CS 1550

Week 7 - Project 2 Discussion

Teaching Assistant

Henrique Potter

CS 1550 – Project 2 is out

- **Due**: Monday, March 03, 2020 @11:59pm
- **Late**: Wednesday, March 05, 2020 @11:59pm
  - 10% reduction per late day

CS 1550 – Project 2 is out

- We will be using Qemu again for Project 2

CS 1550 – Project 2 is out

- We will be using Qemu again for Project 2
- You will need a working semaphore implementation
  - You can reuse your Project 1 Linux kernel (bzImage)
  - Or you can download a working kernel from here.

CS 1550 – Project 2 is out

- We will be using Qemu again for Project 2
- You will need a working semaphore implementation
  - You can reuse your Project 1 Linux kernel (bzImage)
  - Or you can download a working kernel from here.
- You only need to cp the working kernel once in Linux-devel
- Afterwards you will only need to compile your program in thoth and copy to Qemu (with SCP)

Project 2 - Safe Museum Tour Problem

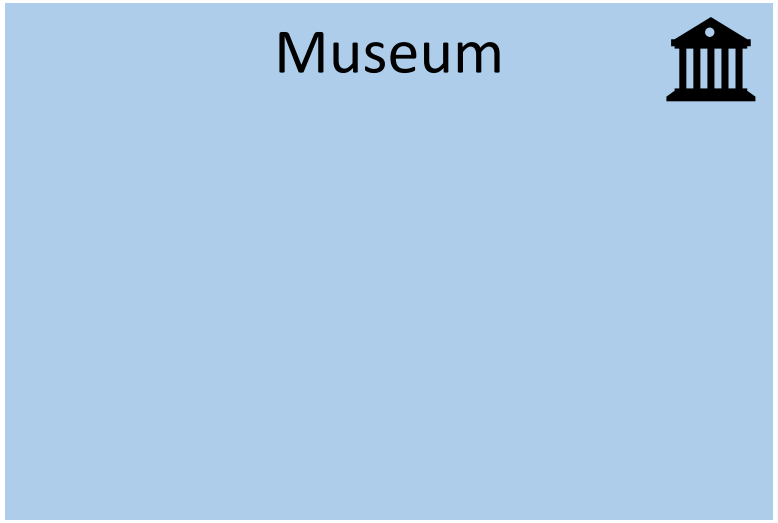
- A visitor can not tour a museum without a tour guide

Project 2 - Safe Museum Tour Problem

- A visitor can not tour a museum without a tour guide

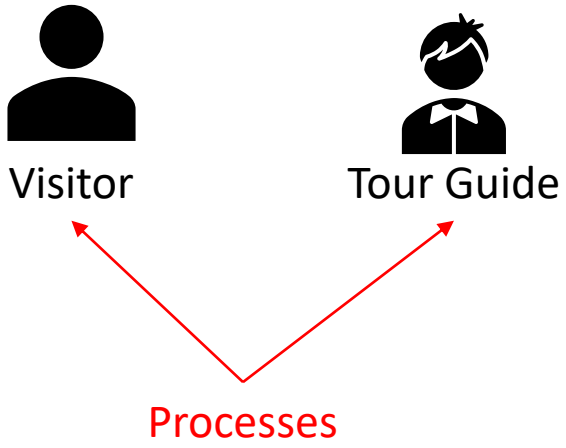
Visitor

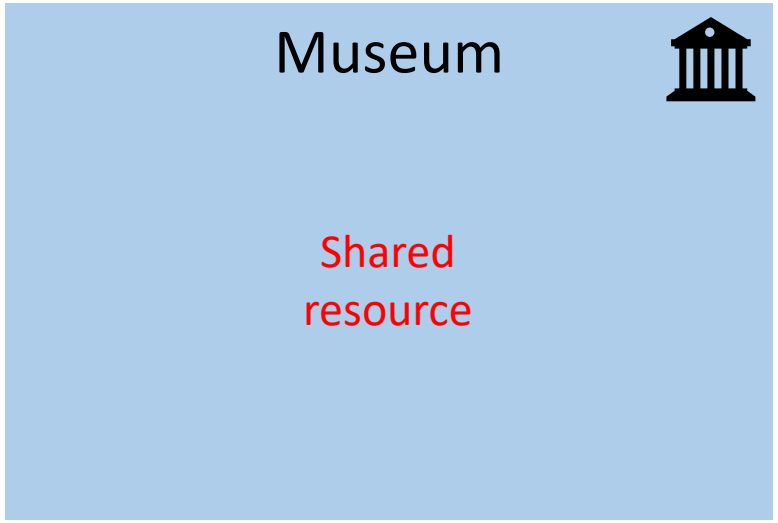
Tour Guide



Project 2 - Safe Museum Tour Problem

- A visitor can not tour a museum without a tour guide





Project 2 - Safe Museum Tour Problem

- A visitor can not tour a museum without a tour guide

```
Main:
        int pid = fork();                   //create child process (visitor arrival)
        if(pid == 0){                       //child process when pid == 0
            VisitorArrivalProcess           //visitor arrival process
        }
```

