ESTRUCTURAS DE DATOS

TIPOS ABSTRACTOS DE DATOS LINEALES

Listas doblemente enlazadas (2)

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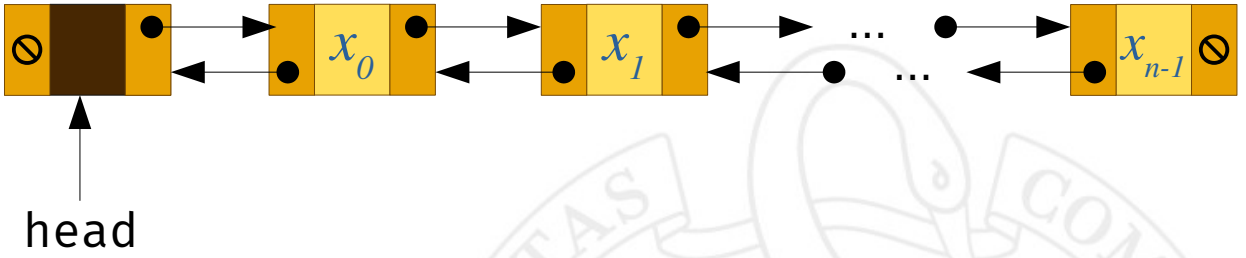
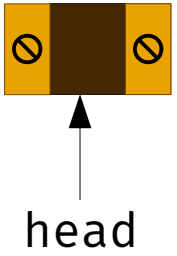
Listas doblemente enlazadas

$[\ x_0, x_1, \ldots, x_{n-1}\ ]$



$[\ ]$



Mejorando algunas operaciones

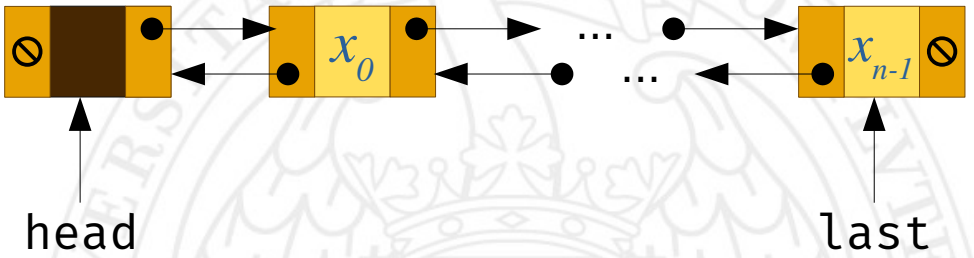
- Las siguientes operaciones requieren situarnos en el último nodo de la lista:
  - `push_back()`
  - `pop_back()`
  - `back()`
- Esto hace que tengan coste lineal, ya que requiere navegar a lo largo de toda la cadena, partiendo del nodo cabeza.
- ¿Podemos mejorar esto?

Añadiendo un nuevo atributo

```
class ListLinkedDouble {
public:
  ListLinkedDouble();
  ListLinkedDouble(const ListLinkedDouble &other);
  ~ListLinkedDouble();

  void push_front(const std::string &elem);
  void push_back(const std::string &elem);
  void pop_front();
  void pop_back();
  int size() const;
  bool empty() const;
  const std::string & front() const;
  std::string & front();
  const std::string & back() const;
  std::string & back();
  const std::string & at(int index) const;
  std::string & at(int index);
  void display() const;
private:
   ...
  Node *head, *last;
};
```

Nuevo atributo

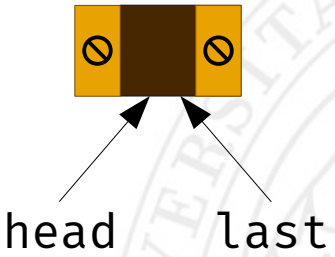


Añadiendo un nuevo atributo

- **Ventajas:**
  - La operación privada `last_node()` pasa a tener coste constante, ya que se limita a devolver el atributo `last`.
  - De hecho, podemos eliminar la función `last_node()`.
- **Desventajas:**
  - Tenemos que actualizar el atributo `last` cada vez que añadamos un nodo.

