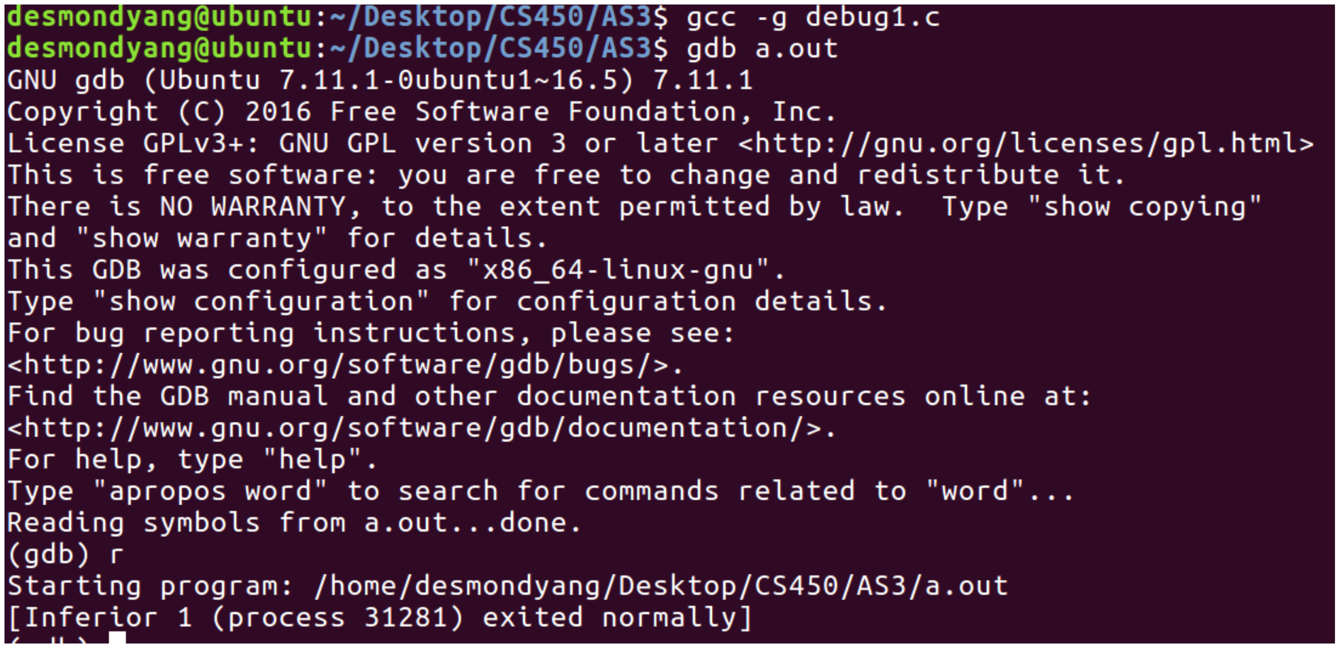
we have created two programs as following:

debug1.c: using malloc() but forgets to free it before exiting.

