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CIS 3990 Recitation 06

Midterm review

2025-10-16

Agenda

01	Course logistics
02	Midterm logistics
03	Content review & practice
04	Open Q&A

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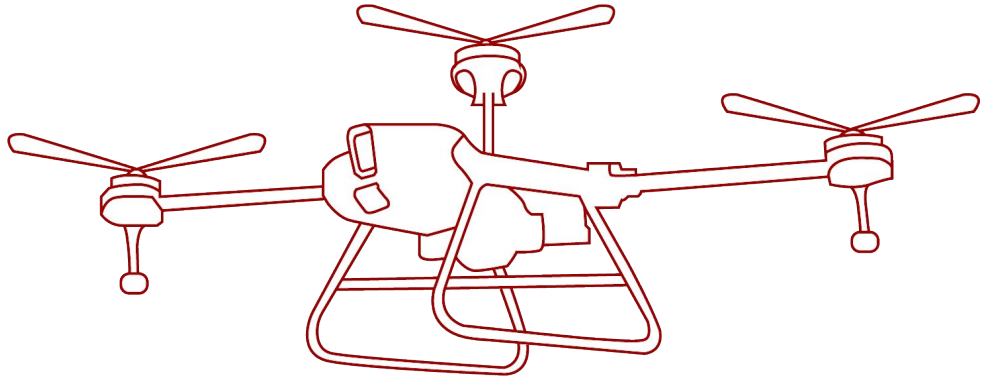
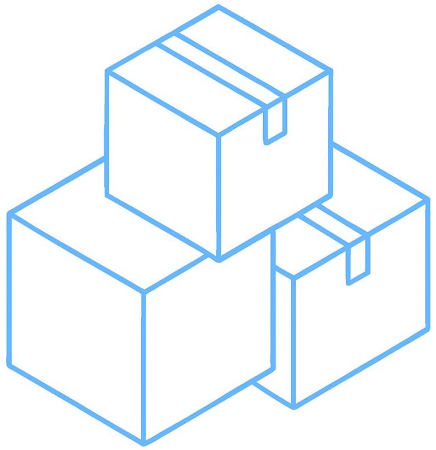
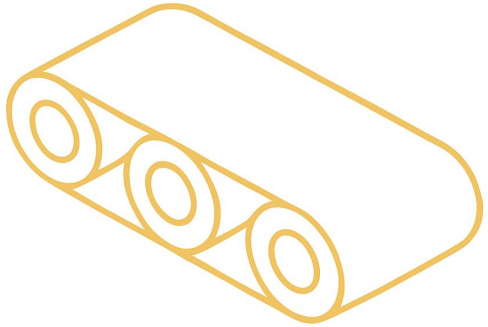
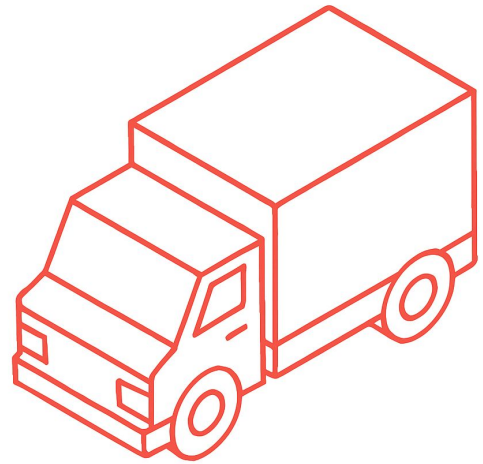


Logistics







Logistics

- HW06 out - due 11:59pm on **Fri, Oct 17** - via Gradescope
- Re-opens for the last check-in are processed, let me know if forgot anything/ selected the wrong date/assignment
- Remember HW06 is graded for style!
- Check-in due Mon, Oct 20 is posted

