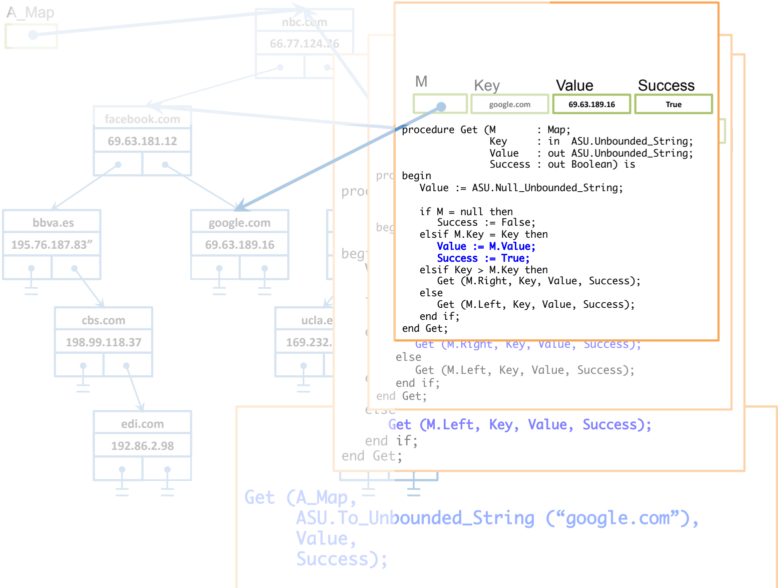
Ejemplo de ejecución: Get en un ABB



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               Key     : in  ASU.Unbounded_String;
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      Get (M.Right, Key, Value, Success);
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Get (A_Map,
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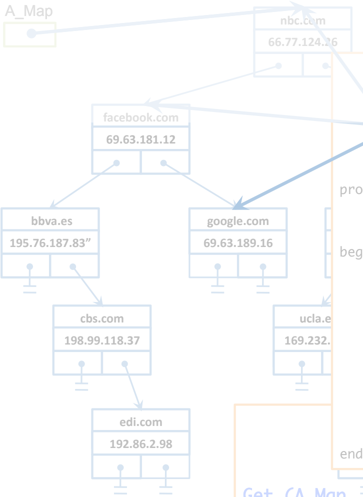
     Value,
     Success);
```



M

Key	Value	Success
google.com	69.63.189.16	True

```
procedure Get (M       : Map;
               Key     : in  ASU.Unbounded_String;
               Value   : out ASU.Unbounded_String;
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begin
   Value := ASU.Null_Unbounded_String;

   if M = null then
      Success := False;
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   elsif Key > M.Key then
      Get (M.Right, Key, Value, Success);
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      Get (M.Right, Key, Value, Success);
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      Get (M.Left, Key, Value, Success);
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Get (A_Map,
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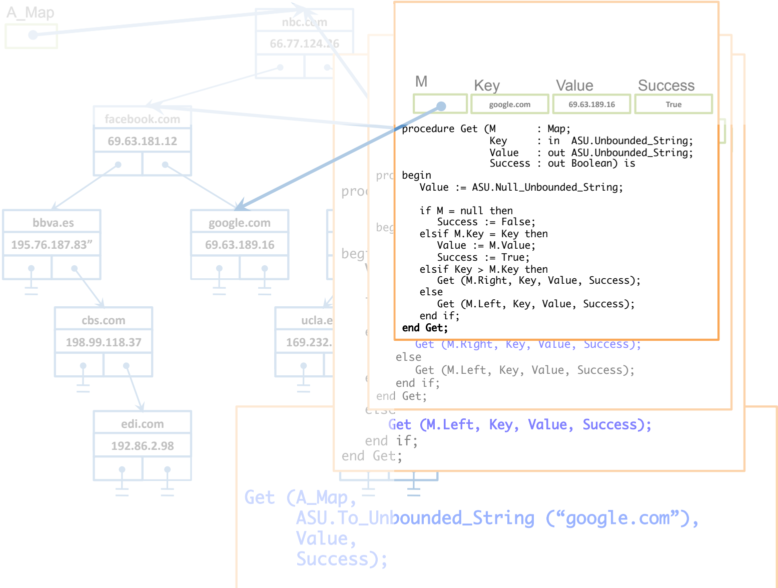

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procedure Get (M       : Map;
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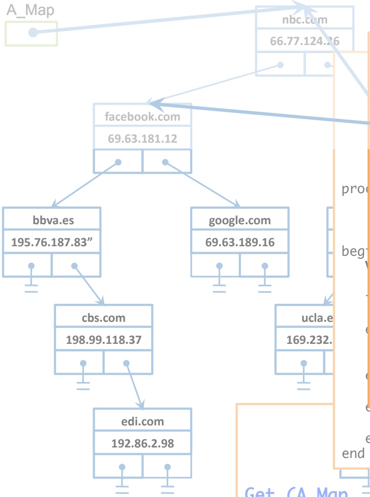

M	Key	Value	Success
●	google.com	69.63.189.16	True

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proc

beg

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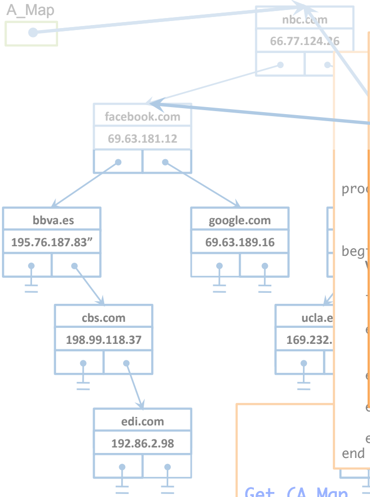

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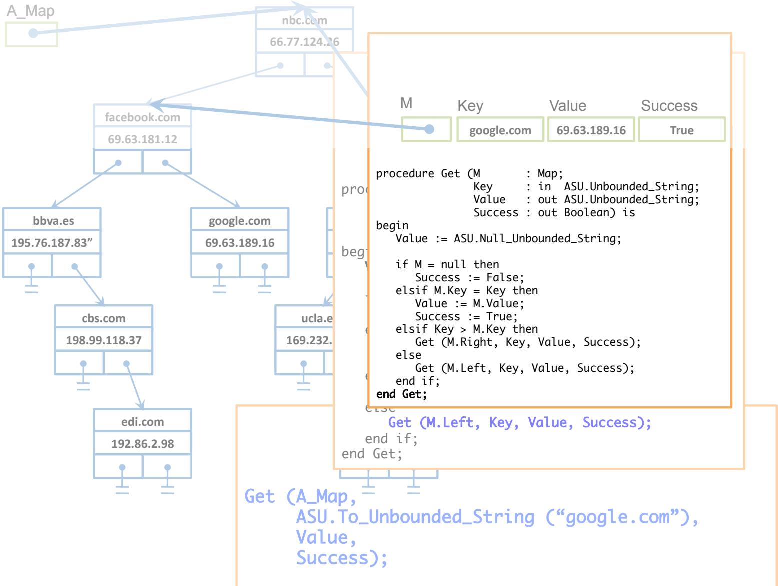

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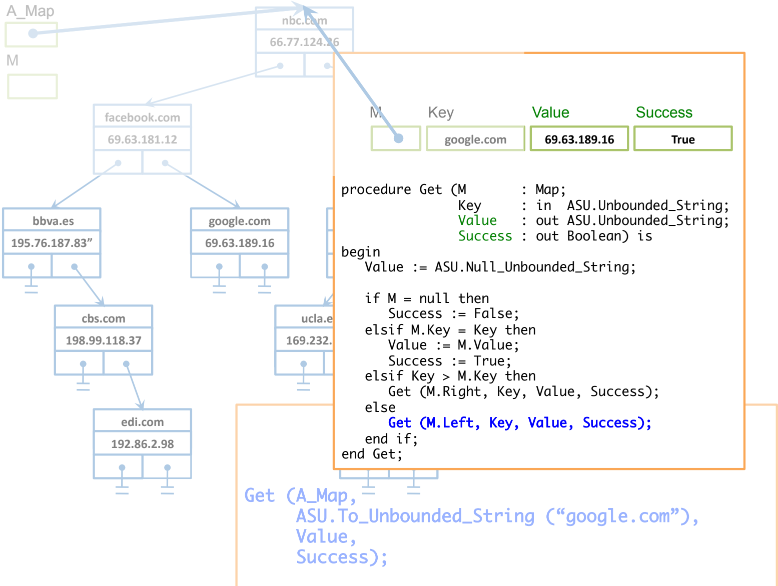

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```

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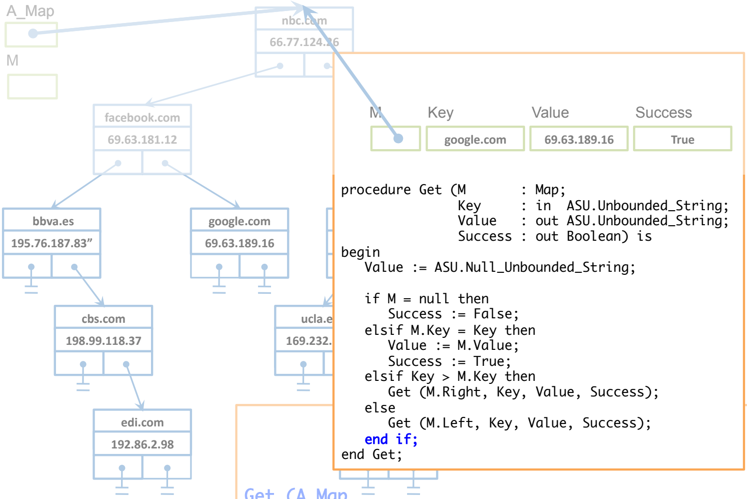