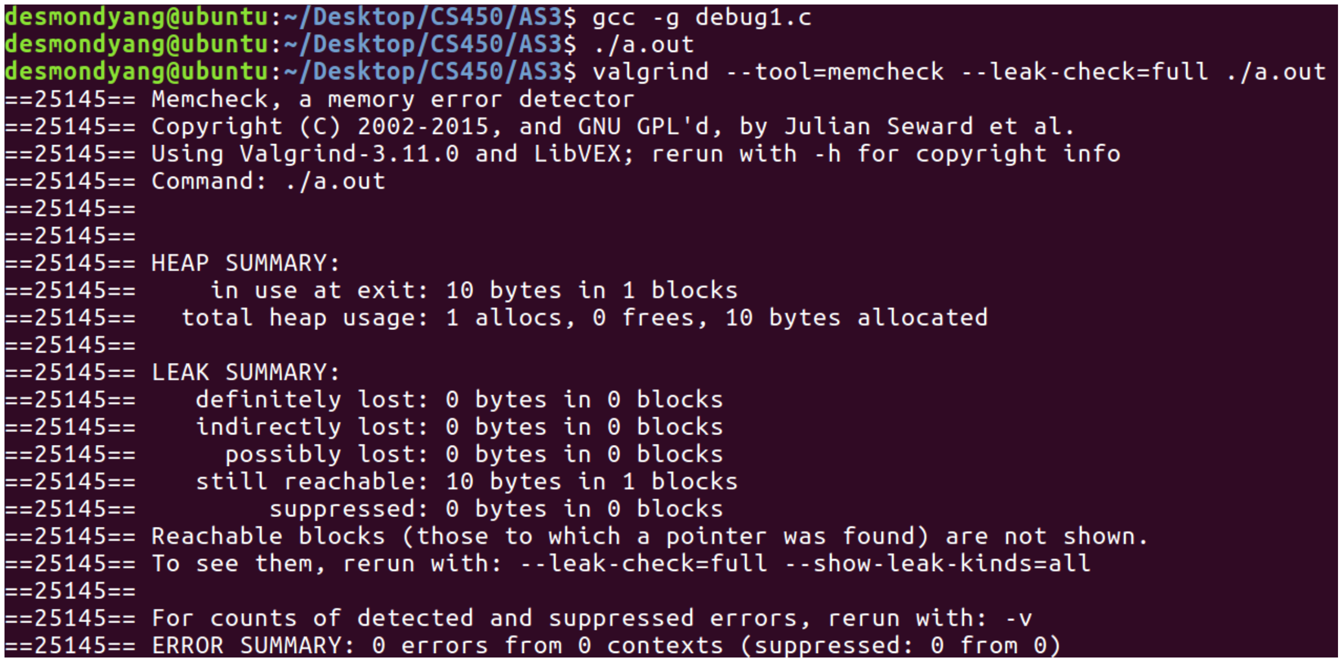
debug2.c: print the value of a integer from an array allocated with malloc() after free().

In **debug1.c**, we can find noting with **gdb**. But with the help of **Valgrind**, we can find the memory leak that this piece of memory is still accessible in the heap. it's still been consumed.



```
desmondyang@ubuntu:~/Desktop/CS450/AS3$ gcc -g debug1.c
desmondyang@ubuntu:~/Desktop/CS450/AS3$ gdb a.out
GNU gdb (Ubuntu 7.11.1-0ubuntu1~16.5) 7.11.1
Copyright (C) 2016 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.  Type "show copying"
and "show warranty" for details.
This GDB was configured as "x86_64-linux-gnu".
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<http://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
<http://www.gnu.org/software/gdb/documentation/>.
For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from a.out...done.
(gdb) r
Starting program: /home/desmondyang/Desktop/CS450/AS3/a.out
[Inferior 1 (process 31281) exited normally]
```

