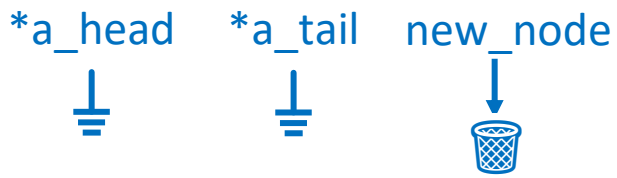
# Appending to a linear linked list with the `append(…)` function.



**Step 1. `main(…)` calls `append(3, &head, &tail)`. The variables `head` and `tail` (in `main(…)`) are `NULL` because the list is empty.**

```
1  void append(int value, struct Node** a_head, struct Node** a_tail) {
2      // Assert:  If head is NULL then tail must be NULL
3      assert( (*a_tail == NULL) == (*a_head == NULL) );
4      ▶AS OF HERE◀
5      // Allocate memory on heap for new_node.
6      struct Node* new_node = malloc(sizeof(*new_node));
7
8      // Initialize all fields of new_node using compound initializer
9      *new_node = (struct Node) { .value=value, .next=NULL };
10
11     if(*a_tail == NULL) {              // If list is empty…
12         *a_head = new_node;            //     Set head to new_node
13     }
14     else {                             // If list is not empty…
15         (*a_tail) -> next = new_node; //     Connect tail to new_node
16     }
17     *a_tail = new_node;                // Set the tail to new_node.
18 }
```




**Stack**

| addr | type* | name* | value | part | fn |
|---|---|---|---|---|---|
| 200 | int | argc | 1 | args | main(…) |
| 204 | char** | argv | → {"./foo"} | | |
| 212 | void* | | | ret addr | |
| 220 | struct Node* | head | NULL | locals | |
| 228 | struct Node* | tail | NULL | | |
| 236 | struct Node** | a_head | 220 | args | append(…) |
| 244 | struct Node** | a_tail | 228 | | |
| 252 | int | value | 3 | | |
| 256 | void* | | | ret addr | |
| 264 | struct Node* | new_node | | locals | |

**Heap**

| addr | value | |
|---|---|---|
| 400 | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

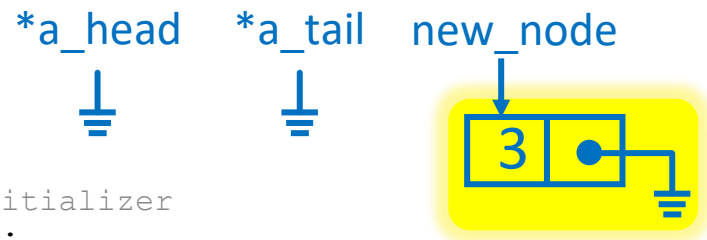
Types and names are not stored in memory or executable. Addresses shown are fictional. Assume `sizeof(int)==4`, `sizeof(char)==1`, `sizeof(void*)==8`.

# Appending to a linear linked list with the `append(…)` function.



**Step 2. The first node in the list is allocated (line 6) and initialized (line 9).**

```
1  void append(int value, struct Node** a_head, struct Node** a_tail) {
2      // Assert:  If head is NULL then tail must be NULL
3      assert( (*a_tail == NULL) == (*a_head == NULL) );
4
5      // Allocate memory on heap for new_node.
6      struct Node* new_node = malloc(sizeof(*new_node));
7
8      // Initialize all fields of new_node using compound initializer
9      *new_node = (struct Node) { .value=value, .next=NULL };
10     ▶AS OF HERE◀
11     if(*a_tail == NULL) {                // If list is empty…
12         *a_head = new_node;              //     Set head to new_node
13     }
14     else {                               // If list is not empty…
15         (*a_tail) -> next = new_node;    //     Connect tail to new_node
16     }
17     *a_tail = new_node;                  // Set the tail to new_node.
18 }
```