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   elsif Key > M.Key then
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   end if;
end Get;
```

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Get (A_Map,
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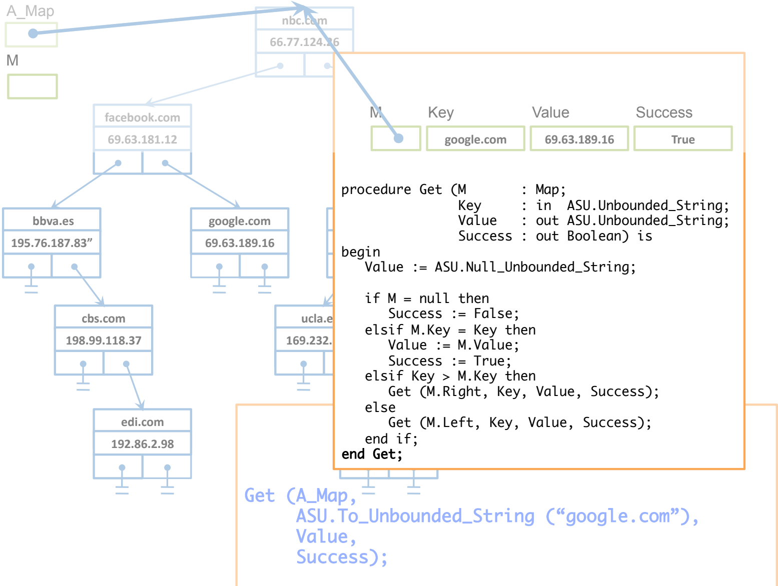

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procedure Get (M       : Map;
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   if M = null then
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      Success := True;
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Get (A_Map,
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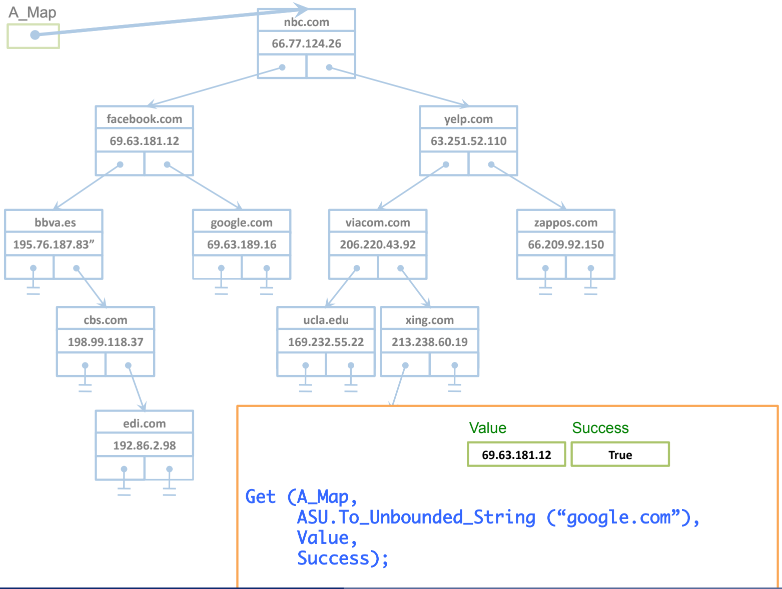

```
Get (A_Map,
     ASU.To_Unbounded_String (“google.com”),
     Value,
     Success);
```

Inserción de un nodo en un árbol

Se recorre el árbol desde la raíz hasta encontrar la posición que corresponda al nodo que se inserta en función de su clave

Para insertar un nuevo nodo con (`Key`, `Value`) en un árbol del que conocemos su nodo raíz (`Root`):

- Si el árbol está vacío ⇒ se crea un nuevo nodo con (`Key`, `Value`), que se convierte en la nueva raíz
- Si el árbol no está vació ⇒
    - Si $Key = Root.Key \Rightarrow Root.Value := Value$
    - Si $Key < Root.Key \Rightarrow$ se asigna al subárbol izquierdo el resultado de insertar el nodo en el subárbol izquierdo
    - Si $Key > Root.Key \Rightarrow$ se asigna al subárbol derecho el resultado de insertar el nodo en el subárbol derecho

Inserción de un nodo en un árbol: código

```
procedure Put (M     : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String) is
begin
   if M = null then
      M := new Tree_Node'(Key, Value, null, null);
      return;
   end if;

   if Key = M.Key then
      M.Value := Value;
   elsif Key < M.Key then
      Put (M.Left, Key, Value);
   elsif Key > M.Key then
      Put (M.Right, Key, Value);
   end if;

end Put;
```

Contenidos

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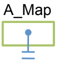
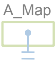
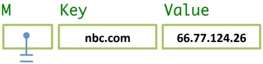
3. Implementación de TS mediante una lista enlazada no ordenada
4. Ejemplo de ejecución (TS mediante lista enlazada no ordenada)
5. Iteración sobre todos los elementos de una colección
6. Implementación de TS mediante un Array ordenado
7. Implementación de TS mediante una lista enlazada ordenada
8. Implementación de TS mediante un árbol de búsqueda binaria (ABB)
9. Ejemplo de ejecución: Get en un ABB
10. Ejemplo de ejecución: Put en un ABB vacío
11. Ejemplo de ejecución: Put en un ABB
12. Borrado de un nodo en un ABB



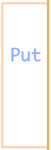
```
Put (A_Map,
     ASU.To_Unbounded_String (“nbc.com”),
     ASU.To_Unbounded_String (“66.77.124.26”));
```

Ejemplo de ejecución: Put en un ABB vacío

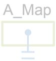


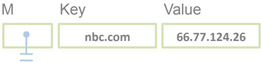


```
procedure Put (M : in out Map;
               Key     : ASU.Unbounded_String;
               Value   : ASU.Unbounded_String)

begin
   if M = null then
      M := new Tree_Node'(Key, Value, null, null);
      return;
   end if;

   if Key = M.Key then
      M.Value := Value;
   elsif Key < M.Key then
      Put (M.Left, Key, Value);
   elsif Key > M.Key then
      Put (M.Right, Key, Value);
   end if;

end Put;
```



Ejemplo de ejecución: Put en un ABB vacío

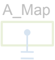


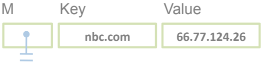


Put

```
procedure Put (M : in out Map;
               Key     : ASU.Unbounded_String;
               Value   : ASU.Unbounded_String)

begin
   if M = null then
      M := new Tree_Node'(Key, Value, null, null);
      return;
   end if;

   if Key = M.Key then
      M.Value := Value;
   elsif Key < M.Key then
      Put (M.Left, Key, Value);
   elsif Key > M.Key then
      Put (M.Right, Key, Value);
   end if;


end Put;
```

Ejemplo de ejecución: Put en un ABB vacío





Put

```
procedure Put (M : in out Map;
              Key    : ASU.Unbounded_String;
              Value  : ASU.Unbounded_String)

begin
   if M = null then
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      return;
   end if;

   if Key = M.Key then
      M.Value := Value;
   elsif Key < M.Key then
      Put (M.Left, Key, Value);
   elsif Key > M.Key then
      Put (M.Right, Key, Value);
   end if;


end Put;
```
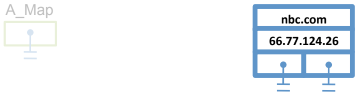
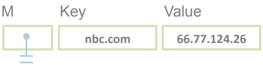

Ejemplo de ejecución: Put en un ABB vacío





```
procedure Put (M : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String)

begin
   if M = null then
      M := new Tree_Node'(Key, Value, null, null);
      return;
   end if;

   if Key = M.Key then
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   elsif Key < M.Key then
      Put (M.Left, Key, Value);
   elsif Key > M.Key then
      Put (M.Right, Key, Value);
   end if;


end Put;
```
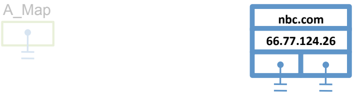
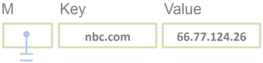

Put

Ejemplo de ejecución: Put en un ABB vacío





Put

```
procedure Put (M : in out Map;
               Key     : ASU.Unbounded_String;
               Value   : ASU.Unbounded_String)

begin
   if M = null then
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      return;
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   elsif Key < M.Key then
      Put (M.Left, Key, Value);
   elsif Key > M.Key then
      Put (M.Right, Key, Value);
   end if;


end Put;
```
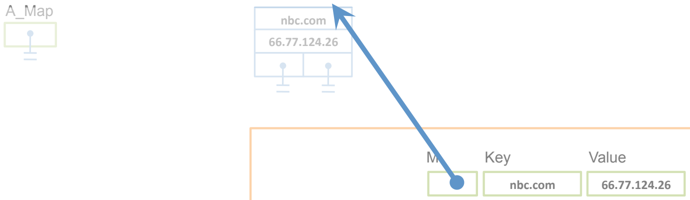
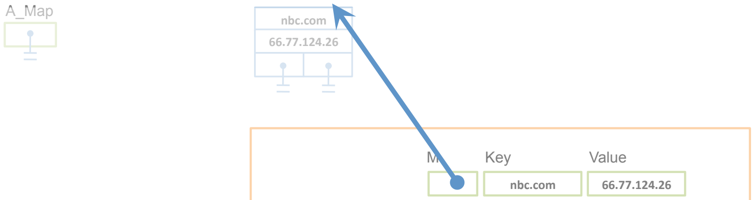

Ejemplo de ejecución: Put en un ABB vacío



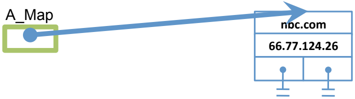
Put