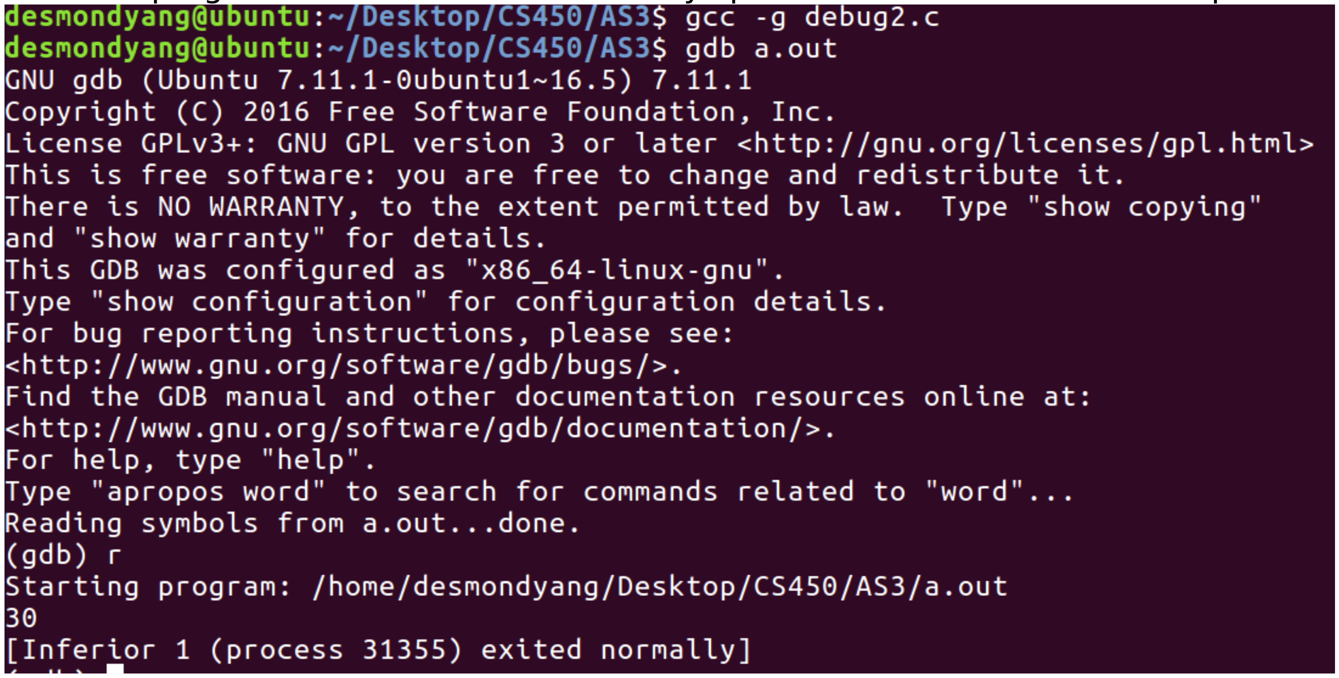
GDB Result



```
desmondyang@ubuntu:~/Desktop/CS450/AS3$ gcc -g debug1.c
desmondyang@ubuntu:~/Desktop/CS450/AS3$ ./a.out
desmondyang@ubuntu:~/Desktop/CS450/AS3$ valgrind --tool=memcheck --leak-check=full ./a.out
==25145== Memcheck, a memory error detector
==25145== Copyright (C) 2002-2015, and GNU GPL'd, by Julian Seward et al.
==25145== Using Valgrind-3.11.0 and LibVEX; rerun with -h for copyright info
==25145== Command: ./a.out
==25145==
==25145==
==25145== HEAP SUMMARY:
==25145==     in use at exit: 10 bytes in 1 blocks
==25145==   total heap usage: 1 allocs, 0 frees, 10 bytes allocated
==25145==
==25145== LEAK SUMMARY:
==25145==    definitely lost: 0 bytes in 0 blocks
==25145==    indirectly lost: 0 bytes in 0 blocks
==25145==      possibly lost: 0 bytes in 0 blocks
==25145==    still reachable: 10 bytes in 1 blocks
==25145==         suppressed: 0 bytes in 0 blocks
==25145== Reachable blocks (those to which a pointer was found) are not shown.
==25145== To see them, rerun with: --leak-check=full --show-leak-kinds=all
==25145==
==25145== For counts of detected and suppressed errors, rerun with: -v
==25145== ERROR SUMMARY: 0 errors from 0 contexts (suppressed: 0 from 0)
```