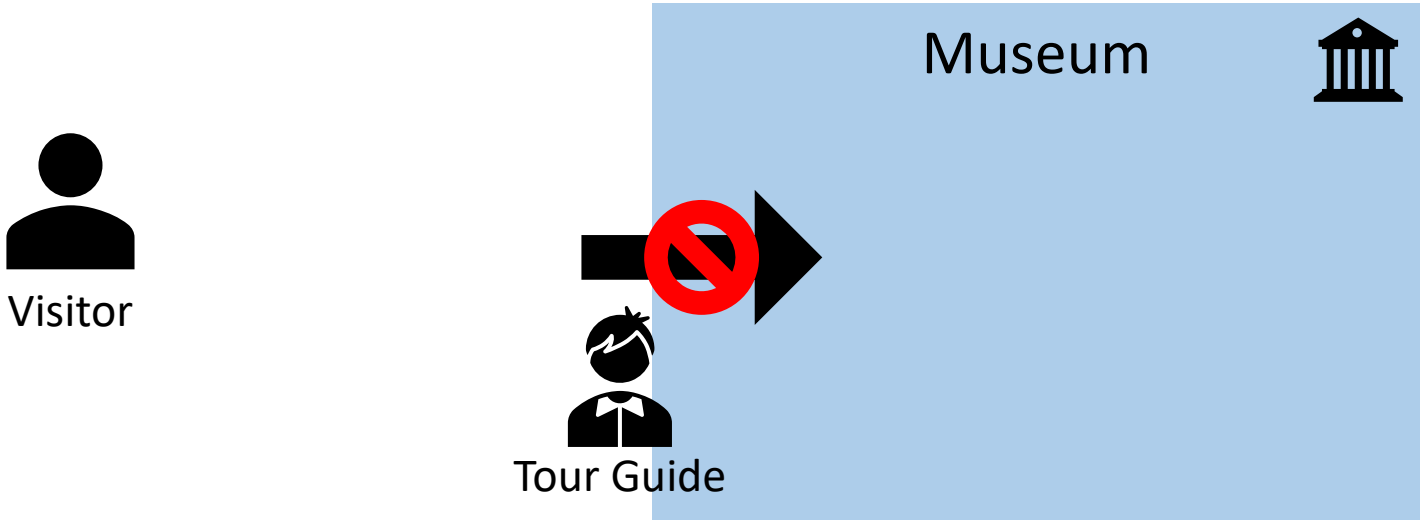
Project 2 - Safe Museum Tour Problem

- A visitor can not tour a museum without a tour guide

```
Main:
        int pid = fork();                   //create child process (visitor arrival)
        if(pid == 0){                       //child process when pid == 0
            VisitorArrivalProcess           //visitor arrival process
        } else {                            //original process when pid != 0
            int pid = fork()                //create following child process(guides)
            if(pid == 0){                   //child process when pid == 0
            Guides
        }
```