**Stack**

| addr | type* | name* | value | part | fn |
|---|---|---|---|---|---|
| 200 | int | argc | 1 | args | main(…) |
| 204 | char** | argv | → {"./foo"} | | |
| 212 | void* | | | ret addr | |
| 220 | struct Node* | head | NULL | locals | |
| 228 | struct Node* | tail | NULL | | |
| 236 | struct Node** | a_head | 220 | args | append(…) |
| 244 | struct Node** | a_tail | 228 | | |
| 252 | int | value | 3 | | |
| 256 | void* | | | ret addr | |
| 264 | struct Node* | new_node | 400 | locals | |

**Heap**

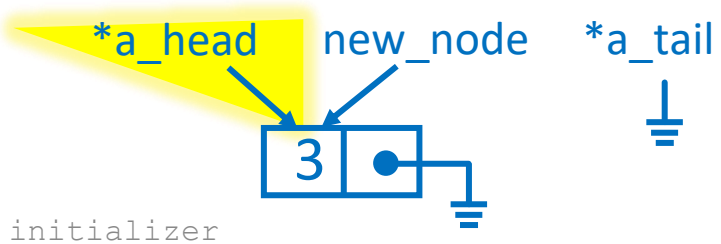
| addr | value |
|---|---|
| 400 | .value = 3 |
| | .next = NULL |
| 412 | |

Types and names are not stored in memory or executable. Addresses shown are fictional. Assume `sizeof(int)==4`, `sizeof(char)==1`, `sizeof(void*)==8`.

# Appending to a linear linked list with the `append(…)` function. 

**Step 3. Since the list is currently empty (`*a_tail == NULL`), the `head` (in `main(…)`'s stack frame) is initialized by way of `a_head`.**

```
1  void append(int value, struct Node** a_head, struct Node** a_tail) {
2      // Assert:  If head is NULL then tail must be NULL
3      assert( (*a_tail == NULL) == (*a_head == NULL) );
4
5      // Allocate memory on heap for new_node.
6      struct Node* new_node = malloc(sizeof(*new_node));
7
8      // Initialize all fields of new_node using compound initializer
9      *new_node = (struct Node) { .value=value, .next=NULL };
10
11     if(*a_tail == NULL) {                    // If list is empty…
12         *a_head = new_node; ▶AS OF HERE◀     //     Set head to new_node
13     }
14     else {                                   // If list is not empty…
15         (*a_tail) -> next = new_node;        //     Connect tail to new_node
16     }
17     *a_tail = new_node;                      // Set the tail to new_node.
18 }
```




**Stack**

| addr | type* | name* | value | part | fn |
|---|---|---|---|---|---|
| 200 | int | argc | 1 | args | main(…) |
| 204 | char** | argv | → {"./foo"} | | |
| 212 | void* | | | ret addr | |
| 220 | struct Node* | head | ~~NULL~~ 400 | locals | |
| 228 | struct Node* | tail | NULL | | |
| 236 | struct Node** | a_head | 220 | args | append(…) |
| 244 | struct Node** | a_tail | 228 | | |
| 252 | int | value | 3 | | |
| 256 | void* | | | ret addr | |
| 264 | struct Node* | new_node | 400 | locals | |

**Heap**

| addr | value | 🔒 |
|---|---|---|
| 400 | .value = 3 | 🔒 |
| | .next = NULL | |
| 412 | | |

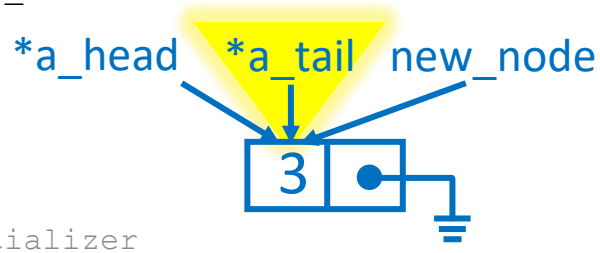
Types and names are not stored in memory or executable. Addresses shown are fictional. Assume `sizeof(int)==4`, `sizeof(char)==1`, `sizeof(void*)==8`.