```
procedure Put (M : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String)

begin
   if M = null then
      M := new Tree_Node'(Key, Value, null, null);
      return;
   end if;

   if Key = M.Key then
      M.Value := Value;
   elsif Key < M.Key then
      Put (M.Left, Key, Value);
   elsif Key > M.Key then
      Put (M.Right, Key, Value);
   end if;


end Put;
```

Ejemplo de ejecución: Put en un ABB vacío



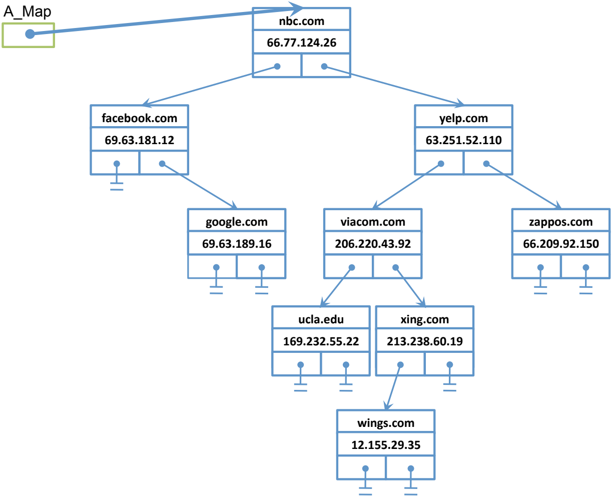
```
procedure Put (M : in out Map;
               Key     : ASU.Unbounded_String;
               Value   : ASU.Unbounded_String)

begin
   if M = null then
      M := new Tree_Node'(Key, Value, null, null);
      return;
   end if;

   if Key = M.Key then
      M.Value := Value;
   elsif Key < M.Key then
      Put (M.Left, Key, Value);
   elsif Key > M.Key then
      Put (M.Right, Key, Value);
   end if;


end Put;
```

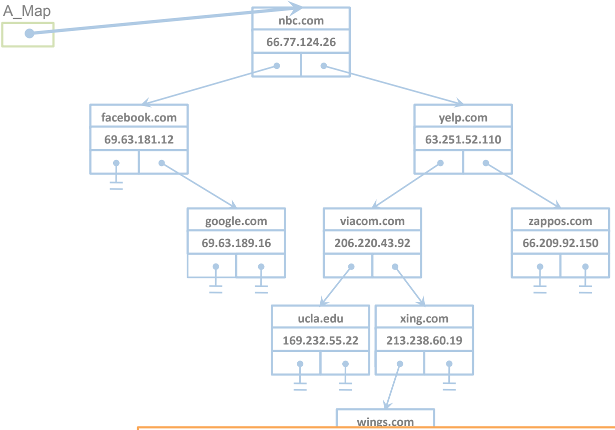


```
Put (A_Map,
     ASU.To_Unbounded_String (“nbc.com”),
     ASU.To_Unbounded_String (“66.77.124.26”));
```

Contenidos

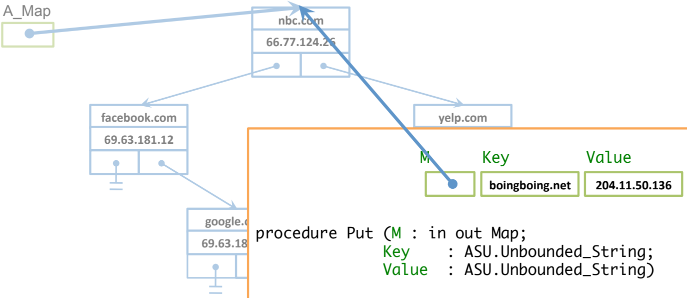
1. Tablas de Símbolos
2. Implementación de TS mediante un array no ordenado
3. Implementación de TS mediante una lista enlazada no ordenada
4. Ejemplo de ejecución (TS mediante lista enlazada no ordenada)
5. Iteración sobre todos los elementos de una colección
6. Implementación de TS mediante un Array ordenado
7. Implementación de TS mediante una lista enlazada ordenada
8. Implementación de TS mediante un árbol de búsqueda binaria (ABB)
9. Ejemplo de ejecución: Get en un ABB
10. Ejemplo de ejecución: Put en un ABB vacío
11. Ejemplo de ejecución: Put en un ABB
12. Borrado de un nodo en un ABB


A_Map
nbc.com
66.77.124.26
facebook.com
69.63.181.12
yelp.com
63.251.52.110
google.com
69.63.189.16
viacom.com
206.220.43.92
zappos.com
66.209.92.150
ucla.edu
169.232.55.22
xing.com
213.238.60.19
wings.com
12.155.29.35



```
Put (A_Map,
     ASU.To_Unbounded_String (“boingboing.net”),
     ASU.To_Unbounded_String (“204.11.50.136”));
```

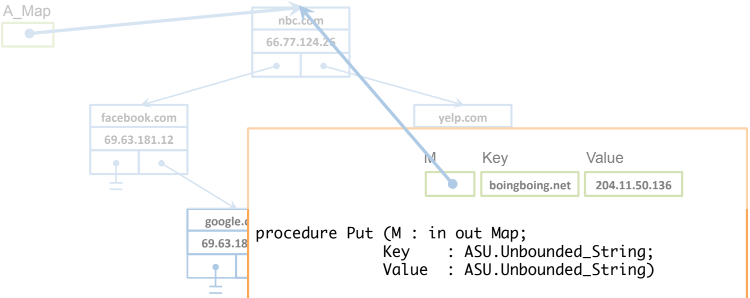
Ejemplo de ejecución: Put en un ABB



```
procedure Put (M : in out Map;
               Key     : ASU.Unbounded_String;
               Value   : ASU.Unbounded_String)

begin
   if M = null then
      M := new Tree_Node'(Key, Value, null, null);
      return;
   end if;

   if Key = M.Key then
      M.Value := Value;
   elsif Key < M.Key then
      Put (M.Left, Key, Value);
   elsif Key > M.Key then
      Put (M.Right, Key, Value);
   end if;


end Put;
```

```
Put (A_Map
     ASU.T
     ASU.T
```

Ejemplo de ejecución: Put en un ABB



```
procedure Put (M : in out Map;
               Key     : ASU.Unbounded_String;
               Value   : ASU.Unbounded_String)

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   if M = null then
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   elsif Key > M.Key then
      Put (M.Right, Key, Value);
   end if;


end Put;
```
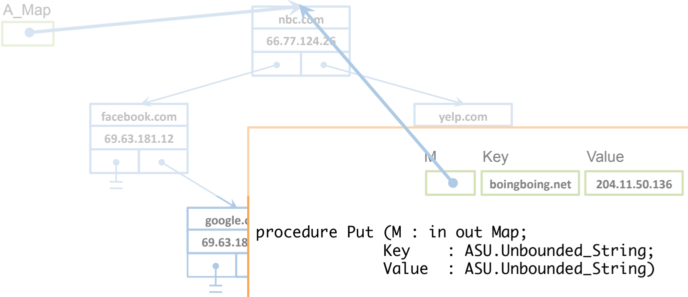

```
Put (A_Map
     ASU.T
     ASU.T
```

Ejemplo de ejecución: Put en un ABB



```
procedure Put (M : in out Map;
               Key     : ASU.Unbounded_String;
               Value   : ASU.Unbounded_String)

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      Put (M.Right, Key, Value);
   end if;


end Put;
```
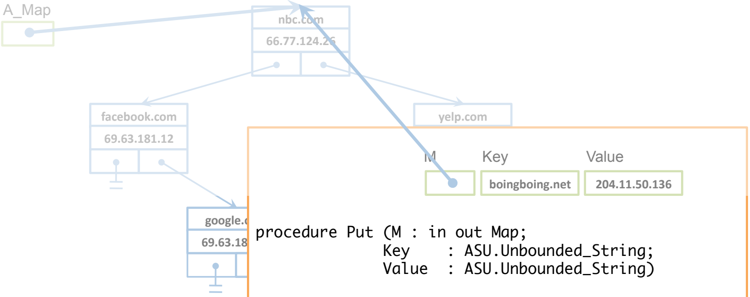

```
Put (A_Map
     ASU.T
     ASU.T
```



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               Value   : ASU.Unbounded_String)

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      M.Value := Value;
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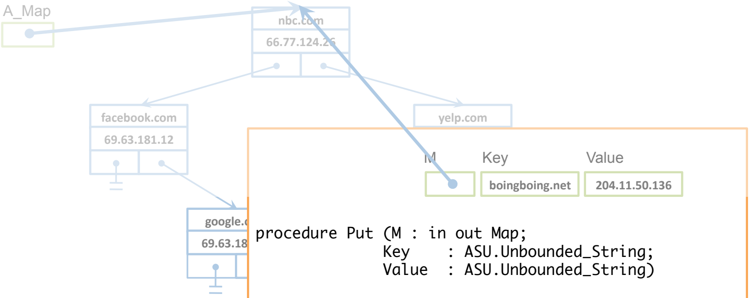
   elsif Key > M.Key then
      Put (M.Right, Key, Value);
   end if;


end Put;
```

```
Put (A_Map
     ASU.T
     ASU.T
```