Logistics

- Every past hw graded as of last night, including resubmissions

HW05: git [REPO CREATION]	0.0	OCT 1, 2025 2:00 PM	OCT 7, 2025 11:59 PM Late Due Date: DEC 8, 2025 11:59 PM	15	100%
HW05: git	100.0	OCT 1, 2025 2:00 PM	OCT 7, 2025 11:59 PM	12	100%
HW04: File Readers	250.0	SEP 23, 2025 11:59 PM	SEP 30, 2025 11:59 PM	10	100%
HW03: NFA	300.0	SEP 17, 2025 5:00 PM	SEP 25, 2025 11:59 PM	13	100%
HW02: Finite State Machine	200.0	SEP 10, 2025 2:00 PM	SEP 16, 2025 11:59 PM	15	100%
Repo Creation	0.0	AUG 27, 2025 1:30 PM	SEP 12, 2025 11:59 PM Late Due Date: OCT 12, 2025 11:59 PM	17	100%
HW01: LinkedList & HashTable	250.0	AUG 29, 2025 11:59 PM	SEP 9, 2025 11:59 PM	16	100%
HW00: Cowsay	100.0	AUG 27, 2025 1:30 PM	SEP 9, 2025 11:59 PM	18	100%

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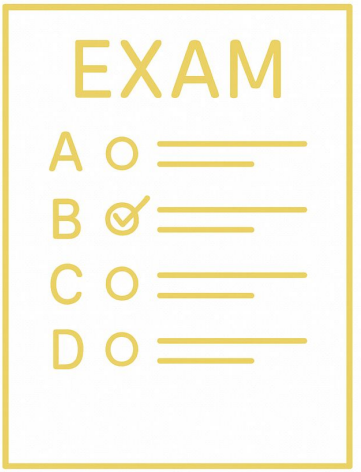
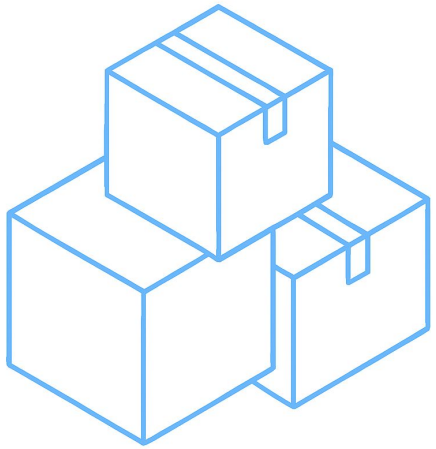
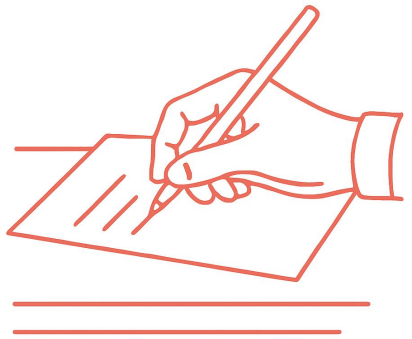


Midterm Logistics





Midterm details

- **Wed, October 22nd 2025**, during lecture, 12:00pm - 1:30pm in AGH 203, our usual room
- You are allowed one double-sided sheet of notes
- Topics are: everything taught up until the exam
  - C concepts, C++ additions, STL, git, System Calls, Locality, Processes, Threads
- https://www.cis.upenn.edu/~tqmcgaha/cis3990/25fa/exams/midterm

Study resources

- Couse & Recitation slides, Ed questions, HW assignments
- Instructor & Staff OH
- CIT 5950 practice questions & past midterms
  - Note your exam will be a bit harder, CIT 5950 assumes only one semester of prior programming experience. Also, there is significant, but not complete overlap between the 2 courses.