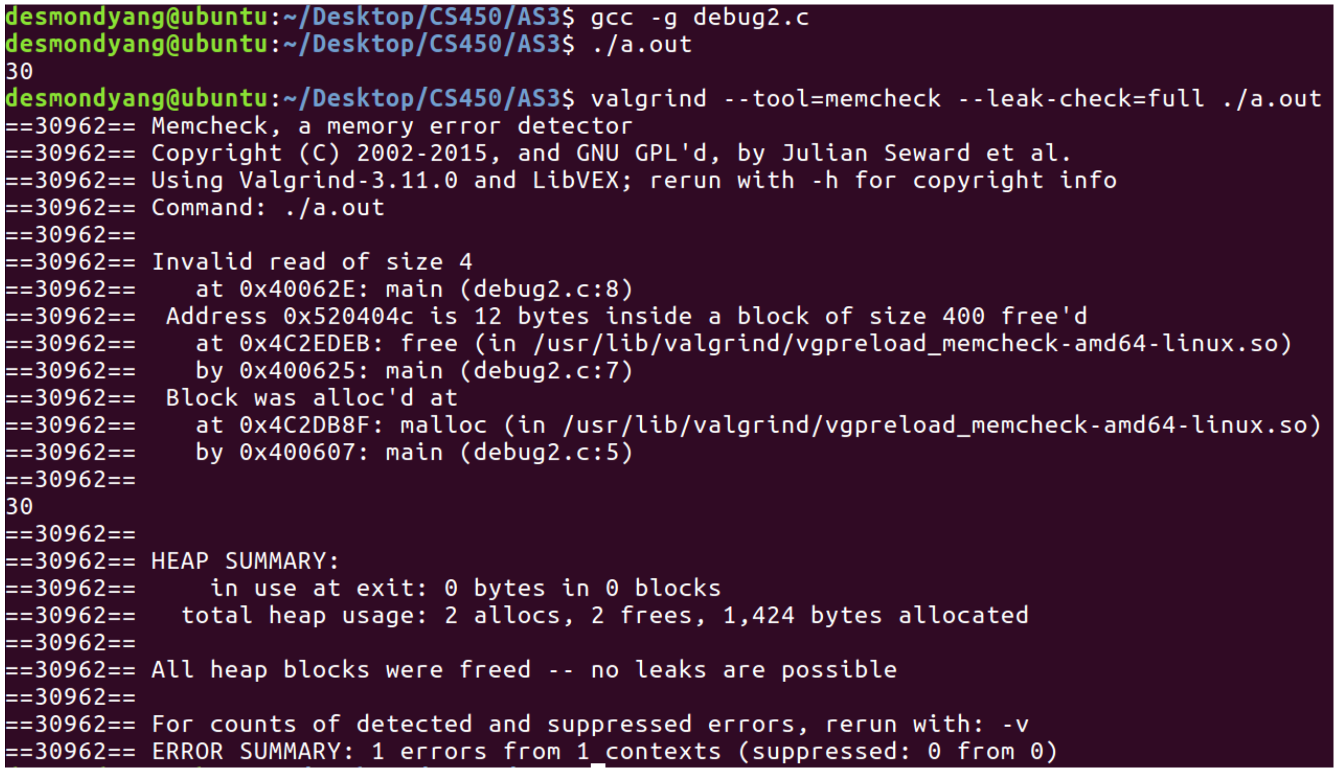
Valgrind Result

In **debug2.c**, we can find noting with **gdb**. But with the help of **Valgrind**, we can find that program tries to access a memory space which is freed in the heap.



```
desmondyang@ubuntu:~/Desktop/CS450/AS3$ gcc -g debug2.c
desmondyang@ubuntu:~/Desktop/CS450/AS3$ gdb a.out
GNU gdb (Ubuntu 7.11.1-0ubuntu1~16.5) 7.11.1
Copyright (C) 2016 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.  Type "show copying"
and "show warranty" for details.
This GDB was configured as "x86_64-linux-gnu".
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<http://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
<http://www.gnu.org/software/gdb/documentation/>.
For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from a.out...done.
(gdb) r
Starting program: /home/desmondyang/Desktop/CS450/AS3/a.out
30
[Inferior 1 (process 31355) exited normally]
```

GDB Result



```
desmondyang@ubuntu:~/Desktop/CS450/AS3$ gcc -g debug2.c
desmondyang@ubuntu:~/Desktop/CS450/AS3$ ./a.out
30
desmondyang@ubuntu:~/Desktop/CS450/AS3$ valgrind --tool=memcheck --leak-check=full ./a.out
==30962== Memcheck, a memory error detector
==30962== Copyright (C) 2002-2015, and GNU GPL'd, by Julian Seward et al.
==30962== Using Valgrind-3.11.0 and LibVEX; rerun with -h for copyright info
==30962== Command: ./a.out
==30962==
==30962== Invalid read of size 4
==30962==    at 0x40062E: main (debug2.c:8)
==30962==  Address 0x520404c is 12 bytes inside a block of size 400 free'd
==30962==    at 0x4C2EDEB: free (in /usr/lib/valgrind/vgpreload_memcheck-amd64-linux.so)
==30962==    by 0x400625: main (debug2.c:7)
==30962==  Block was alloc'd at
==30962==    at 0x4C2DB8F: malloc (in /usr/lib/valgrind/vgpreload_memcheck-amd64-linux.so)
==30962==    by 0x400607: main (debug2.c:5)
==30962==
30
==30962==
==30962== HEAP SUMMARY:
==30962==     in use at exit: 0 bytes in 0 blocks
==30962==   total heap usage: 2 allocs, 2 frees, 1,424 bytes allocated
==30962==
==30962== All heap blocks were freed -- no leaks are possible
==30962==
==30962== For counts of detected and suppressed errors, rerun with: -v
==30962== ERROR SUMMARY: 1 errors from 1 contexts (suppressed: 0 from 0)
```

Valgrind Result