CSSE 490

Dynamic Storage Reclamation

Course Introduction

Roll call and introductions

- Name (nickname)
- Hometown
- Local residence
- Major(s)
- Something exciting you did over the break

Administrivia!

- Background
- Syllabus
- Schedule
- Index page
- First assignment due next Tuesday

Course logistics

- Goals
  - Explore GC
  - Perform research
- Discussion and presentations
  - Read and present papers
- Individual or group project
  - Build a collector
- Documentation
  - Important part of project

Key concepts in managing memory

- Key challenges and key ideas
  - Explicit vs Automated memory management
    - In which languages is each done?
    - Why?
  - Memory allocation
    - Contiguous allocation
    - Free-list allocation
  - Memory reclamation
    - Tracing
    - Reference counting

What is memory management?

- Programs contain
  - Objects
  - Data
  - Occupy memory
- Runtime system must allocate and reclaim memory for program in an efficient manner
  - Why is this important?
  - Why is this hard?
  - Why is this interesting?

Allocation and Reclamation

- Allocation
  - Objects dynamically allocated on HEAP
  - malloc(), new()
- Reclamation
  - Manual/Explicit
    - free()
    - delete()
  - Automated
    - Garbage collection (GC)

Explicit memory management pluses

- Efficiency can be very high
- Puts the programmer in control

Explicit memory management challenges

- Consumes software development time
  - new → allocate storage for new object
  - delete → reclaim storage
- Prone to software faults (reclaim too soon)

```
Foo* p = new Foo();
Foo* q = p;
delete p;
p->DoSomething();
p = NULL;
q->ProcessFoo();
```

- **Statically undecidable**
- **Problem for developers**

Explicit memory management challenges

- Memory leak (never reclaim)

```
#include <stdlib.h>
void f(void){
    void* s;
    s = malloc(50);
    return;
}

int main(void){
    while (1) f();
    return 0;
}
```

Automated memory management

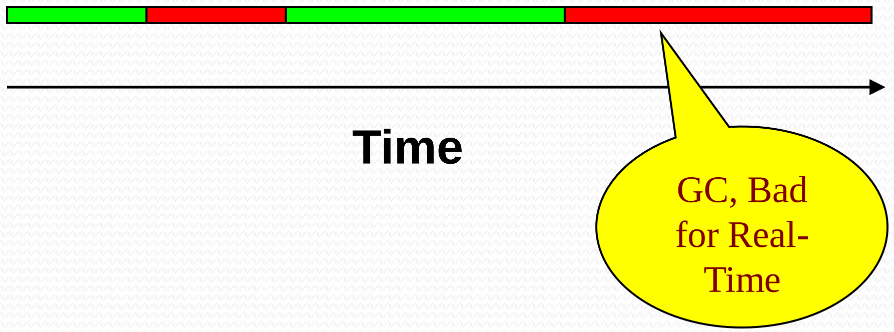
- Runtime system automatically
  - Detects dead objects (garbage detection)
  - Reclaims dead objects (garbage reclamation)
  - Garbage collection
- Preserves software development time
  - Relieves programmer burden
  - Less prone to errors
- Utilized by most modern OOP and scripting languages
  - Python, Java, C#, php

Garbage collection challenges

- Occurs an unpredictable times
- Duration is unbounded
- Performance efficiency issues

```
public void f(){
    startLaser();
    Obj o = new Obj();
    stopLaser();
}

public static void main(…){
    while (true) f();
}
```



Major concerns

- Explicit memory management
  - Reclaiming objects at the right time
- Garbage collection
  - Discriminating live objects from garbage
- Both
  - Fast allocation
  - Fast reclamation
  - Low fragmentation