Ejemplo de ejecución: Put en un ABB



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procedure Put (M : in out Map;
               Key     : ASU.Unbounded_String;
               Value   : ASU.Unbounded_String)

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      Put (M.Right, Key, Value);
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end Put;
```
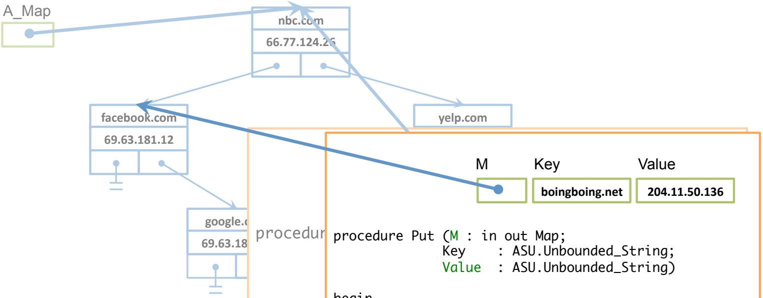

```
Put (A_Map
     ASU.T
     ASU.T
```



```
Put (A_Map
     ASU.T
     ASU.T
```

```
procedur

begin
   if M
      M
   end i

   if Ke
      M.
   elsif
      Pu
   elsif
      Pu
   end i

end Put;
```

```
procedure Put (M : in out Map;
               Key     : ASU.Unbounded_String;
               Value   : ASU.Unbounded_String)

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      Put (M.Left, Key, Value);
   elsif Key > M.Key then
      Put (M.Right, Key, Value);
   end if;


end Put;
```

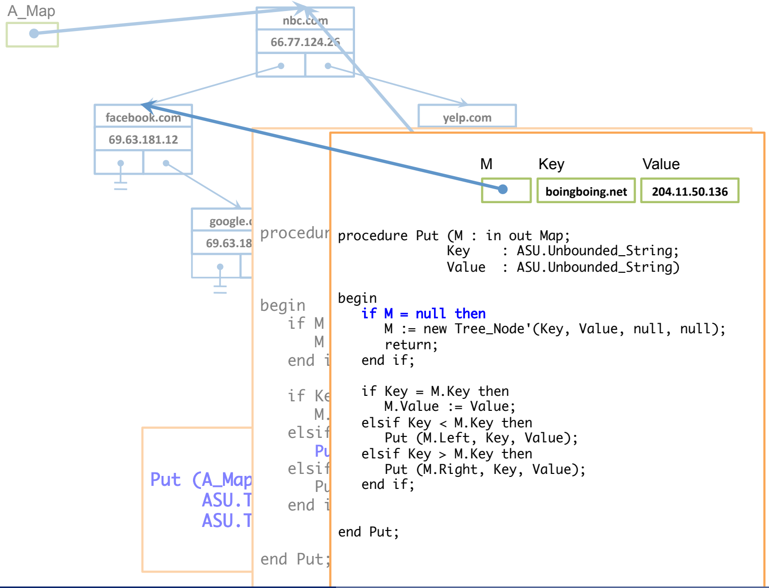

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               Key   : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String)

begin
   if M = null then
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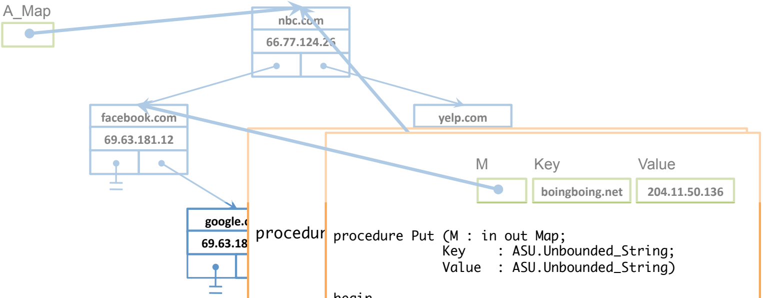
end Put;
```

Ejemplo de ejecución: Put en un ABB



```
procedur

begin
   if M
      M
   end i

   if Ke
      M.
   elsif
      Pu
   elsif
      Pu
   end i

end Put;
```

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Put (A_Map
     ASU.T
     ASU.T
```

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               Key     : ASU.Unbounded_String;
               Value   : ASU.Unbounded_String)

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      Put (M.Right, Key, Value);
   end if;

end Put;
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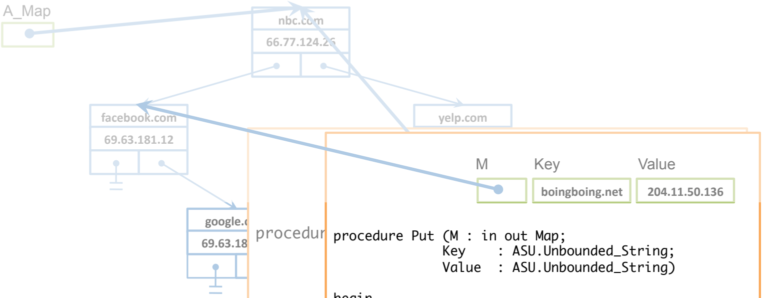

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Put (A_Map
     ASU.T
     ASU.T
```

```
procedur


begin
   if M
      M
   end i

   if Ke
      M.
   elsif
      Pu
   elsif
      Pu
   end i


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               Key    : ASU.Unbounded_String;
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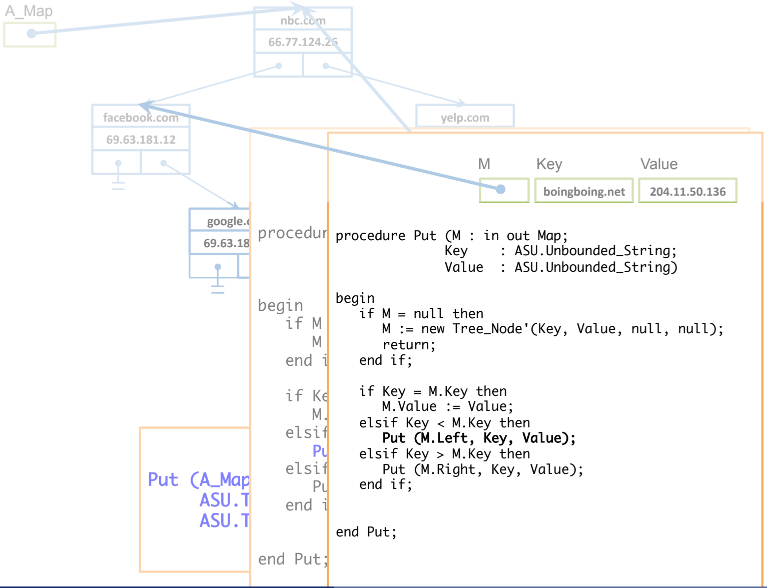

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procedure Put (M : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String)

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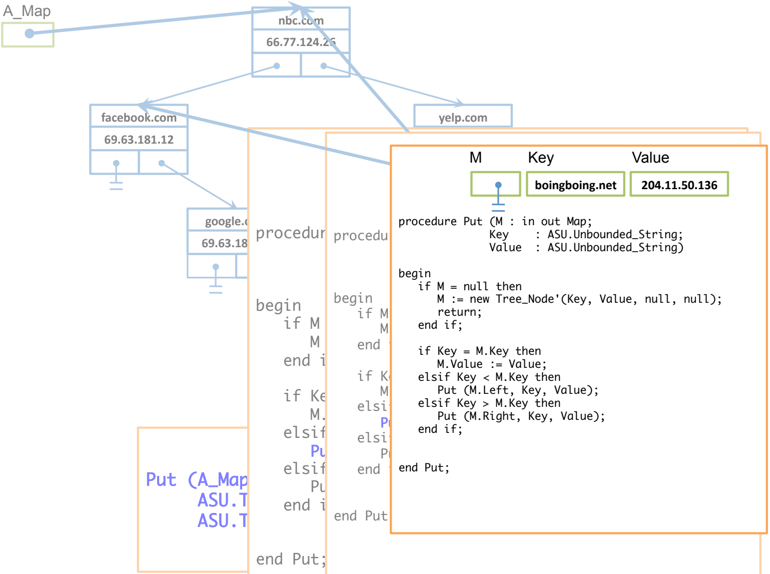

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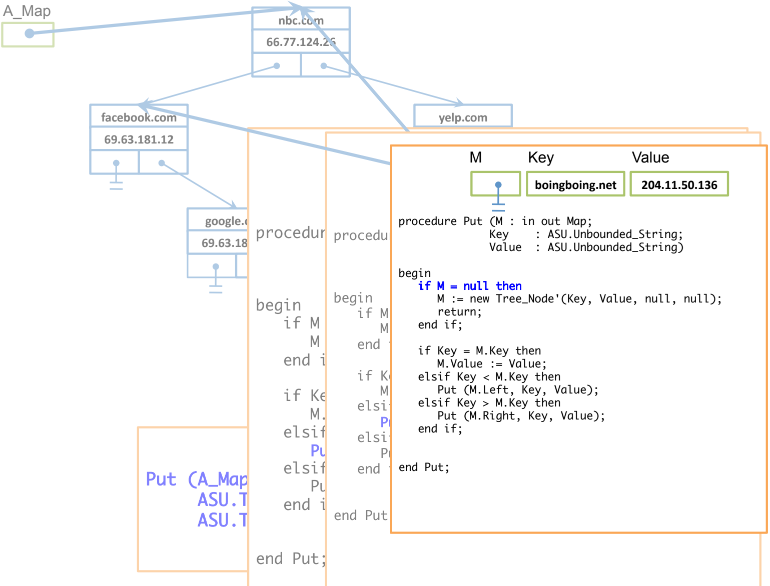
Ejemplo de ejecución: Put en un ABB



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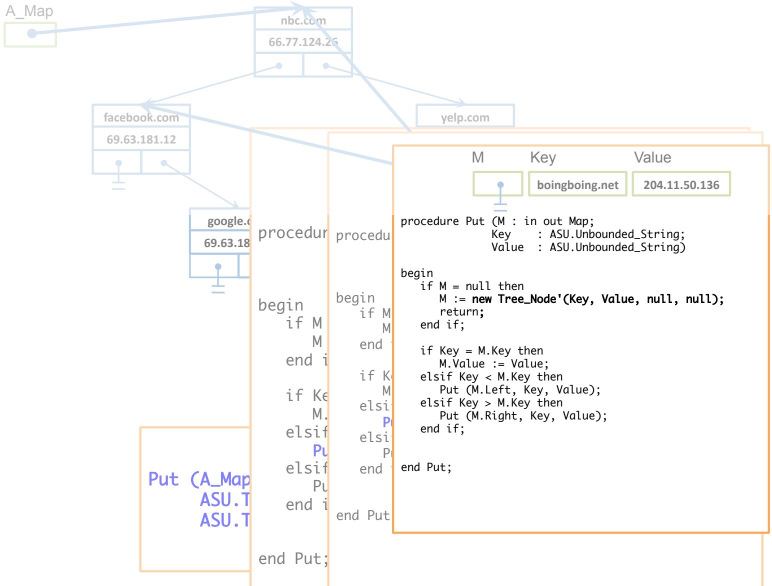
Ejemplo de ejecución: Put en un ABB



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procedure Put (M : in out Map;
               Key   : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String)

begin
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      M := new Tree_Node'(Key, Value, null, null);
      return;
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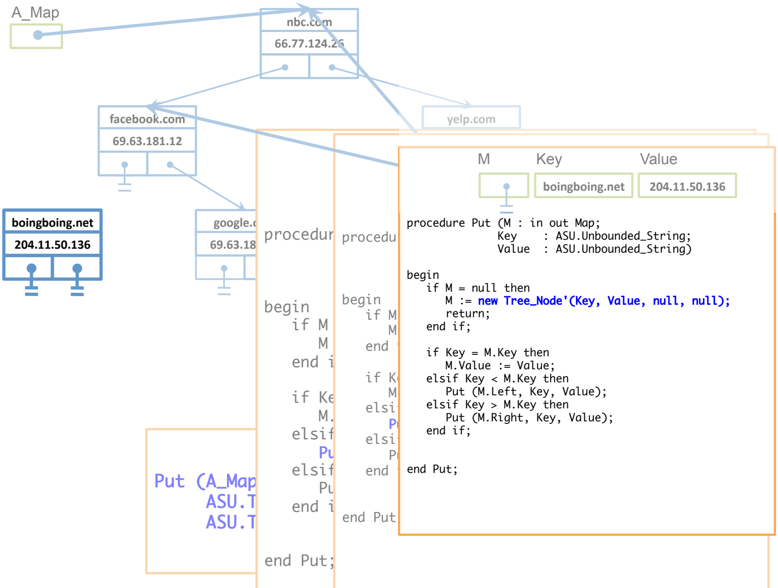
   end if;

end Put;
```