Creación de una cadena de nodos

```
ListLinkedDouble() {
  head = new Node;
  head→next = nullptr;
  head→prev = nullptr;
  last = head;
}
```

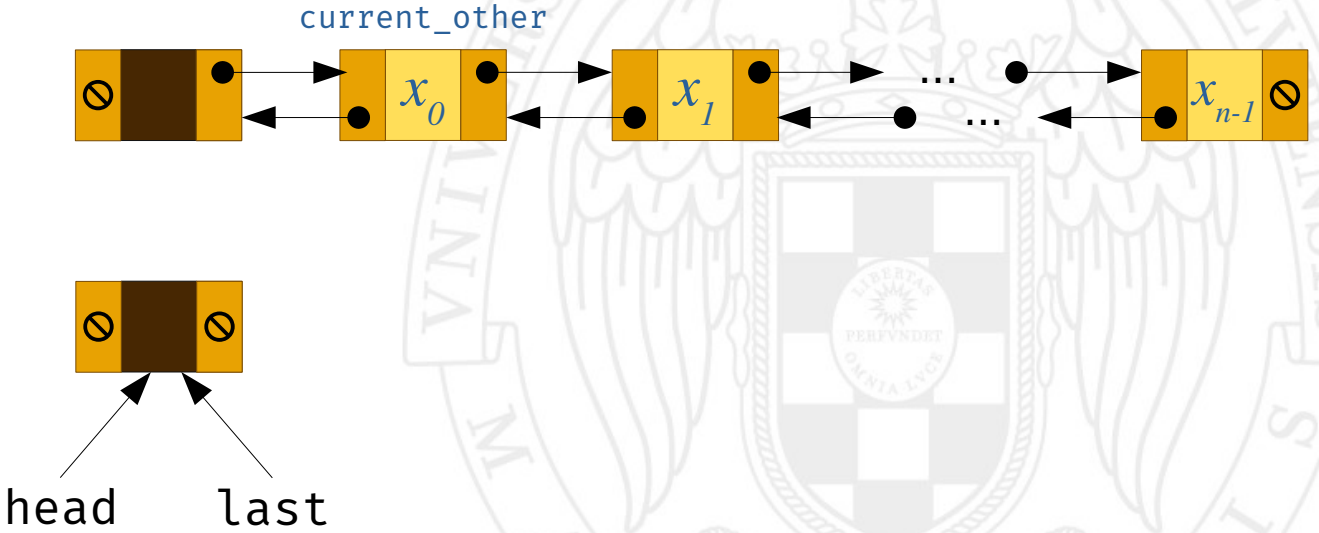


Copia de una cadena de nodos

```
ListLinkedDouble(const ListLinkedDouble &other): ListLinkedDouble() {
  Node *current_other = other.head→next;

  while (current_other ≠ nullptr) {
    Node *new_node = new Node { current_other→value, nullptr, last };
    last→next = new_node;

    last = new_node;
    current_other = current_other→next;
  }
}
```



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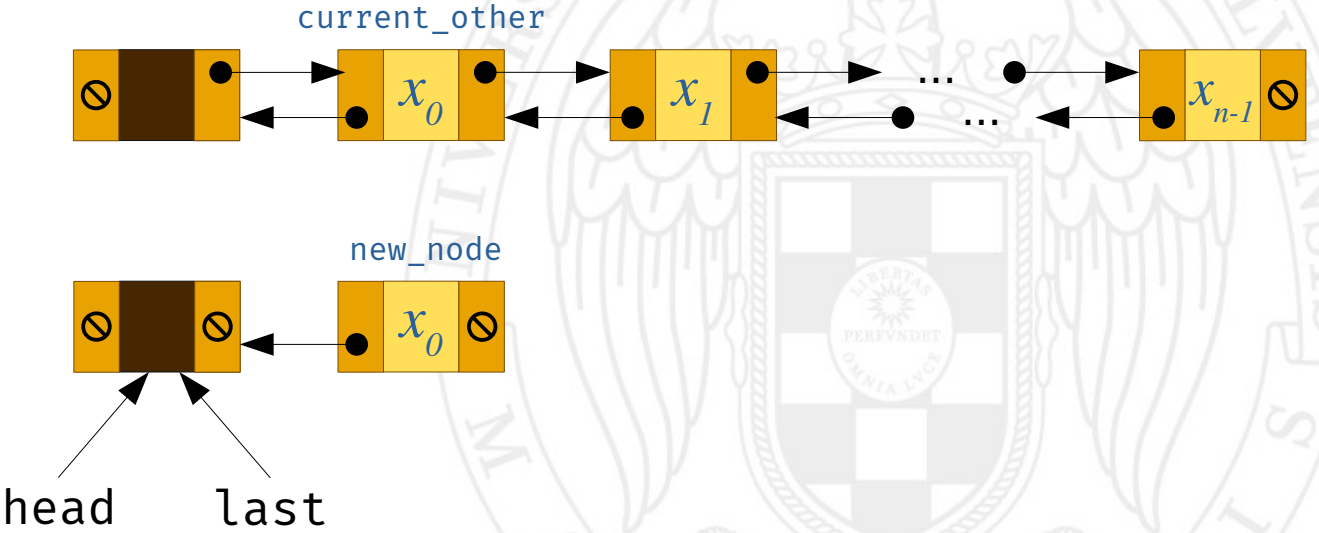
  Node *current_other = other.head→next;