# Appending to a linear linked list with the `append(…)` function.



**Step 4. The tail (in `main(…)`'s stack frame) is initialized by way of `a_tail`. The list now has size 1.**

```
1  void append(int value, struct Node** a_head, struct Node** a_tail) {
2      // Assert:  If head is NULL then tail must be NULL
3      assert( (*a_tail == NULL) == (*a_head == NULL) );
4
5      // Allocate memory on heap for new_node.
6      struct Node* new_node = malloc(sizeof(*new_node));
7
8      // Initialize all fields of new_node using compound initializer
9      *new_node = (struct Node) { .value=value, .next=NULL };
10
11     if(*a_tail == NULL) {                  // If list is empty…
12         *a_head = new_node;                //     Set head to new_node
13     }
14     else {                                 // If list is not empty…
15         (*a_tail) -> next = new_node;      //     Connect tail to new_node
16     }
17     *a_tail = new_node;  ▶AS OF HERE◀      // Set the tail to new_node.
18 }
```




**Stack**

| addr | type* | name* | value | part | fn |
|---|---|---|---|---|---|
| 200 | int | argc | 1 | args | main(…) |
| 204 | char** | argv | → {"./foo"} | | |
| 212 | void* | | | ret addr | |
| 220 | struct Node* | head | ~~NULL~~ 400 | locals | |
| 228 | struct Node* | tail | ~~NULL~~ 400 | | |
| 236 | struct Node** | a_head | 220 | args | append(…) |
| 244 | struct Node** | a_tail | 228 | | |
| 252 | int | value | 3 | | |
| 256 | void* | | | ret addr | |
| 264 | struct Node* | new_node | 400 | locals | |

**Heap**

| addr | value | 🔒 |
|---|---|---|
| 400 | .value = 3 | 🔒 |
| | .next = NULL | |
| 412 | | |

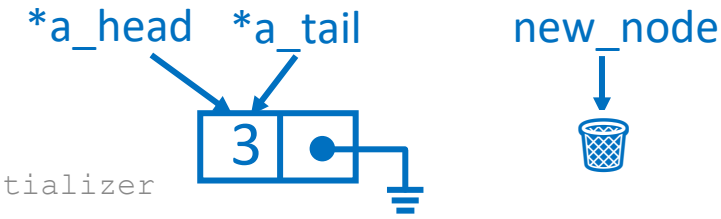
Types and names are not stored in memory or executable. Addresses shown are fictional. Assume `sizeof(int)==4`, `sizeof(char)==1`, `sizeof(void*)==8`.

# Appending to a linear linked list with the `append(…)` function.



**Step 5. `main(…)` calls `append(4, &head, &tail)`. The variables `head` and `tail` (in `main(…)`) both refer to the one and only node in the list.**

```
1  void append(int value, struct Node** a_head, struct Node** a_tail) {
2      // Assert:  If head is NULL then tail must be NULL
3      assert( (*a_tail == NULL) == (*a_head == NULL) );
4      ▶AS OF HERE◀
5      // Allocate memory on heap for new_node.
6      struct Node* new_node = malloc(sizeof(*new_node));
7
8      // Initialize all fields of new_node using compound initializer
9      *new_node = (struct Node) { .value=value, .next=NULL };
10
11     if(*a_tail == NULL) {              // If list is empty…
12         *a_head = new_node;            //     Set head to new_node
13     }
14     else {                             // If list is not empty…
15         (*a_tail) -> next = new_node; //     Connect tail to new_node
16     }
17     *a_tail = new_node;                // Set the tail to new_node.
18 }
```




**Stack**

| addr | type* | name* | value | part | fn |
|---|---|---|---|---|---|
| 200 | int | argc | 1 | args | main(…) |
| 204 | char** | argv | → {"./foo"} | | |
| 212 | void* | | | ret addr | |
| 220 | struct Node* | head | NULL | locals | |
| 228 | struct Node* | tail | NULL | | |
| 236 | struct Node** | a_head | 220 | args | append(…) |
| 244 | struct Node** | a_tail | 228 | | |
| 252 | int | value | 4 | | |
| 256 | void* | | | ret addr | |
| 264 | struct Node* | new_node | 🗑 | locals | |

**Heap**

| addr | value | 🔒 |
|---|---|---|
| 400 | .value = 3 | 🔒 |
| | .next = NULL | |
| 412 | | |