Ejemplo de ejecución: Put en un ABB



```
procedure Put (M : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String)

begin
   if M = null then
      M := new Tree_Node'(Key, Value, null, null);
      return;
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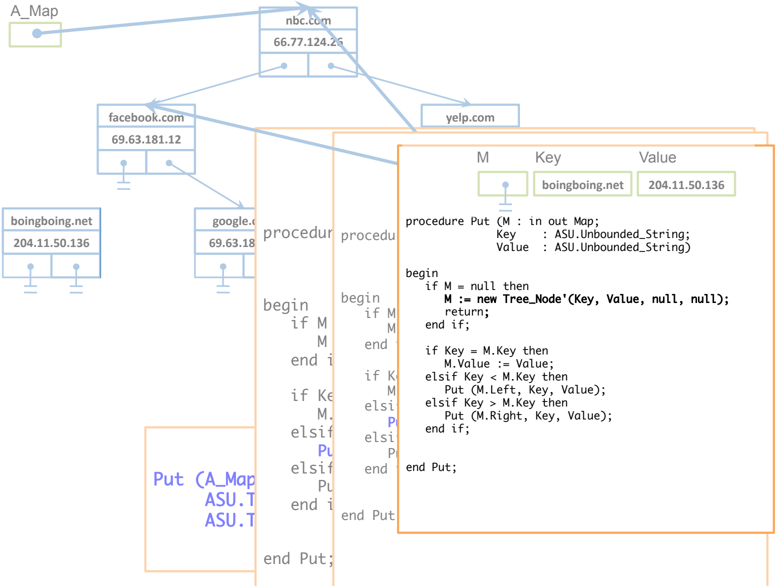
   elsif Key > M.Key then
      Put (M.Right, Key, Value);
   end if;


end Put;
```



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procedure Put (M : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String)

begin
   if M = null then
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      return;
   end if;

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      M.Value := Value;
   elsif Key < M.Key then
      Put (M.Left, Key, Value);
   elsif Key > M.Key then
      Put (M.Right, Key, Value);
   end if;

end Put;
```
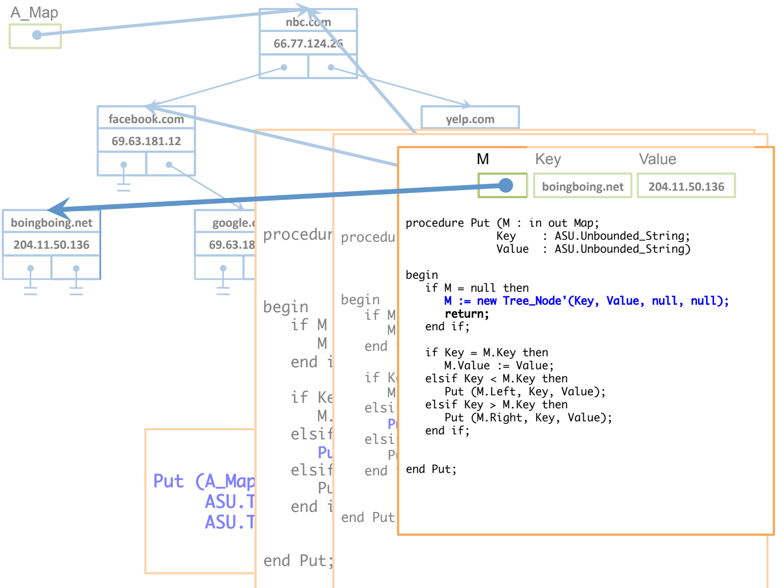
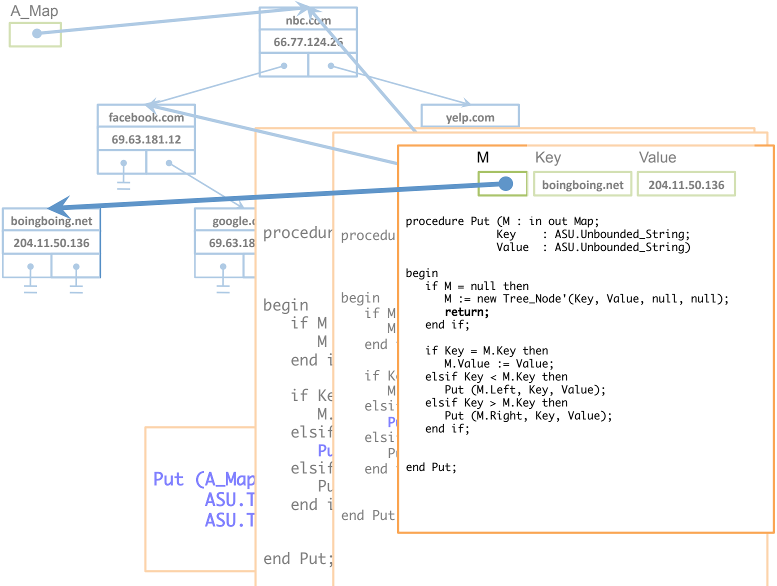
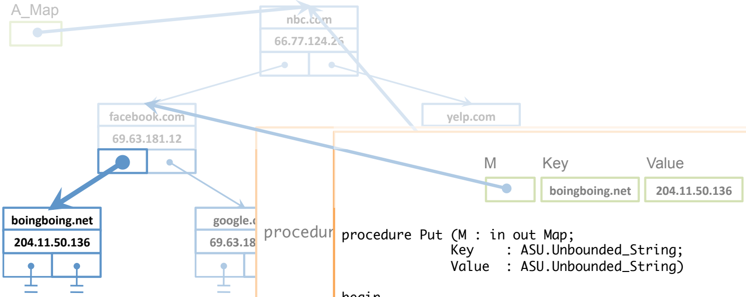

Ejemplo de ejecución: Put en un ABB