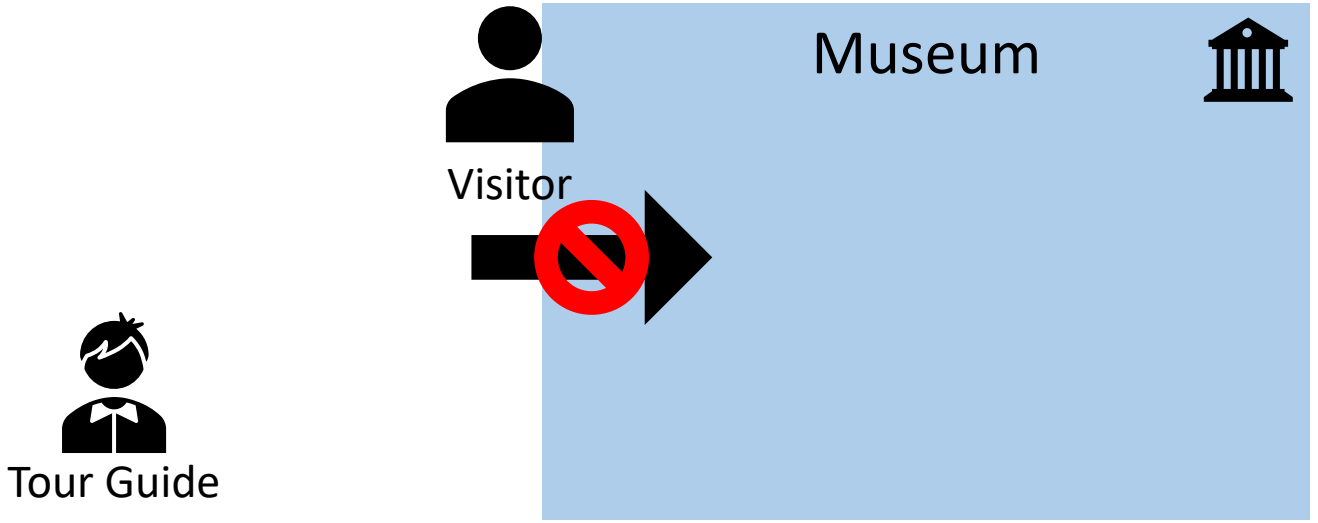
Project 2 - Safe Museum Tour Problem

- A visitor can not tour a museum without a tour guide
- A tour guide cannot open the museum without a visitor



Project 2 - Safe Museum Tour Problem

- A visitor can not tour a museum without a tour guide
- A tour guide cannot open the museum without a visitor



Project 2 - Safe Museum Tour Problem

- A visitor can not tour a museum without a tour guide
- A tour guide cannot open the museum without a visitor

```
Main:
        int pid = fork();
        if(pid == 0){
            VisitorArrivalProcess
        } else {
            int pid = fork()
            if(pid == 0){
            Guides
        }
```

Project 2 - Safe Museum Tour Problem

- A visitor can not tour a museum without a tour guide
- A tour guide cannot open the museum without a visitor

```
Main:
        int pid = fork();
        if(pid == 0){
            VisitorArrivalProcess
        } else {
            int pid = fork()
            if(pid == 0){
              Guides
        }
```

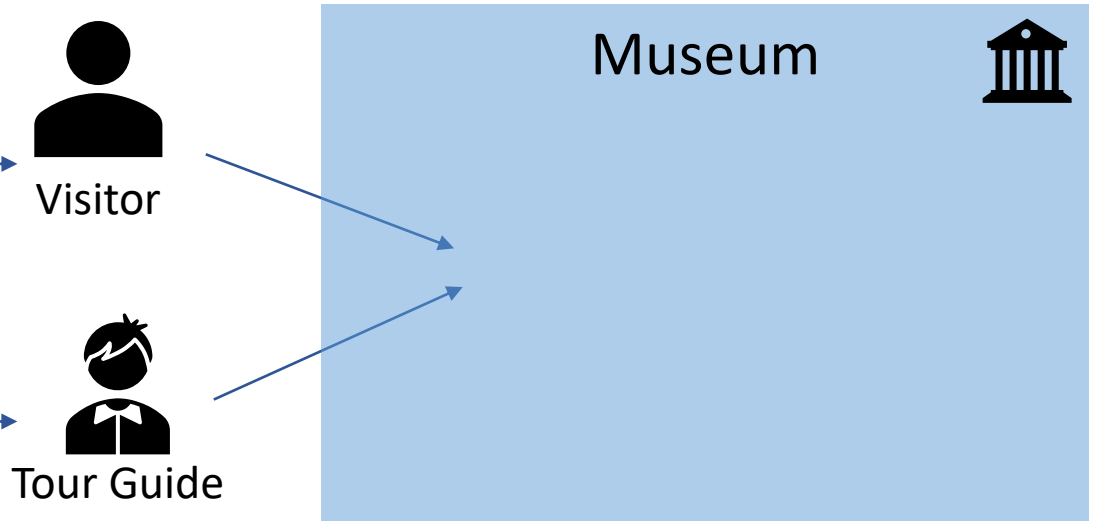
Visitor

Tour Guide

Project 2 - Safe Museum Tour Problem

- A visitor can not tour a museum without a tour guide
- A tour guide cannot open the museum without a visitor

```
Main:
        int pid = fork();
        if(pid == 0){
            VisitorArrivalProcess
        } else {
            int pid = fork()
            if(pid == 0){
              Guides
        }
```