  while (current_other ≠ nullptr) {
    Node *new_node = new Node { current_other→value, nullptr, last };
    last→next = new_node;
    last = new_node;
    current_other = current_other→next;
  }
}
```



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  Node *current_other = other.head→next;

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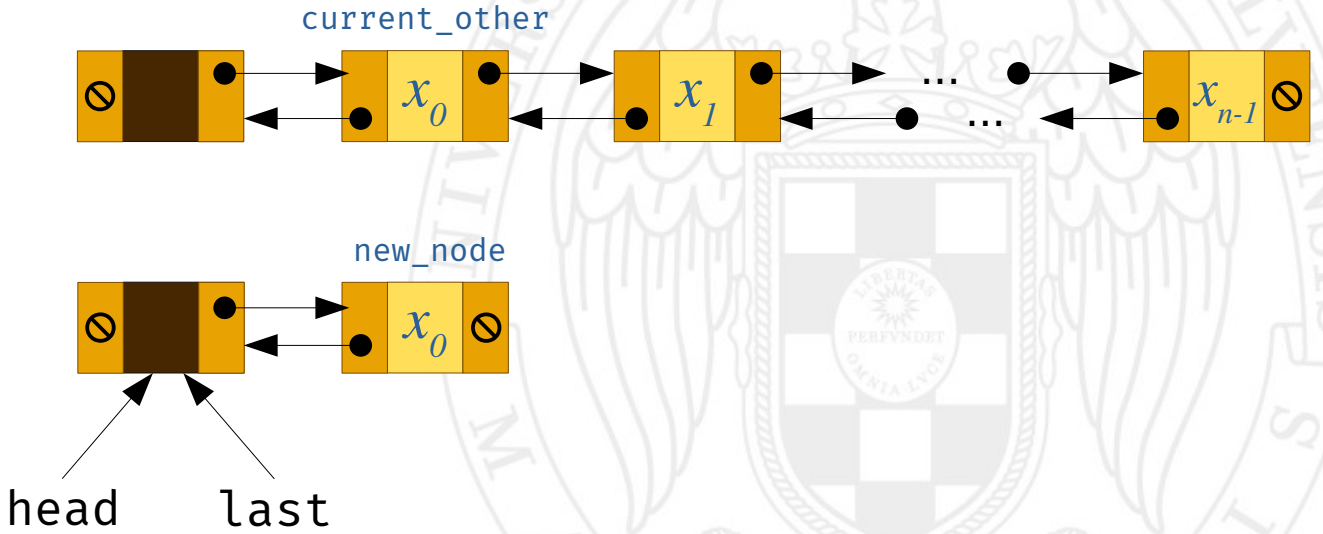
    Node *new_node = new Node { current_other→value, nullptr, last };
    last→next = new_node;
    last = new_node;
    current_other = current_other→next;
  }
}
```



Copia de una cadena de nodos

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  Node *current_other = other.head→next;