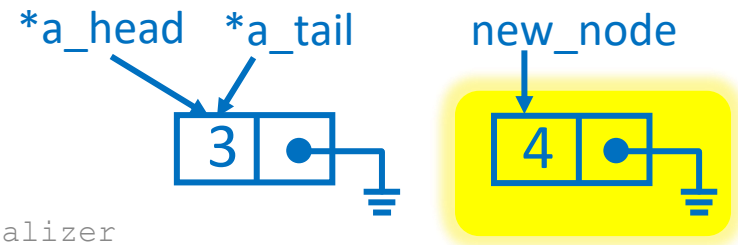
Types and names are not stored in memory or executable. Addresses shown are fictional. Assume `sizeof(int)==4`, `sizeof(char)==1`, `sizeof(void*)==8`.

# Appending to a linear linked list with the append(…) function.



**Step 6. The second node in the list is allocated (line 6) and initialized (line 9).**

```
1  void append(int value, struct Node** a_head, struct Node** a_tail) {
2      // Assert:  If head is NULL then tail must be NULL
3      assert( (*a_tail == NULL) == (*a_head == NULL) );
4
5      // Allocate memory on heap for new_node.
6      struct Node* new_node = malloc(sizeof(*new_node));
7
8      // Initialize all fields of new_node using compound initializer
9      *new_node = (struct Node) { .value=value, .next=NULL };
10     ▶AS OF HERE◀
11     if(*a_tail == NULL) {                  // If list is empty…
12         *a_head = new_node;                //     Set head to new_node
13     }
14     else {                                 // If list is not empty…
15         (*a_tail) -> next = new_node;      //     Connect tail to new_node
16     }
17     *a_tail = new_node;                    // Set the tail to new_node.
18 }
```




**Stack**

| addr | type* | name* | value | part | fn |
|---|---|---|---|---|---|
| 200 | int | argc | 1 | args | main(…) |
| 204 | char** | argv | → {"./foo"} | | |
| 212 | void* | | | ret addr | |
| 220 | struct Node* | head | 400 | locals | |
| 228 | struct Node* | tail | 400 | | |
| 236 | struct Node** | a_head | 220 | args | append(…) |
| 244 | struct Node** | a_tail | 228 | | |
| 252 | int | value | 4 | | |
| 256 | void* | | | ret addr | |
| 264 | struct Node* | new_node | 412 | locals | |

**Heap**

| addr | value | |
|---|---|---|
| 400 | .value = 3 | 🔒 |
| | .next = NULL | |
| 412 | .value = 4 | 🔒 |
| | .next = NULL | |
| 424 | | |

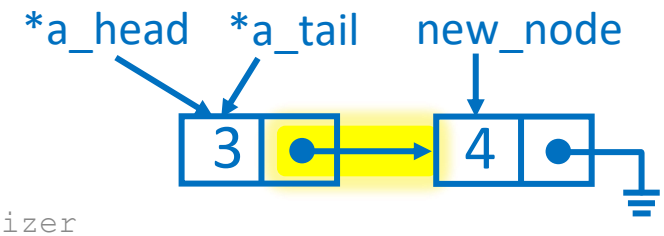
Types and names are not stored in memory or executable. Addresses shown are fictional. Assume `sizeof(int)==4`, `sizeof(char)==1`, `sizeof(void*)==8`.

# Appending to a linear linked list with the `append(…)` function.



**Step 7. Since the list is *not* empty (`*a_tail != NULL`), the `tail` (in `main(…)`'s stack frame) is connected to the `new_node` by way of `a_tail`.**

```
1  void append(int value, struct Node** a_head, struct Node** a_tail) {
2      // Assert:  If head is NULL then tail must be NULL
3      assert( (*a_tail == NULL) == (*a_head == NULL) );
4
5      // Allocate memory on heap for new_node.
6      struct Node* new_node = malloc(sizeof(*new_node));
7
8      // Initialize all fields of new_node using compound initializer
9      *new_node = (struct Node) { .value=value, .next=NULL };
10
11     if(*a_tail == NULL) {                  // If list is empty…
12         *a_head = new_node;                //     Set head to new_node
13     }
14     else {                                 // If list is not empty…
15         (*a_tail) -> next = new_node; ▶AS OF HERE◀  // Connect tail to new_node
16     }
17     *a_tail = new_node;                    // Set the tail to new_node.
18 }
```