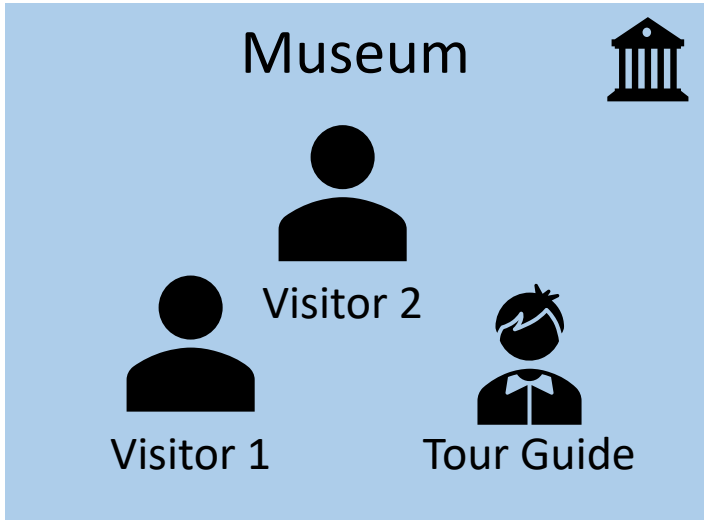
Project 2 - Safe Museum Tour Problem

- A visitor can not tour a museum without a tour guide
- A tour guide cannot open the museum without a visitor
- A tour guide leaves when no more visitors are in the museum

Project 2 - Safe Museum Tour Problem

- A tour guide leaves when no more visitors are in the museum
- A tour guide **cannot leave until all visitors** in the museum leave

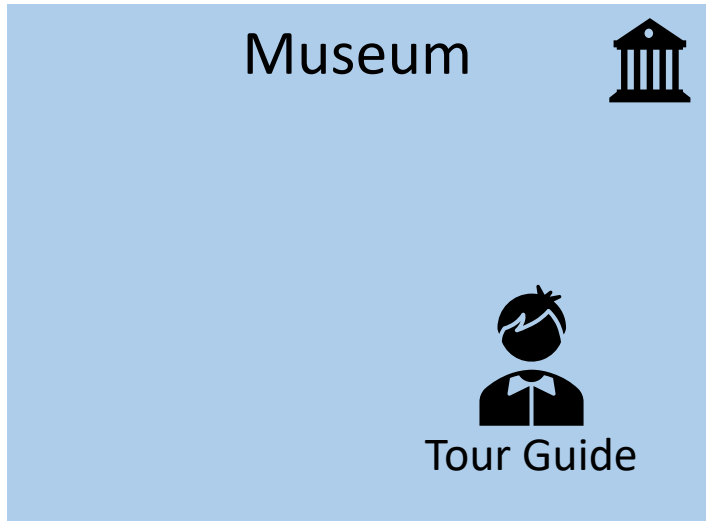
```
Main:
        int pid = fork();
        if(pid == 0){
            VisitorArrivalProcess
        } else {
            int pid = fork()
            if(pid == 0){
              Guides
        }
```



Project 2 - Safe Museum Tour Problem

- A tour guide **leaves when no more visitors** are in the museum
- A tour guide cannot leave until all visitors in the museum leave

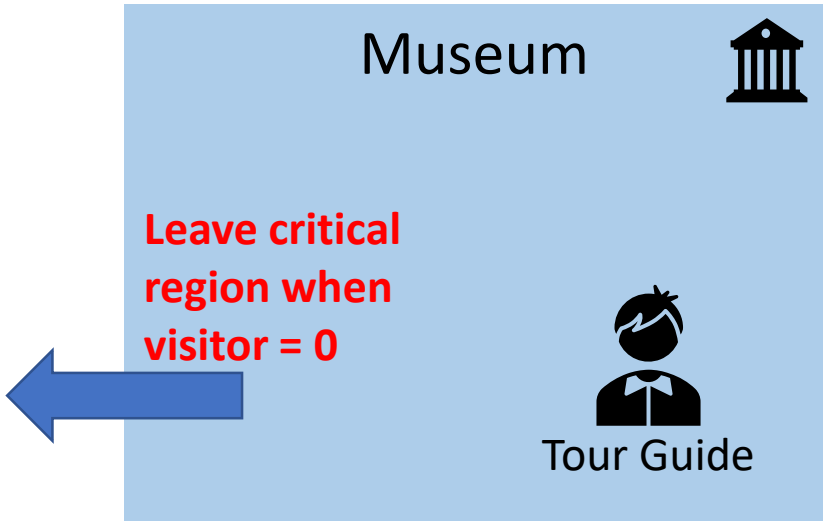
```
Main:
        int pid = fork();
        if(pid == 0){
            VisitorArrivalProcess
        } else {
            int pid = fork()
            if(pid == 0){
              Guides
        }
```



Project 2 - Safe Museum Tour Problem

- A tour guide **leaves when no more visitors** are in the museum
- A tour guide cannot leave until all visitors in the museum leave

