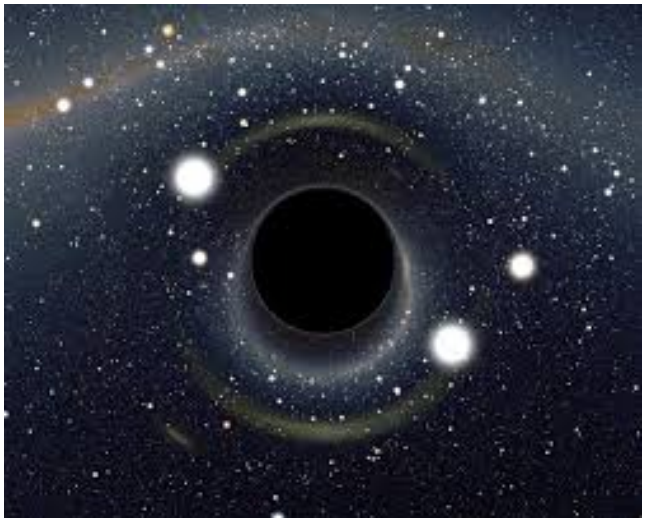
Today's lecture

- **Generics, `void*`**
  - Library functions that operate on raw memory
  - Manual pointer arithmetic
- **Function pointers**
  - How client callback function coordinates with generic operation
- **C/pointer wrap**
  - C as thin layer on underlying memory reality



Generic pointers

- `void*` pointer
  - Variable of type address with unspecified/unknown pointee type
- What you can do with a `void *`
  - Pass to/from function, pointer assignment
- What you cannot
  - Cannot dereference
  - Cannot do pointer arithmetic
  - Cannot use array indexing (depends on both arithmetic & dereference!)
- Why do you want one?
  - What gain is there in "forgetting" the pointer type?
- Generic functions!
  - All data has an address, by referring to it by address we can smooth over differences in data type

Operations that rely on data type

- **Process raw bytes without knowing what they are**
  - memcpy, memmove, memchr, memcmp, …
- **What if need more meaningful behavior per-type?**
  - Do "something" to each element or filter/sort elements
- **Coordinate with client via callback function**
  - Generic operation "calls back" to client who knows the specifics of data
- **Generic implementation**
  - Works in terms of void*, manual pointer arithmetic, raw memory operations
  - No knowledge of what the data is, only its size
  - Client refers to data by address (void * "forgets" knowledge of type)
- **Generic client**
  - Supplies the callback function that operates in specific on the data
  - Must cast void* back to specific type and dereference (cast "restores" knowledge of type)

Let's code & draw!

`/afs/ir/class/cs107/samples/lect9`

`generic.c`

Common void* idioms

- **Call generic function**

```
qsort(arr, n, sizeof(arr[0]), compare_widget);
bsearch(&key, arr, n, sizeof(arr[0]), compare_widget);
```

- **Comparison callback function**

```
int compare_widget(const void *a, const void *b)
{
   const widget *first  = (const widget *)a;
   const widget *second = (const widget *)b;
   ...
```

- **Calculate address of the ith element in a void* array**

```
void *ith = (char *)base + i*elemsz;
```

The void* blues

- If typed pointers are dangerous, what about untyped ones…?
  - Pointer of any type is compatible
- What could possibly go wrong?
  - Mismatched pointee type
  - Size mismatched to pointee type
  - Wrong level of indirection on pointer
  - Mishandle manual scaling
  - Wrong typecast
- How do other languages support generic behavior?

To be wise in the ways of memory

- **Prefer array notation to pointer arithmetic where possible**

```
arr[index]
  *(arr + index)
    *(type *)((char *)arr + index*elemSize)
```

  Same effect & efficiency, but subscript more readable, easier to get right

- **Use void * only when you must**

  If you know the type of pointee, don't keep it a secret!

- **Drop down to memxxx functions only when you must**

  If you know the type being copied, use assignment (typecast if necessary)

- **Prefer stack to heap allocation where possible**

  Cheaper, more readable, less potential for error

- **Don't store/declare/pass variables with extra levels of indirection**

  Use extra layer of pointer only when necessary

- **Use pointer typecasts exactly and only when required**

  Don't ignore warnings about pointer mismatch, don't cast indiscriminately

Go forth and * (*dereference*)

- Your pointer questions here