```
procedure Put (M : in out Map;
               Key     : ASU.Unbounded_String;
               Value   : ASU.Unbounded_String)

begin
   if M = null then
      M := new Tree_Node'(Key, Value, null, null);
      return;
   end if;

   if Key = M.Key then
      M.Value := Value;
   elsif Key < M.Key then
      Put (M.Left, Key, Value);
   elsif Key > M.Key then
      Put (M.Right, Key, Value);
   end if;

end Put;
```



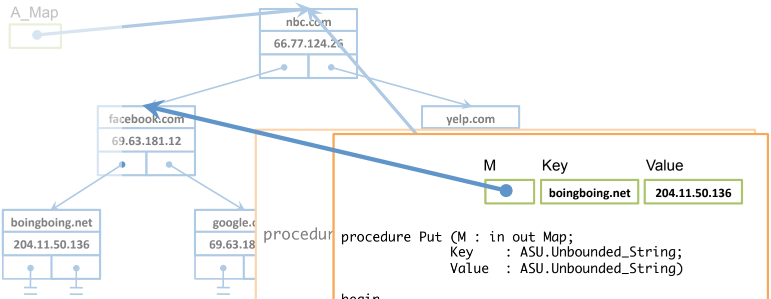
```
procedure Put (M : in out Map;
               Key   : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String)

begin
   if M = null then
      M := new Tree_Node'(Key, Value, null, null);
      return;
   end if;

   if Key = M.Key then
      M.Value := Value;
   elsif Key < M.Key then
      Put (M.Left, Key, Value);
   elsif Key > M.Key then
      Put (M.Right, Key, Value);
   end if;

end Put;
```



```
procedur

begin
   if M
      M
   end i

   if Ke
      M.
   elsif
      Pu
   elsif
      Pu
   end i

end Put;
```

```
Put (A_Map
     ASU.T
     ASU.T
```

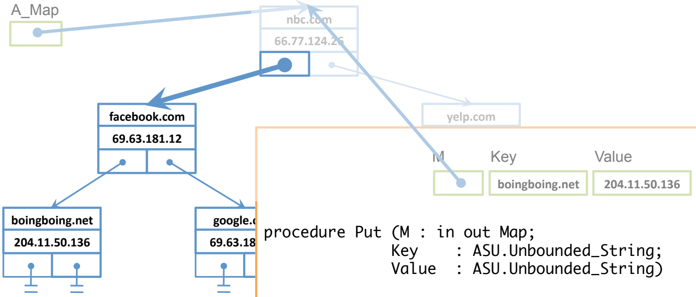
```
procedure Put (M : in out Map;
               Key     : ASU.Unbounded_String;
               Value   : ASU.Unbounded_String)

begin
   if M = null then
      M := new Tree_Node'(Key, Value, null, null);
      return;
   end if;

   if Key = M.Key then
      M.Value := Value;
   elsif Key < M.Key then
      Put (M.Left, Key, Value);
   elsif Key > M.Key then
      Put (M.Right, Key, Value);
   end if;


end Put;
```



```
Put (A_Map
     ASU.T
     ASU.T
```

```
procedur


begin
   if M
      M
   end i

   if Ke
      M.
   elsif
      Pu
   elsif
      Pu
   end i


end Put;
```

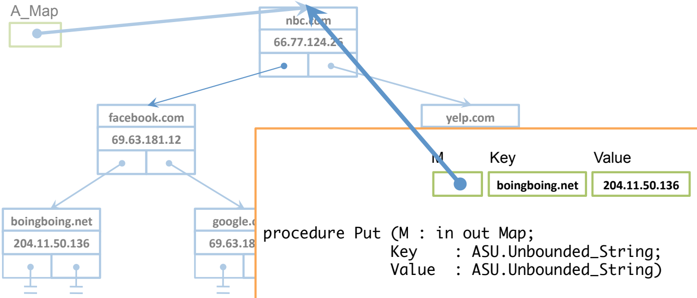
```
procedure Put (M : in out Map;
               Key     : ASU.Unbounded_String;
               Value   : ASU.Unbounded_String)

begin
   if M = null then
      M := new Tree_Node'(Key, Value, null, null);
      return;
   end if;

   if Key = M.Key then
      M.Value := Value;
   elsif Key < M.Key then
      Put (M.Left, Key, Value);
   elsif Key > M.Key then
      Put (M.Right, Key, Value);
   end if;


end Put;
```



```
procedure Put (M : in out Map;
               Key   : ASU.Unbounded_String;
               Value : ASU.Unbounded_String)

begin
   if M = null then
      M := new Tree_Node'(Key, Value, null, null);
      return;
   end if;

   if Key = M.Key then
      M.Value := Value;
   elsif Key < M.Key then
      Put (M.Left, Key, Value);
   elsif Key > M.Key then
      Put (M.Right, Key, Value);
   end if;


end Put;
```

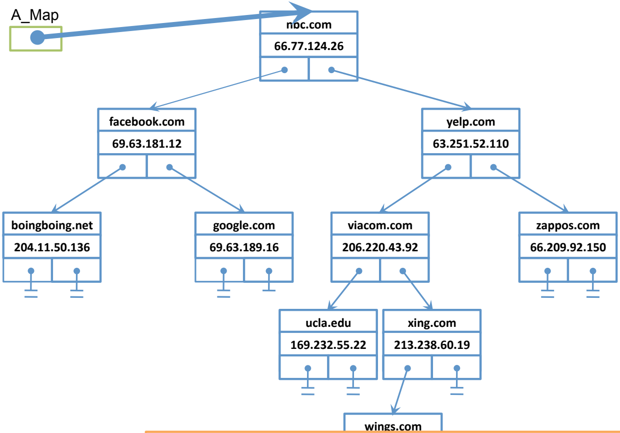
```
Put (A_Map
     ASU.T
     ASU.T
```

Ejemplo de ejecución: Put en un ABB



```
procedure Put (M : in out Map;
               Key    : ASU.Unbounded_String;
               Value  : ASU.Unbounded_String)

begin
   if M = null then
      M := new Tree_Node'(Key, Value, null, null);
      return;
   end if;

   if Key = M.Key then
      M.Value := Value;
   elsif Key < M.Key then
      Put (M.Left, Key, Value);
   elsif Key > M.Key then
      Put (M.Right, Key, Value);
   end if;


end Put;
```

```
Put (A_Map
     ASU.T
     ASU.T
```



```
Put (A_Map,
     ASU.To_Unbounded_String (“boingboing.net”),
     ASU.To_Unbounded_String (“204.11.50.136”));
```

Contenidos

1. Tablas de Símbolos
2. Implementación de TS mediante un array no ordenado
3. Implementación de TS mediante una lista enlazada no ordenada
4. Ejemplo de ejecución (TS mediante lista enlazada no ordenada)
5. Iteración sobre todos los elementos de una colección
6. Implementación de TS mediante un Array ordenado
7. Implementación de TS mediante una lista enlazada ordenada
8. Implementación de TS mediante un árbol de búsqueda binaria (ABB)
9. Ejemplo de ejecución: Get en un ABB
10. Ejemplo de ejecución: Put en un ABB vacío
11. Ejemplo de ejecución: Put en un ABB
12. Borrado de un nodo en un ABB

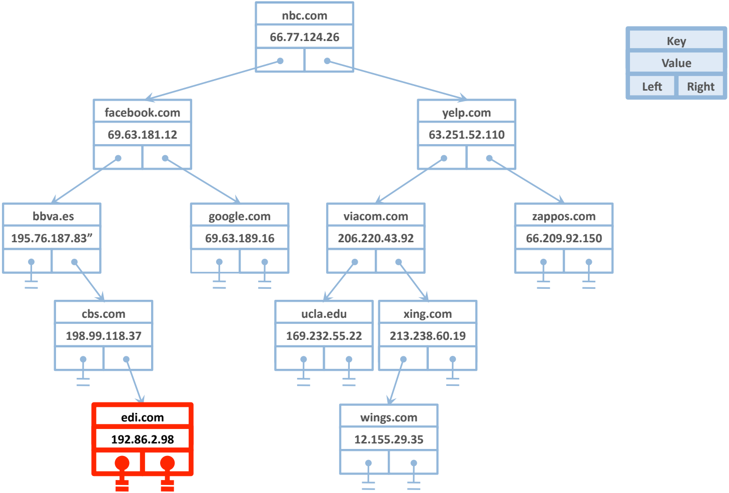
Borrado de un nodo

También requiere buscar el nodo a borrar, pero una vez localizado el nodo a borrar surgen varios casos:

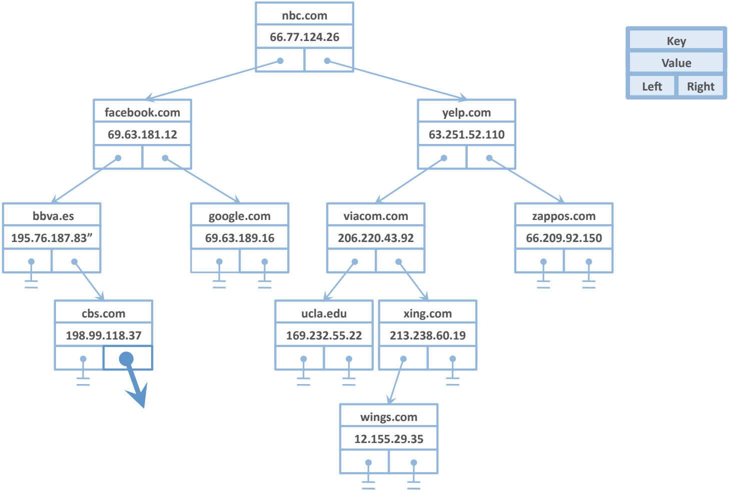
1. Borrado de un nodo que no tiene hijos
2. Borrado de un nodo que sólo tiene un subárbol hijo
3. Borrado de un nodo con dos subárboles hijos

1. Borrado de un nodo *j* que no tiene hijos

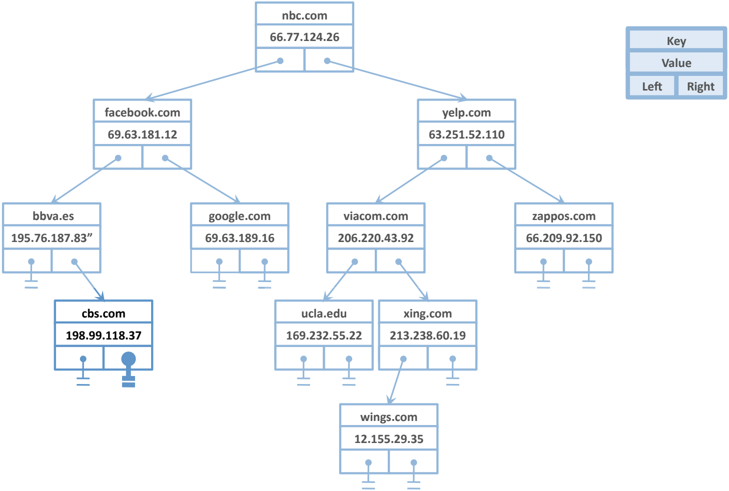
Se asigna null al campo (*Left* o *Right*) que apunta a *j* en el nodo padre de *j*