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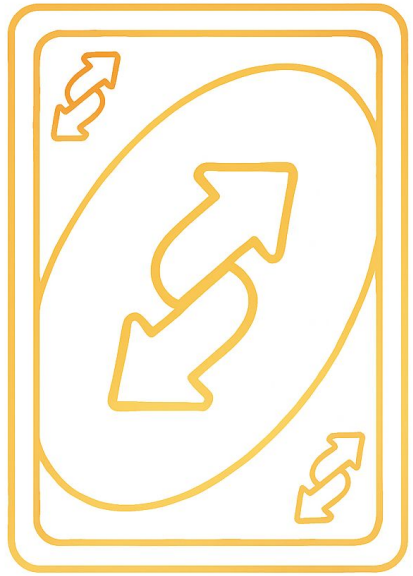
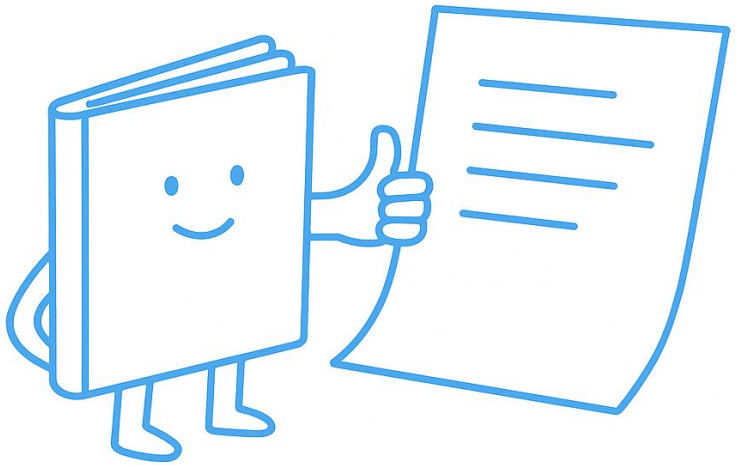
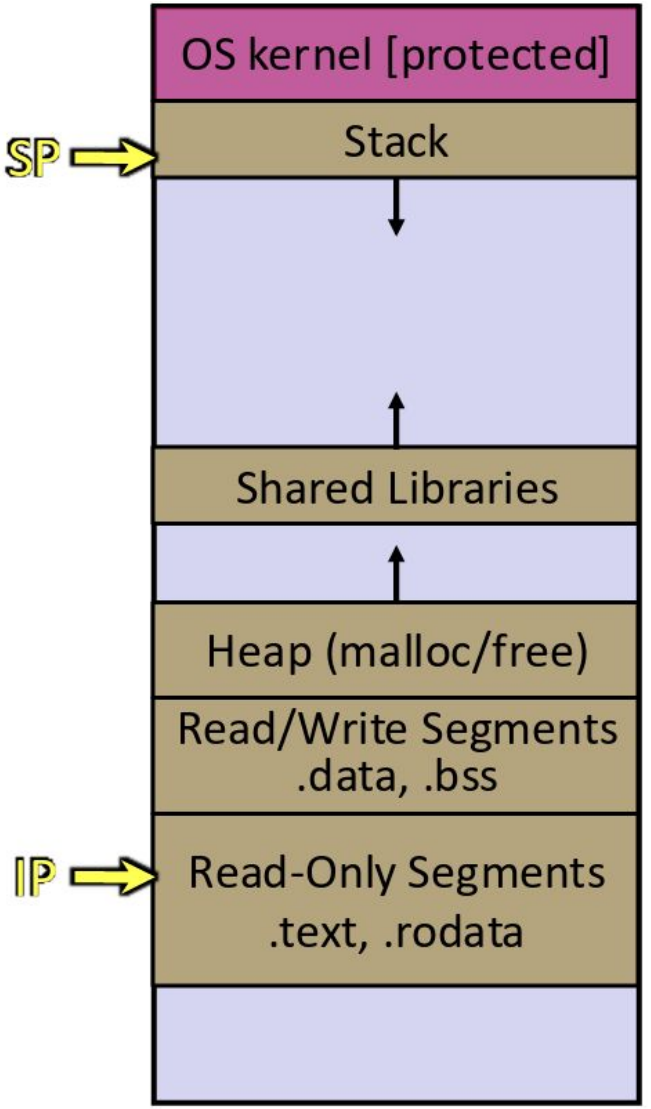


Content review



C stuff 👴

- Almost all legal C is legal C++
- Most relevant C-specific stuff:
  - Pointers
  - Memory layout and allocation - Stack frames, where stuff goes



C stuff 👴- Practice

- Draw the abstract memory diagram for this program, executed until line 13.
  - Where are *x, y, arr, i_msg, o_msg, ans*?
- Where does *ans* point once *my_gen* returns?
- Can I modify the string in *i_msg*? What about *o_msg*?
- What are the bugs and bad practices in the program?

```
1  #include <cstdlib>
2  #include <iostream>
3
4  char* my_gen(int x) {
5    char arr[x + 1];
6
7    for (int i = 0; i < x; i++) {
8      arr[i] = 'a' + rand() % ('z' - 'a' + 1);
9    }
10   arr[x] = '\0';
11
12   std::cout << "My_gen says: " << arr << std::endl;
13
14   return arr;
15 }
16
17 int main() {
18   int y;
19
20   char* i_msg = "Give me a number: ";
21   char o_msg[] = "Here is your string: ";
22
23   std::cout << i_msg;
24   std::cin >> y;
25
26   char* ans = my_gen(y);
27
28   std::cout << o_msg << ans << std::endl;
29
30   return 0;
31 }
32
```