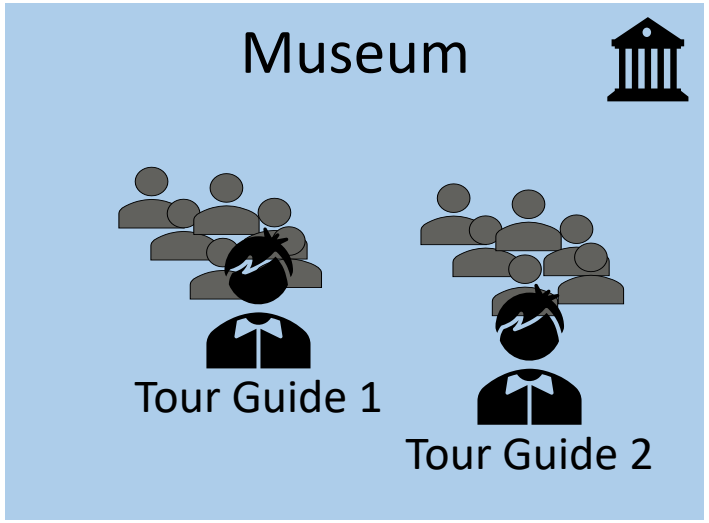
```
Main:
        int pid = fork();
        if(pid == 0){
            VisitorArrivalProcess
        } else {
            int pid = fork()
            if(pid == 0){
              Guides
        }
```



Project 2 - Safe Museum Tour Problem

- At most **two tour guides** can be in the museum at a time
- Each tour guide provides a tour **for at most ten visitors**

```
Main:
        int pid = fork();
        if(pid == 0){
            VisitorArrivalProcess
        } else {
            int pid = fork()
            if(pid == 0){
              Guides
        }
```



Project 2 - Safe Museum Tour Problem

- Your program **should always** satisfy those **constraints**
- Under **no conditions** will cause a **deadlock** to occur
  - When the museum is empty
  - Tour guide and a visitor arrive and wait outside forever

```
Main:
        int pid = fork();
        if(pid == 0){
            VisitorArrivalProcess
        } else {
            int pid = fork()
            if(pid == 0){
              Guides
        }
```

Project 2 - Safe Museum Tour Problem

- The visitor **process** (Program Parameter)
- The tour guide **process** (Program Parameter)

Project 2 - Safe Museum Tour Problem

- The visitor **process** (Program Parameter)
- The tour guide **process** (Program Parameter)

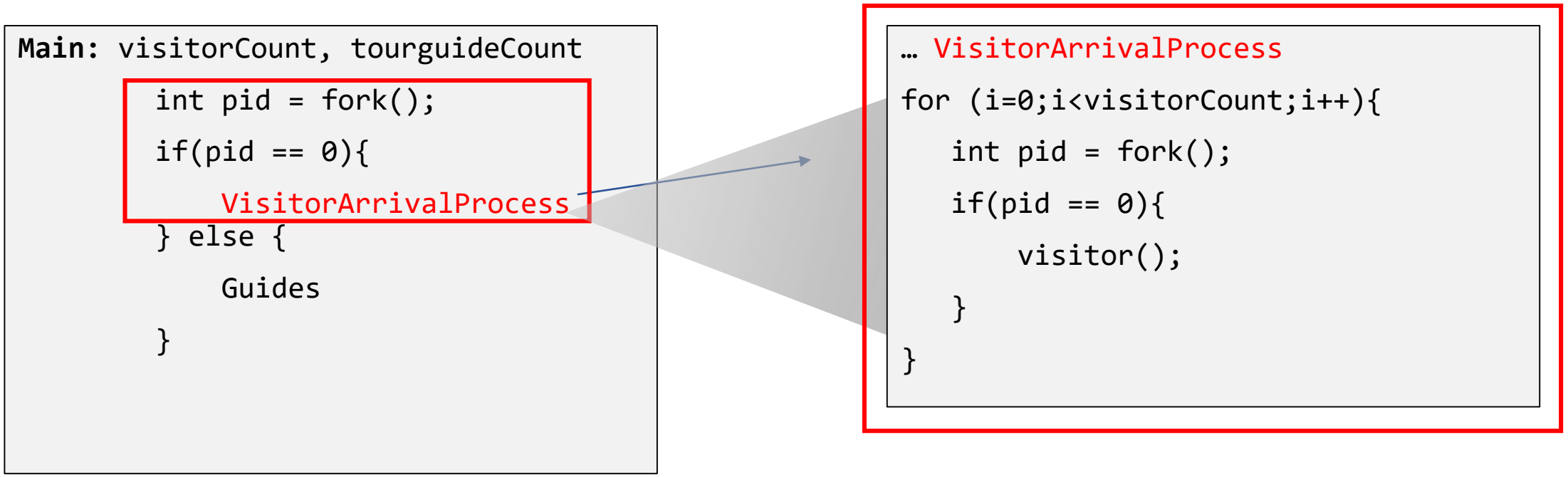
```
Main: visitorCount, tourguideCount
        int pid = fork();
        if(pid == 0){
            VisitorArrivalProcess
        } else {
            Guides
        }
```