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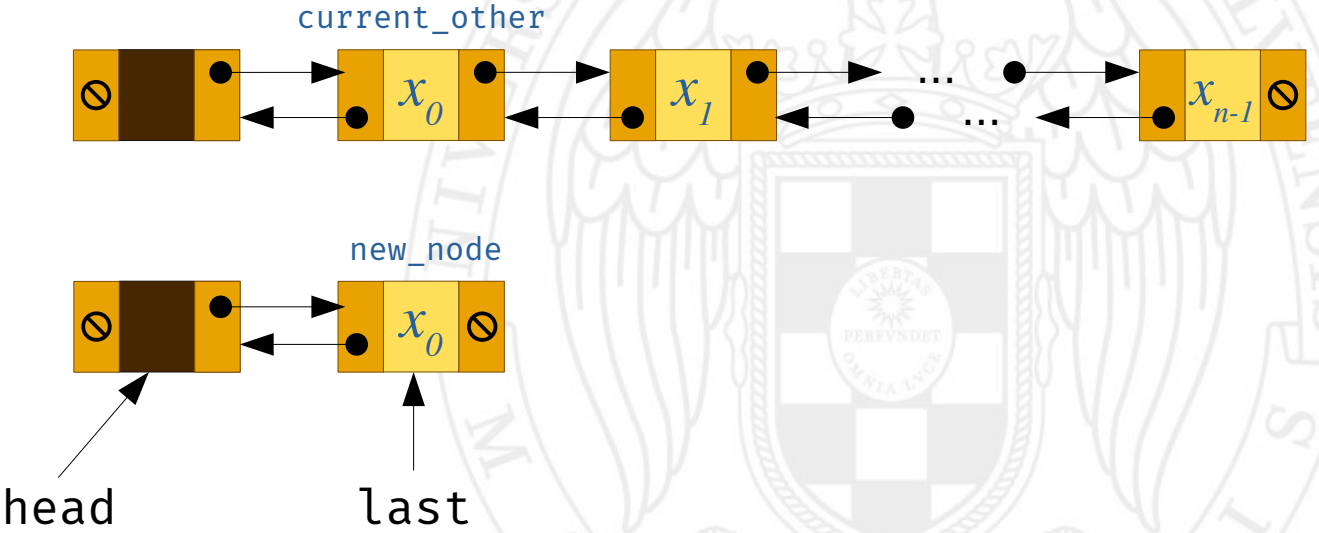
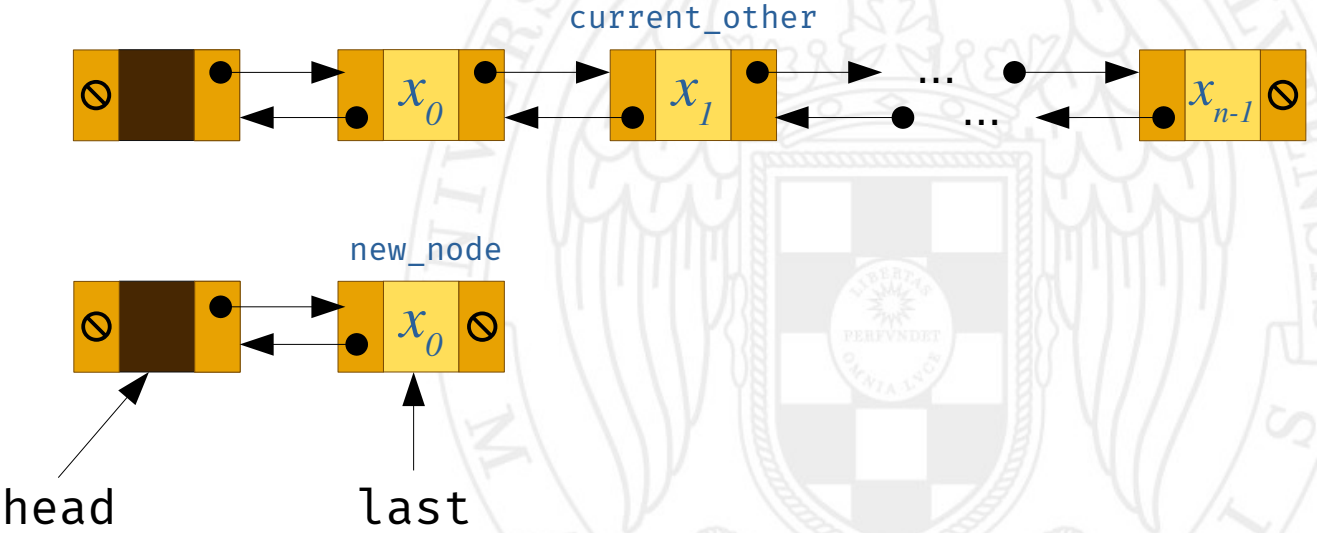
    Node *new_node = new Node { current_other→value, nullptr, last };
    last→next = new_node;
    last = new_node;
    current_other = current_other→next;
  }
}
```



Copia de una cadena de nodos

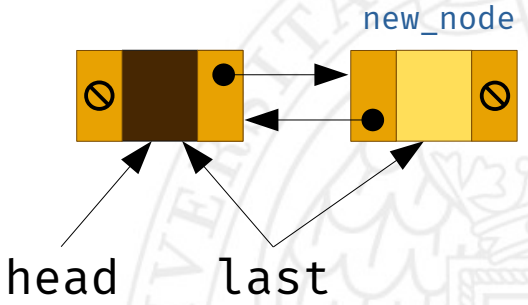
```
ListLinkedDouble(const ListLinkedDouble &other): ListLinkedDouble() {
  Node *current_other = other.head→next;

  while (current_other ≠ nullptr) {
    Node *new_node = new Node { current_other→value, nullptr, last };
    last→next = new_node;
    last = new_node;
    current_other = current_other→next;
  }
}
```



Añadir al principio de la lista