- Pass by reference - the reference is the object itself
- Nicer syntax than pointers
- Prevents unnecessary copies of objects - especially important for function calls and iterations
- Works like *type * const*

```cpp
#include <iostream>

void my_swap(int& a, int& b) {
  int c = a;
  a = b;
  b = c;
}

int main() {
  int x = 30;
  int y = 40;
  int& z = x;

  my_swap(x, y);

  std::cout << "x: " << x << " y: " << y << " z: " << z << std::endl;
  // x: 40 y: 30 z: 40

  z = 50;

  std::cout << "x: " << x << " y: " << y << " z: " << z << std::endl;
  // x: 50 y: 30 z: 50

  return 0;
}
```

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Classes, i.e. fancy structs

- RAII - Resource Acquisition Is Initialization
- Rule of 5:
  - Destructor:
    - *~ClassName()*
  - Copy Constructor:
    - *ClassName(const ClassName&)*
  - Copy Assignment Operator:
    - *ClassName& operator=(const ClassName&)*
  - Move Constructor:
    - *ClassName(ClassName&&)*
  - Move Assignment Operator:
    - *ClassName& operator=(ClassName&&)*

©++ - Sample Rule of 5

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```
Str::Str() {
  data = new char[11];
  memset(data, '\0', 11);
  capacity = 10;
}

Str::Str(const char* str) {
  data = new char[strlen(str) + 1];
  capacity = strlen(str);
  strcpy(data, str);
}

// Copy constructor
Str::Str(const Str& other) {
  data = new char[other.capacity + 1];
  strcpy(data, other.data);  // deep copy
  capacity = other.capacity;
}

// Move constructor
Str::Str(Str&& other) noexcept {
  data = other.data;
  capacity = other.capacity;
  other.data = nullptr;
}
```

```
Str::~Str() {
  delete[] data;
}

Str& Str::operator=(const Str& other) {
  if (this != &other) {
    delete[] this->data;
    this->data = new char[other.capacity + 1];
    this->capacity = other.capacity;
    memcpy(this->data, other.data, other.capacity + 1);
  }
  return *this;
}

Str& Str::operator=(Str&& other) noexcept {
  if (this != &other) {
    delete[] this->data;
    this->data = other.data;
    this->capacity = other.capacity;
    other.data = nullptr;
    other.capacity = 0;
  }
  return *this;
}
```

C++ - Practice

- Out of calls on lines 15-17 which are allowed?
- What will the compiler complain about regarding lines 19-23?

```
1  #include <iostream>
2
3  void foo(const int& arg) { std::cout << "foo: " << arg << std::endl; }
4
5  void bar(int& arg) { std::cout << "bar: " << arg << std::endl; }
6
7  int main() {
8    int x = 5;
9    int& ref_1 = x;
10   int* ptr_1 = &x;
11   const int& ref_2 = x;
12   const int* ptr_2 = &x;
13   int* const ptr_3 = &x;
14
15   bar(ref_1);
16   bar(ref_2);
17   foo(ref_1);
18
19   ptr_2 = (int*)0xDEADBEEF;
20   ptr_1 = &ref_2;
21   ptr_3 = ptr_3 + 2;
22   *ptr_3 = *ptr_3 + 2;
23   *ptr_2 = *ptr_2 + 1;
24
25   return 0;
26 }
```

C++ - Practice

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```
clang++-15 -g3 -gdwarf-4 -Wall -Wpedantic --std=c++2b -O0 const_example.cpp -o const_example
const_example.cpp:16:3: error: no matching function for call to 'bar'
  bar(ref_2);
  ^~~
const_example.cpp:5:6: note: candidate function not viable: 1st argument ('const int') would lose const qualifier
void bar(int& arg) { std::cout << "bar: " << arg << std::endl; }
     ^
const_example.cpp:20:11: error: assigning to 'int *' from 'const int *' discards qualifiers
  ptr_1 = &ref_2;
          ^~~~~
const_example.cpp:21:9: error: cannot assign to variable 'ptr_3' with const-qualified type 'int *const'
  ptr_3 = ptr_3 + 2;
  ~~~~~ ^
const_example.cpp:13:14: note: variable 'ptr_3' declared const here
  int* const ptr_3 = &x;
  ~~~~~~~~~~~^~~~~~~~~~
const_example.cpp:23:10: error: read-only variable is not assignable
  *ptr_2 = *ptr_2 + 1;
  ~~~~~~ ^
4 errors generated.
```

©++ - Practice - Bad_Str

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```
5   class Bad_Str {
6    private:
7     char* data;
8     size_t capacity;
9
10   public:
11    // Default constructor
12    Bad_Str() {
13      data = new char[11];
14      memset(data, '\0', 11);
15      capacity = 10;
16    }
17    // Parameterized constructor
18    Bad_Str(const char* str) {
19      data = new char[strlen(str) + 1];
20      capacity = strlen(str);
21      strcpy(data, str);
22    }
23    // Copy constructor
24    Bad_Str(const Bad_Str& other) {
25      data = new char[other.capacity + 1];
26      strcpy(data, other.data);  // deep copy
27      capacity = other.capacity;
28    }
29
30    // Move constructor
31    Bad_Str(Bad_Str&& other) noexcept {
32      data = other.data;
33      capacity = other.capacity;
34    }
```

```
36    // Deconstructor
37    ~Bad_Str() {
38      delete[] data;
39      data = nullptr;
40      capacity = 0;
41    }
42
43    Bad_Str& operator=(const Bad_Str& other) {
44      this->data = new char[other.capacity + 1];
45      this->capacity = other.capacity;
46      memcpy(this->data, other.data, other.capacity + 1);
47      return *this;
48    }
49
50    Bad_Str& operator=(Bad_Str&& other) noexcept {
51      this->data = other.data;
52      this->capacity = other.capacity;
53      delete[] other.data;
54      return *this;
55    }
56
57    // Getters
58    const char * getData() const {return static_cast<const char*>(this->data);}
59    const size_t getCapacity() const {return capacity;}
60  };
61
```