You need to define specific behaviors to the creation of routines of both visitor and guides

50% to sleep after each creation

Project 2 - Safe Museum Tour Problem

- The visitor **process** (Program Parameter)
- The tour guide **process** (Program Parameter)
- Two processes to simulate guides and visitor's arrival



Project 2 - Safe Museum Tour Problem

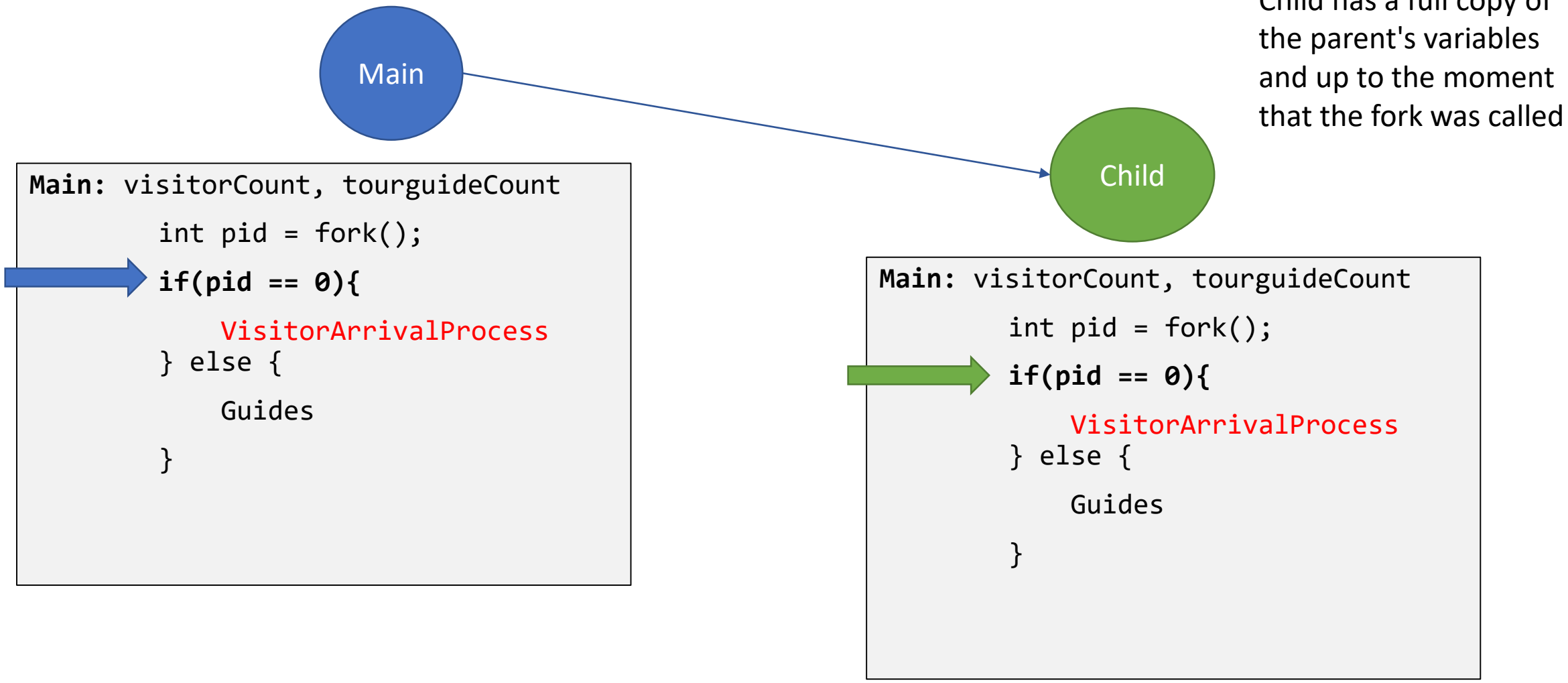

```
Main: visitorCount, tourguideCount
        int pid = fork();
        if(pid == 0){
            VisitorArrivalProcess
        } else {
            Guides
        }
```