```
Delete (A_Map, ASU.To_Unbounded_String (“edi.com”), Success);
```



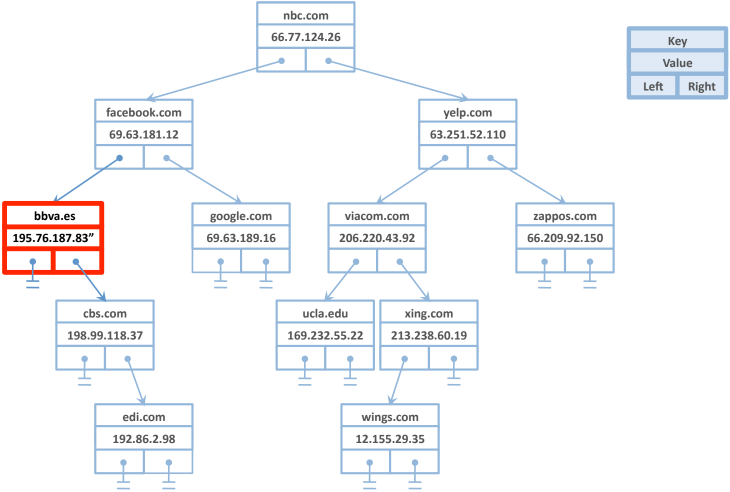
```
Delete (A_Map, ASU.To_Unbounded_String (“edi.com”), Success);
```



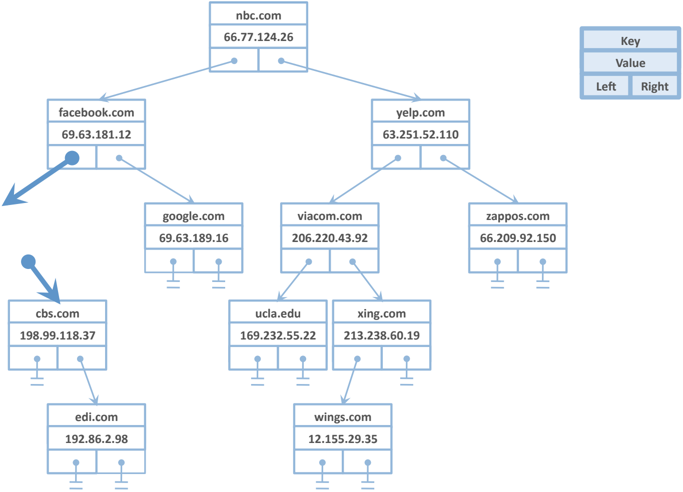
```
Delete (A_Map, ASU.To_Unbounded_String (“edi.com”), Success);
```

2. Borrado de un nodo *j* que sólo tiene un subárbol hijo

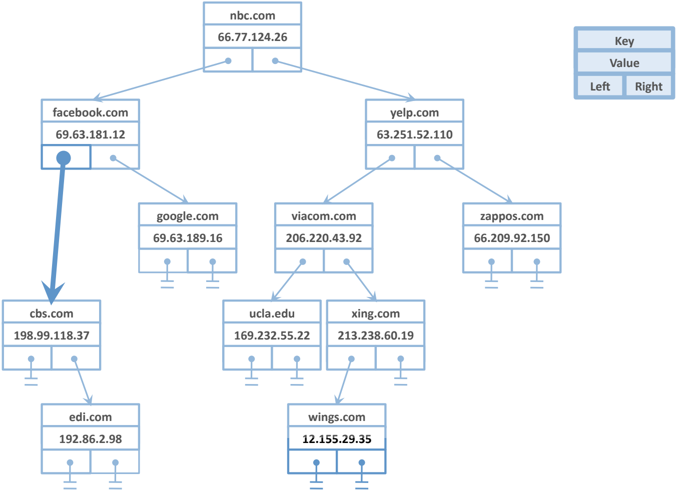
- Si *j* sólo tiene un subárbol derecho, se asigna *j.Right* al campo (*Left* o *Right*) que apunta a *j* en el nodo padre de *j*
- Si *j* sólo tiene un subárbol izquierdo, se asigna *j.Left* al campo (*Left* o *Right*) que apunta a *j* en el nodo padre de *j*



```
Delete (A_Map, ASU.To_Unbounded_String (“bbva.es”), Success);
```



```
Delete (A_Map, ASU.To_Unbounded_String (“bbva.es”), Success);
```

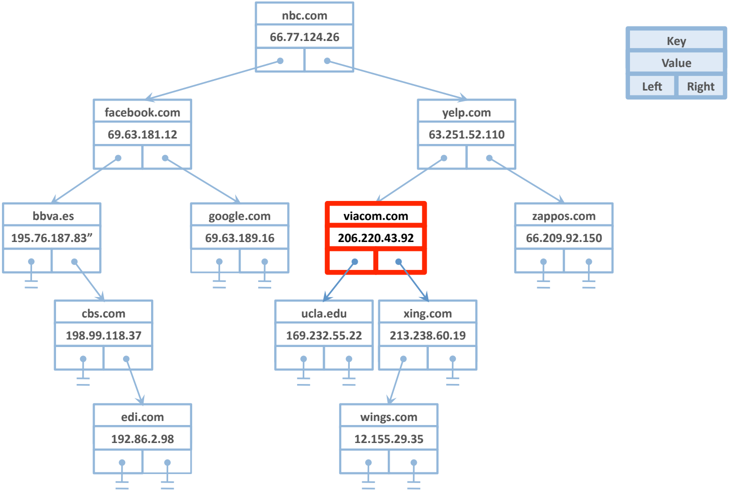


```
Delete (A_Map, ASU.To_Unbounded_String (“bbva.es”), Success);
```

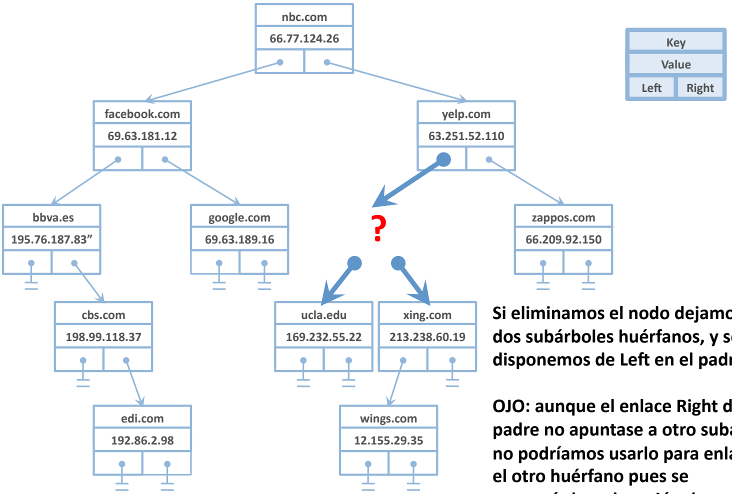
3. Borrado de un nodo *j* con dos subárboles hijos

Problema:

Hay un sólo enlace apuntando al nodo *j* que se borra en su nodo padre, pero *j* apunta a dos subárboles hijos.