STL

- You should be aware of existing member functions and their operation
- More than comprehensive list here:
- https://en.cppreference.com/w/cpp/container.html#Member_function_table

STL - map pitfall demo

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- NEVER search through a map via [] operator!
- RAM goes brrr

Git 

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- add
  - Stages modifications for commit
- commit
  - Creates a commit including all the staged changes
- restore
  - Reverts a file to some other state/ unstages changes
- merge
  - Generate a new commit with 2 parens, reconverging the tree
- remote
  - Some “remote” location holding a copy of your repo - likely GitHub
- push
  - Update the remote to match the local
- pull
  - Update the local to match the remote
- branch, checkout
  - Make your tree diverge in a controlled way
- pull requests
  - Reconverge the tree (on GitHub) by making a branch “pull changes” from another branch

Git 🐱🐙 - Practice at home

- learngitbranching.js.org/
- Sample questions for the exam are:
  - What will the tree look like after these commands?
  - What commands should I run to obtain this tree?

System calls 📞

- Defined in POSIX
- C-based “API” for most basic operations on computers
  - File I/O
    - read, write
    - open, close
    - lseek, pipe
  - Process creation and management
    - fork
    - exec
    - waitpid
  - Threads creation and management
    - create, join, etc.
  - Mutex acquisition and management

System calls 📞

- What should we keep in mind when using system level functions?

System calls 📞

- What should we keep in mind when using system level functions?
- When it comes to I/O, what are the performance implications?

System calls 📞

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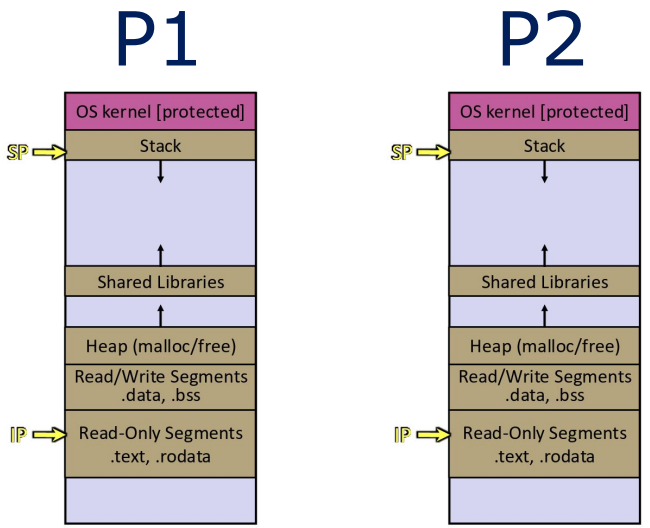
- What should we keep in mind when using system level functions?
- When it comes to I/O, what are the performance implications?
- How can higher-level functions make our lives harder as programmers?