**Stack**

| addr | type* | name* | value | part | fn |
|---|---|---|---|---|---|
| 200 | int | argc | 1 | args | main(…) |
| 204 | char** | argv | → {"./foo"} | | |
| 212 | void* | | | ret addr | |
| 220 | struct Node* | head | 400 | locals | |
| 228 | struct Node* | tail | 400 | | |
| 236 | struct Node** | a_head | 220 | args | append(…) |
| 244 | struct Node** | a_tail | 228 | | |
| 252 | int | value | 4 | | |
| 256 | void* | | | ret addr | |
| 264 | struct Node* | new_node | 412 | locals | |

**Heap**

| addr | value | 🔒 |
|---|---|---|
| 400 | .value = 3 | |
| | .next = ~~NULL~~ 412 | |
| 412 | .value = 4 | |
| | .next = NULL | |
| 424 | | |

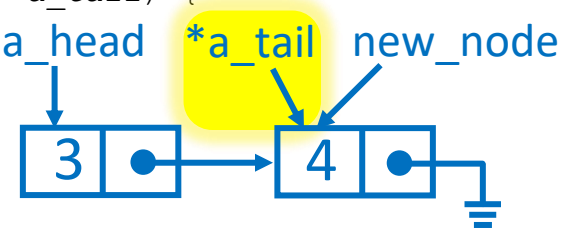
Types and names are not stored in memory or executable. Addresses shown are fictional. Assume `sizeof(int)==4`, `sizeof(char)==1`, `sizeof(void*)==8`.

# Appending to a linear linked list with the `append(…)` function.



**Step 8. The tail (in `main(…)`'s stack frame) is set to the new tail (`new_node`) by way of `a_tail`. The list now has size 2.**

```
1  void append(int value, struct Node** a_head, struct Node** a_tail) {
2      // Assert:  If head is NULL then tail must be NULL
3      assert( (*a_tail == NULL) == (*a_head == NULL) );
4
5      // Allocate memory on heap for new_node.
6      struct Node* new_node = malloc(sizeof(*new_node));
7
8      // Initialize all fields of new_node using compound initializer
9      *new_node = (struct Node) { .value=value, .next=NULL };
10
11     if(*a_tail == NULL) {                  // If list is empty…
12         *a_head = new_node;                //     Set head to new_node
13     }
14     else {                                 // If list is not empty…
15         (*a_tail) -> next = new_node;      //     Connect tail to new_node
16     }
17     *a_tail = new_node;    ▶AS OF HERE◀    // Set the tail to new_node.
18 }
```




**Stack**

| addr | type* | name* | value | part | fn |
|---|---|---|---|---|---|
| 200 | int | argc | 1 | args | main(…) |
| 204 | char** | argv | → {"./foo"} | | |
| 212 | void* | | | ret addr | |
| 220 | struct Node* | head | 400 | locals | |
| 228 | struct Node* | tail | 412 | | |
| 236 | struct Node** | a_head | 220 | args | append(…) |
| 244 | struct Node** | a_tail | 228 | | |
| 252 | int | value | 4 | | |
| 256 | void* | | | ret addr | |
| 264 | struct Node* | new_node | 412 | locals | |

**Heap**

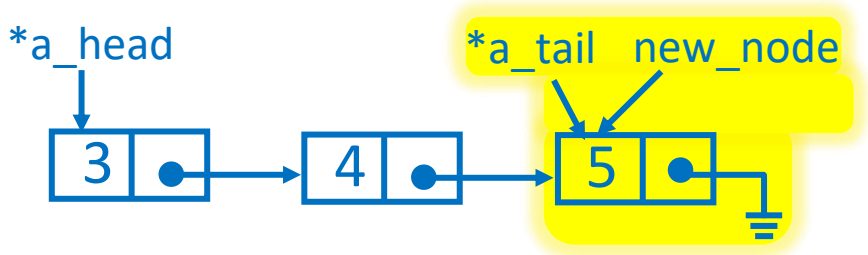
| addr | value | 🔒 |
|---|---|---|
| 400 | .value = 3 | |
| | .next = ~~NULL~~ 412 | |
| 412 | .value = 4 | |
| | .next = NULL | |
| 424 | | |

Types and names are not stored in memory or executable. Addresses shown are fictional. Assume `sizeof(int)==4`, `sizeof(char)==1`, `sizeof(void*)==8`.