```
void push_front(const std::string &elem) {
  Node *new_node = new Node { elem, head→next, head };
  if (head→next ≠ nullptr) {
    head→next→prev = new_node;
  }
  head→next = new_node;
  if (last == head) {
    last = new_node;
  }
}
```

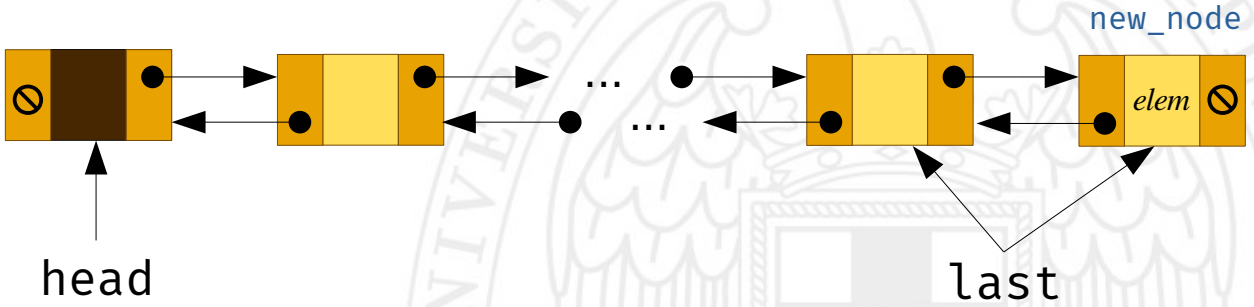


Eliminar al principio de la lista

```
void pop_front() {
  assert (head→next ≠ nullptr);
  Node *target = head→next;
  head→next = target→next;
  if (target→next ≠ nullptr) {
    target→next→prev = head;
  }
  if (last == target) {
    last = head;
  }
  delete target;
}
```

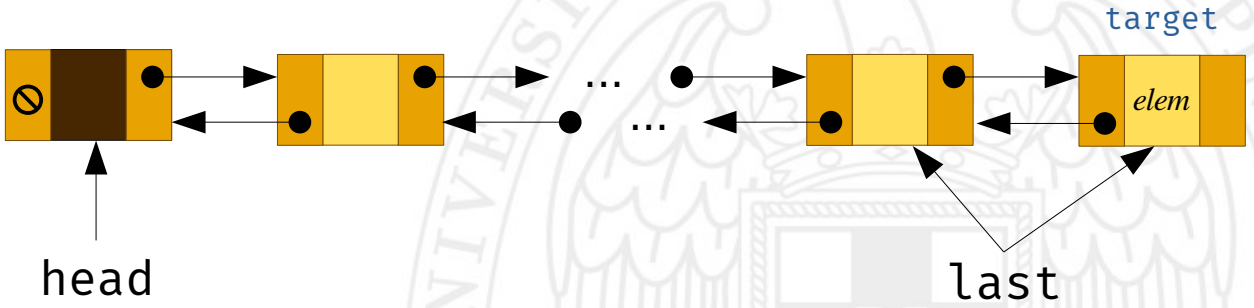
Añadir al final de la lista

```
void push_back(const std::string &elem) {
  Node *new_node = new Node { elem, nullptr, last };
  last→next = new_node;
  last = new_node;
}
```



Eliminar del final de la lista

```
void pop_back() {
  assert (head→next ≠ nullptr);
  Node *target = last;
  target→prev→next = nullptr;
  last = target→prev;
  delete target;
}
```



¿Mejoras en el coste?

Operación	Listas enlazadas simples	Listas doblemente enlazadas
Creación	$O(1)$	$O(1)$
Copia	$O(n)$	$O(n)$
`push_back`	$O(n)$	$O(1)$
`push_front`	$O(1)$	$O(1)$
`pop_back`	$O(n)$	$O(1)$
`pop_front`	$O(1)$	$O(1)$
`back`	$O(n)$	$O(1)$
`front`	$O(1)$	$O(1)$
`display`	$O(n)$	$O(n)$
`at(index)`	$O(index)$	$O(index)$
`size`	$O(n)$	$O(n)$
`empty`	$O(1)$	$O(1)$

n = *número de elementos de la lista de entrada*

¿Podemos mejorar `size()`?

- Sí. Para ello añadimos un nuevo atributo num_elems a la clase que mantenga el número de elementos en la lista.
- La función `size()` devuelve el valor de este atributo.
- Actualizamos este elemento al añadir/quitar elementos de la lista.

```
class ListLinkedDouble {
public:
   ...
   int size() const { return num_elems; }
private:
   ...
   Node *head, *last;
   int num_elems;
};
```