

Eliminating Memory Errors in C



**Thames
Software**

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Existing solutions

- Valgrind
- ElectricFence
- Debug runtimes (I.e MSVC)
- AddressSanitizer (Clang)
 - Older Mudflap (GCC)



Introducing libstent

- A "weak pointer" for C
 - Only enabled at debug time
- A "templated vector" for C
- Header-only library
 - C89+ compatible



Getting started (current)

```
#include <stdlib.h>

struct Employee
{
    int id;
};

int main()
{
    struct Employee *emp = calloc(1, sizeof(struct Employee));
    free(emp);

    return 0;
}
```



Getting started (libstent)

```
#define STENT_IMPLEMENTATION
#include <stent.h>

struct Employee
{
    int id;
};

int main()
{
    ref(Employee) emp = allocate(Employee);
    release(emp);

    return 0;
}
```



Accessing members

```
ref(Employee) emp = allocate(Employee);  
_(emp).id = 2 * 2;  
printf("ID: %i\n", _(emp).id);
```

Result:

ID: 4



Detecting leaks

```
int main()
{
    ref(Employee) emp = allocate(Employee);

    return 0;
}
```

Result:

Warning: Allocated memory [main.c:16] persisted after application exit [Employee]
Aborted



Use after free (simple)

```
int main()
{
    ref(Employee) emp = allocate(Employee);
    release(emp);

    printf("ID: %i\n", _(emp).id);

    return 0;
}
```

Result:

```
Error: Employee pointer no longer valid in main.c:17
Aborted
```



Use after free (continued)

```
ref(Employee) curr;

int main()
{
    ref(Employee) emp = allocate(Employee);
    curr = emp;
    release(emp);

    printf("ID: %i\n", _(curr).id);

    return 0;
}
```

Result:

```
Error: Employee pointer no longer valid in main.c:19
Aborted
```



Use ref for members

```
struct Employee
{
    int id;
    ref(Department) dept;
    ref(Employee) mgr;
};

ref(Employee) EmployeeCreate(ref(Department) dept, ref(Employee) mgr)
{
    ref(Employee) rtn = allocate(Employee);
    _(rtn).dept = dept;
    _(rtn).mgr = mgr;

    return rtn;
}
```



Assume raw to refer to stack

```
struct Employee
{
    int id;
    ref(Department) dept;
    ref(Employee) mgr;
    struct Work *work; /* Avoid raw pointers in structures */
};

void EmployeeWork(ref(Employee) ctx, struct Work *work)
{
    /* work is stack memory so guaranteed be valid in this function */

    if(work->type == WORK_JUMP) { ... }
}
```



Using vectors (simple)

```
int main()
{
    vector<int> ids = vector_new<int>();

    vector_push(ids, 9);
    vector_push(ids, 5);
    vector_push(ids, 3);

    printf("ID: %i\n", vector_at(ids, 1));

    vector_delete(ids);

    return 0;
}
```



Using vectors (continued)

```
int main()
{
    vector(ref(Employee)) emps = vector_new(ref(Employee));

    vector_push(emps, EmployeeCreate());
    vector_push(emps, EmployeeCreate());
    vector_push(emps, EmployeeCreate());

    printf("ID: %i\n", EmployeeId(vector_at(emps, 1)));

    vector_delete(emps);

    return 0;
}
```



We just leaked memory!

Result:

```
Warning: Allocated memory persisted after application exit [Employee]
Warning: Allocated memory persisted after application exit [Employee]
Warning: Allocated memory persisted after application exit [Employee]
Aborted
```

Note: If you forget to call `vector_delete`, you would also see:

```
Warning: Allocated memory persisted after application exit [vector(ref(Employee))]
```



The quick fix (using foreach)

```
/*  
 * Free employees before deleting the vector  
 */  
foreach(ref(Employee) emp, emps,  
        release(emp);  
)  
  
vector_delete(emps);
```



Standard iteration through vectors

```
size_t i = 0;

/*
 * Free employees before deleting the vector
 */
for(; i < vector_size(emps); ++i)
{
    release(vector_at(emps, i));
}

vector_delete(emps);
```



Detecting vector out of bounds

```
vector<int> ids = vector_new<int>;  
vector_push(ids, 0);  
vector_push(ids, 1);  
vector_push(ids, 2);  
  
printf("ID: %i\n", vector_at(ids, 3));
```

Result:

```
Error: Index [index=3] out of bounds [size=3]  
Aborted
```



Additional vector functionality

- `vector_resize`
- `vector_clear`
- `vector_insert`
- `vector_erase`



Type-checked cast from voidref

```
void Callback(refvoid userdata)
{
    ref(Department) dpt = cast(Department, userdata);
    ...
}

ref(Employee) emp = allocate(Employee);
Callback(void_cast(emp));
```

Result:

```
Error: Attempt to cast [Employee] to incompatible type [Department]
Aborted
```



Additional libstent features

- Thread-safe access
- Some additional facilities
 - `sstream_new()`
 - `ifstream_open(...)`
 - `dir_open(...)`



Overhead free release builds

- Simply undefine `STENT_ENABLE`
- Pointers aren't checked
 - `ref(Employee) --> struct Employee *`
- Vector bounds aren't checked

Questions?

- kpedersen@thamessoftware.co.uk
- <https://github.com/osen/stent>