```
Delete (A_Map, ASU.To_Unbounded_String (“viacom.com”), Success);
```



Si eliminamos el nodo dejamos dos subárboles huérfanos, y sólo disponemos de Left en el padre.

OJO: aunque el enlace Right del padre no apuntase a otro subárbol no podríamos usarlo para enlazar el otro huérfano pues se rompería la ordenación de nodos

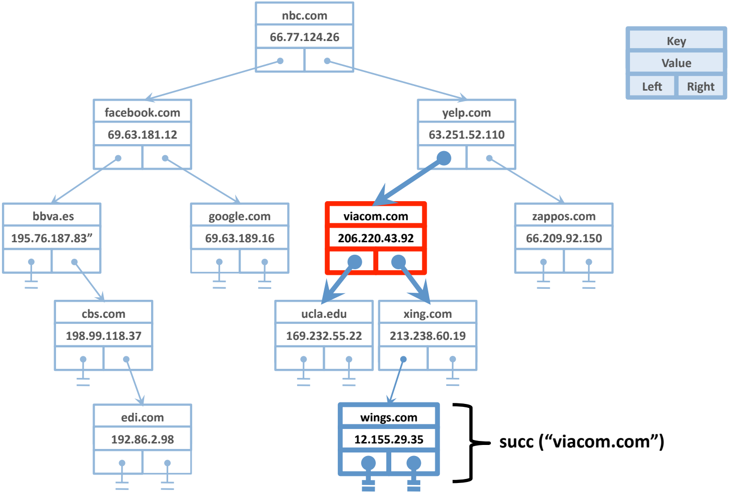
```
Delete (A_Map, ASU.To_Unbounded_String (“viacom.com”), Success);
```

3. Borrado de un nodo j con dos subárboles hijos

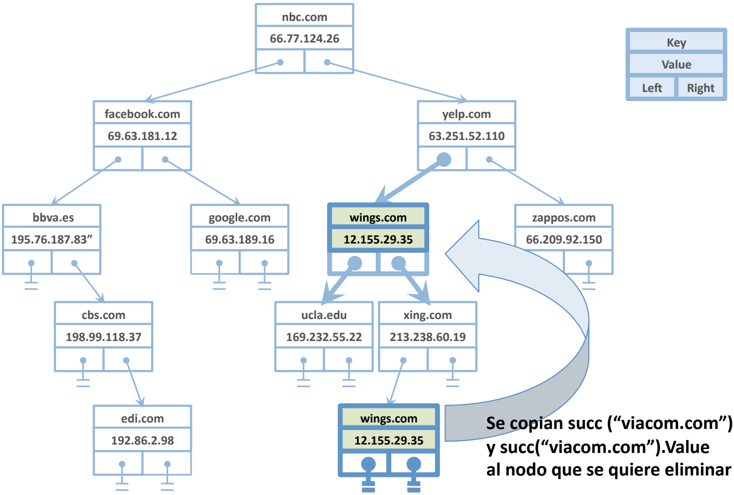
Solución: sustituir el nodo j que se quiere borrar por su sucesor y borrar el sucesor

1. Se sustituye $j.(Key, Value)$ por $succ(j).(Key, Value)$, siendo $succ(j)$ el nodo cuya clave sucede a la de j en el árbol:
   - $j.Key < succ(j).Key$ y
   - no existe un nodo m tal que $j.Key < m.Key < succ(j).Key$
2. Se borra $succ(j)$
   - El nodo $succ(j)$ no puede tener subárbol izquierdo, como mucho sólo tendrá derecho. Si tuviera un subárbol izquierdo no sería el succ(j).

De esta forma se preserva el orden entre los nodos

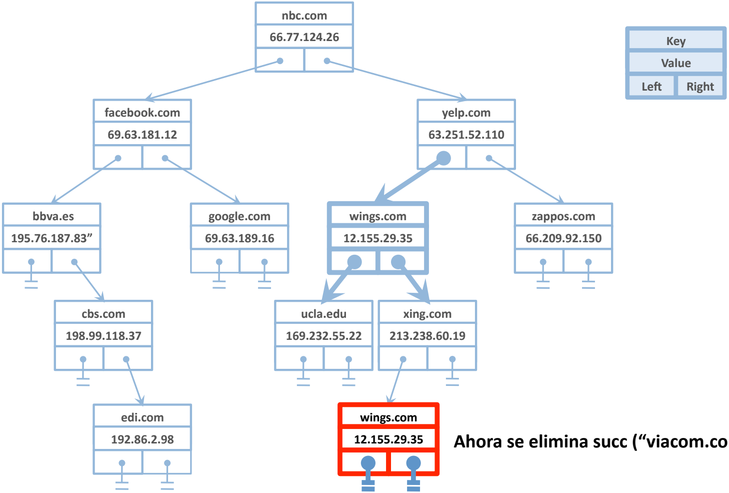


```
Delete (A_Map, ASU.To_Unbounded_String (“viacom.com”), Success);
```



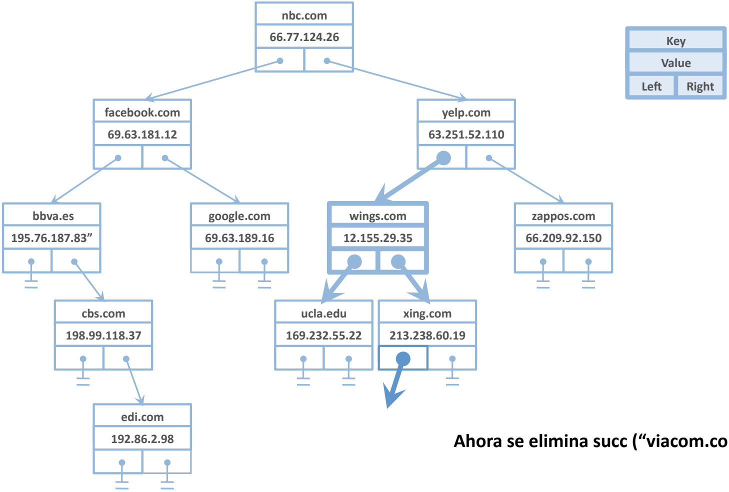
Se copian succ (“viacom.com”).Key
y succ(“viacom.com”).Value
al nodo que se quiere eliminar

```
Delete (A_Map, ASU.To_Unbounded_String (“viacom.com”), Success);
```



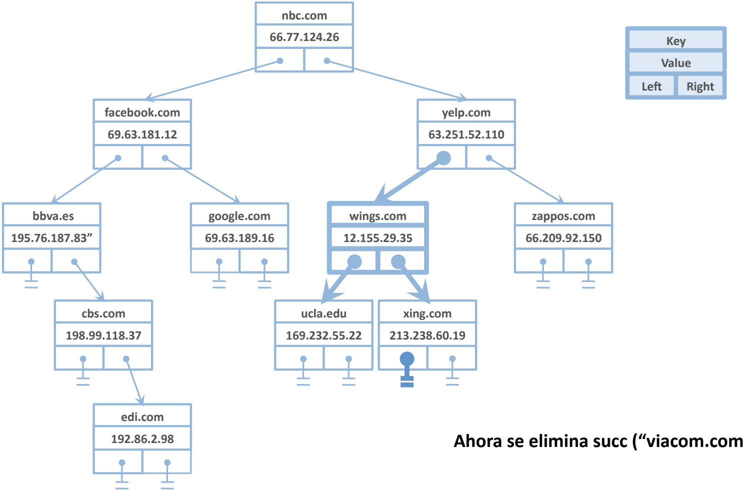
Ahora se elimina succ (“viacom.com”)

```
Delete (A_Map, ASU.To_Unbounded_String (“viacom.com”), Success);
```



Ahora se elimina succ (“viacom.com”)

```
Delete (A_Map, ASU.To_Unbounded_String (“viacom.com”), Success);
```



Ahora se elimina succ (“viacom.com”)

```
Delete (A_Map, ASU.To_Unbounded_String (“viacom.com”), Success);
```

3. Borrado de un nodo j con dos subárboles hijos

¿Cómo programamos succ(j)?

- $succ(j) = min(j.Right)$
  - $succ(j)$ es el nodo mínimo del subárbol derecho de j: el que tiene la menor clave
  - Para encontrar el nódo mínimo de un árbol se recorre recursivamente desde la raíz el árbol a través de los hijos izquierdos hasta encontrar un nodo que no tenga hijo izquierdo.

Borrado del nodo mínimo de un árbol

- El nodo mínimo de un árbol no tiene hijo izquierdo, por lo que ya sabemos cómo borrarlo

3. Borrado de un nodo *j* con dos subárboles hijos: Programación

```
package Maps is
   package ASU renames Ada.Strings.Unbounded;

   type Map is limited private;

   ...

   procedure Delete (M       : in out Map;
                     Key     : in  Asu.Unbounded_String;
                     Success : out Boolean);

private
   ...
end Maps;
```

3. Borrado de un nodo *j* con dos subárboles hijos: Programación

```
package body Maps is

   ...
   function Delete_Min (M : Map)  return Map  is
   begin
      ...
   end Delete_Min;


   procedure Delete (M       : in out Map;
                     Key     : in  Asu.Unbounded_String;
                     Success : out Boolean) is
   begin
      ...
   end Delete;

end Maps;
```

Resumen

Tabla de Símbolos

- La tabla de símbolos es una estructura de datos que almacena elementos compuestos por parejas (`Clave`, `Valor`)
- `Clave` y `Valor` pueden ser tipos de datos cualesquiera
- Tiene tres operaciones básicas:
  - `Put`: Dado un nuevo elemento (`Clave, Valor`) como parámetro, se añade éste a la tabla. Si ya existía un elemento con la misma `Clave`, se sustituye su `Valor` asociado por el especificado en la llamada a `Put`
  - `Get`: Dada una `Clave` como parámetro, devuelve el `Valor` asociado a la misma en la tabla en caso de que exista un elemento (`Clave`, `Valor`)
  - `Delete`: Dada un `Clave` como parámetro, se borra de la tabla, si existe, el elemento (`Clave`, `Valor`)

Implementaciones de una tabla de símbolos

- Mediante un Array no ordenado
- Mediante una Lista enlazada no ordenada
- Mediante un Array ordenado con búsqueda binaria
- Mediante una Lista enlazada ordenada
- Mediante un Árbol de búsqueda binaria