Project 2 - Safe Museum Tour Problem

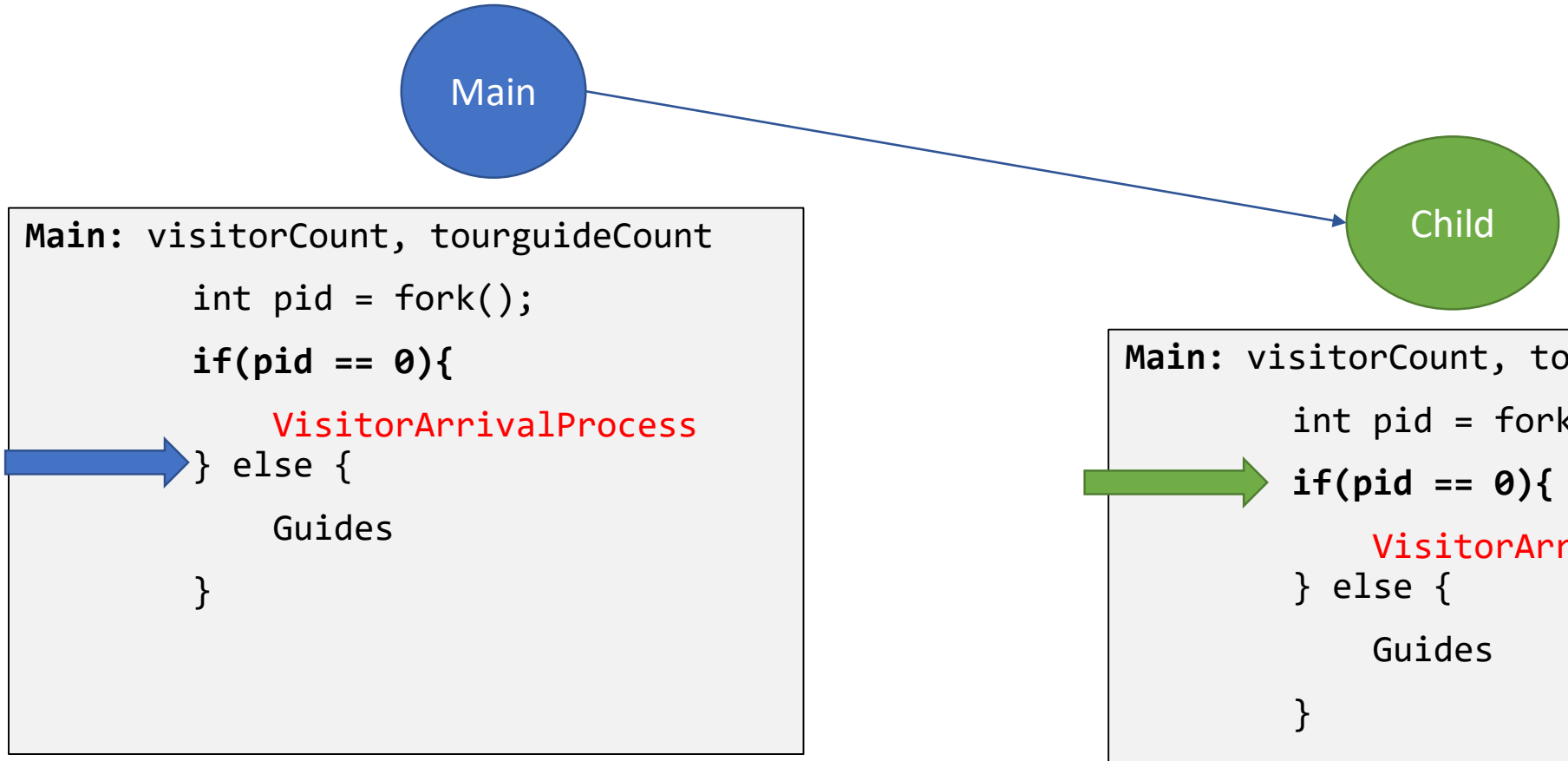

```
Main: visitorCount, tourguideCount
        int pid = fork();
        if(pid == 0){
            VisitorArrivalProcess
        } else {
            Guides
        }
```

Calling fork creates a new process. The **pid** is a value **bigger than** 0 for the parent **but is 0 for the child**.