# Appending to a linear linked list with the `append(…)` function.



**Step 9. `main(…)` calls `append(5, &head, &tail)` to add a third node. This is as of line 17 (just before returning from `append(…)`).**




**Stack**

| addr | type* | name* | value | part | fn |
|---|---|---|---|---|---|
| 200 | int | argc | 1 | args | main(…) |
| 204 | char** | argv | → {"./foo"} | | |
| 212 | void* | | | ret addr | |
| 220 | struct Node* | head | 400 | locals | |
| 228 | struct Node* | tail | 424 | | |
| 236 | struct Node** | a_head | 220 | args | append(…) |
| 244 | struct Node** | a_tail | 228 | | |
| 252 | int | value | 5 | | |
| 256 | void* | | | ret addr | |
| 264 | struct Node* | new_node | 424 | locals | |

**Heap**

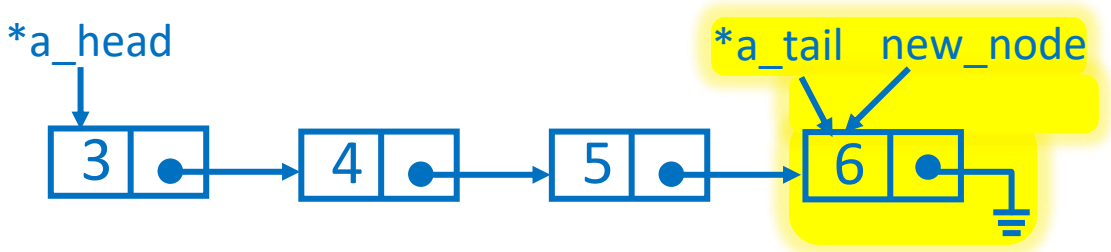
| addr | value | |
|---|---|---|
| 400 | .value = 3 | |
| | .next = 412 | |
| 412 | .value = 4 | |
| | .next = ~~NULL~~ 424 | |
| 424 | .value = 5 | |
| | .next = NULL | |
| 436 | | |
| | | |
| | | |
| | | |

Types and names are not stored in memory or executable. Addresses shown are fictional. Assume `sizeof(int)==4`, `sizeof(char)==1`, `sizeof(void*)==8`.

# Appending to a linear linked list with the `append(…)` function.



**Step 10. `main(…)` calls `append(6, &head, &tail)` to add a fourth node. This is as of line 17 (just before returning from `append(…)`).**




**Stack**

| addr | type* | name* | value | part | fn |
|---|---|---|---|---|---|
| 200 | int | argc | 1 | args | main(…) |
| 204 | char** | argv | → {"./foo"} | | |
| 212 | void* | | | ret addr | |
| 220 | struct Node* | head | 400 | locals | |
| 228 | struct Node* | tail | 436 | | |
| 236 | struct Node** | a_head | 220 | args | append(…) |
| 244 | struct Node** | a_tail | 228 | | |
| 252 | int | value | 6 | | |
| 256 | void* | | | ret addr | |
| 264 | struct Node* | new_node | 436 | locals | |

**Heap**

| addr | value | |
|---|---|---|
| 400 | .value = 3 | |
| | .next = 412 | |
| 412 | .value = 4 | |
| | .next = 424 | |
| 424 | .value = 5 | |
| | .next = ~~NULL~~ 436 | |
| 436 | .value = 6 | |
| | .next = NULL | |
| 448 | | |
| | | |

Types and names are not stored in memory or executable. Addresses shown are fictional. Assume `sizeof(int)==4`, `sizeof(char)==1`, `sizeof(void*)==8`.