Processes 

- Every process thinks it has its own memory, registers, everything
- fork() -> duplicate perfectly the calling process, except for the pid. the fork() returns
  - 0 in child process
  - the pid of the child in the parent process
  - -1 on error
- wait() -> tell the kernel to not schedule the calling process until something happens with the process(es) being waited for
  - dying, receiving a signal, etc. depending on the exact wait call



Processes ⏳

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- Copy of everything includes copy of file descriptors - whatever the parent had access to, the child does as well
- After fork, processes can independently open and close their fds, without influencing the other processes
- However, if no close and reopen happen, the processes still share the same file cursor - one calling lseek, read, write will influence the other
- Exec asks the system to clear stack, heap, instructions of the calling process, and load up the instructions and data of another process to be run

Processes ⏳ - shared fd demo

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```c
int main() {
  int fd = open("two_lines.txt", O_RDONLY);
  char buf[1024];
  memset(buf, '\0', 1024);
  pid_t pid = fork();

  if (pid == 0) {
    read(fd, buf, 10);
    write(2, "Child: ", 7);
    write(2, buf, 1024);
    write(2, "\n", 1);
    close(fd);
  } else {
    int ret_s;
    wait(&ret_s);
    read(fd, buf, 1023);
    write(2, "Parent: ", 8);
    write(2, buf, 1024);
    write(2, "\n", 1);
  }
}
```

```c
int main() {
  char buf[1024];
  memset(buf, '\0', 1024);
  pid_t pid = fork();

  if (pid == 0) {
    int fd = open("two_lines.txt", O_RDONLY);
    read(fd, buf, 10);
    write(2, "Child: ", 7);
    write(2, buf, 1024);
    write(2, "\n", 1);
    close(fd);
  } else {
    int fd = open("two_lines.txt", O_RDONLY);
    int ret_s;
    wait(&ret_s);
    read(fd, buf, 1023);
    write(2, "Parent: ", 8);
    write(2, buf, 1024);
    write(2, "\n", 1);
  }
}
```

Threads 

- Creating more than 1 thread = telling the kernel that, if hardware permits, the current process would like to execute multiple things in parallel
- Threads share memory - we can have data races, non-deterministic outputs, etc. - at the mercy of the scheduler once again
- We can avoid data issues via locks i.e. mutexes

Threads Or Process

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For the following, state whether it would be better to use multiple threads or processes:

1. You want to process a big image by calculating the average of all pixels.

2. You have a system of receiving and logging lots of transactions, each action needs data integrity.

3. You have a word processor that constantly checks for spelling mistakes, grammar issues, and syntax errors.

4. You want to enforce security or privacy when performing concurrent transactions.

Threads Or Process

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For the following, state whether it would be better to use multiple threads or processes:

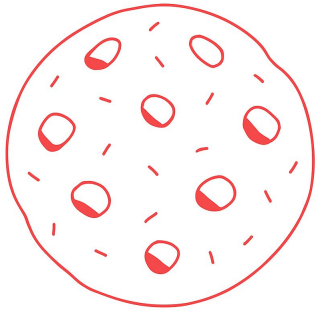
1. You want to process a big image by calculating the average of all pixels. **Threads**

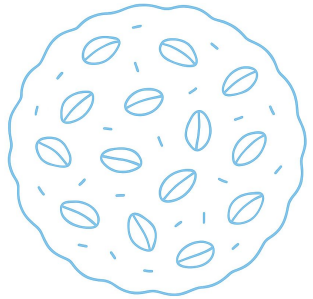
2. You have a system of receiving and logging lots of transactions, each action needs data integrity. **Processes**

3. You have a word processor that constantly checks for spelling mistakes, grammar issues, and syntax errors. **Threads**

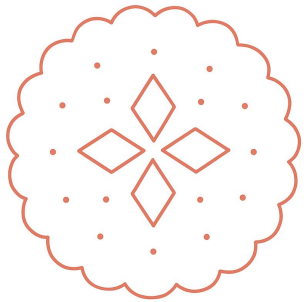
4. You want to enforce security or privacy when performing concurrent actions. **Processes**

Open Q&A





Ask and we shall answer.




That's all Folks!