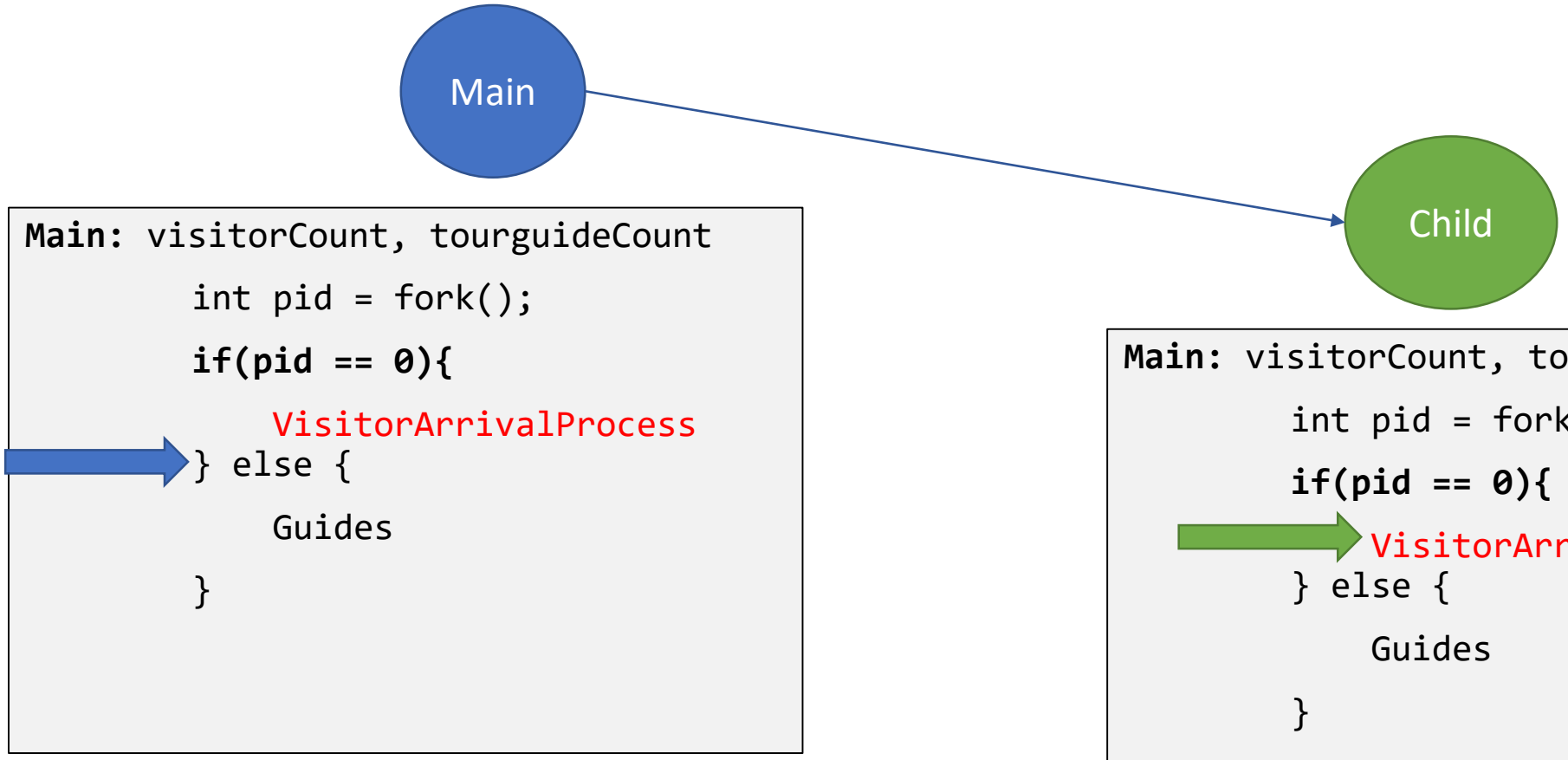
Project 2 - Safe Museum Tour Problem



Project 2 - Safe Museum Tour Problem

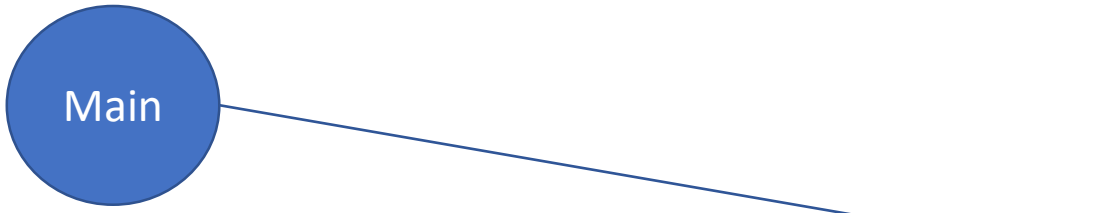


Project 2 - Safe Museum Tour Problem



Child has a full copy of the parent's variables and up to the moment that the fork was called

Project 2 - Safe Museum Tour Problem



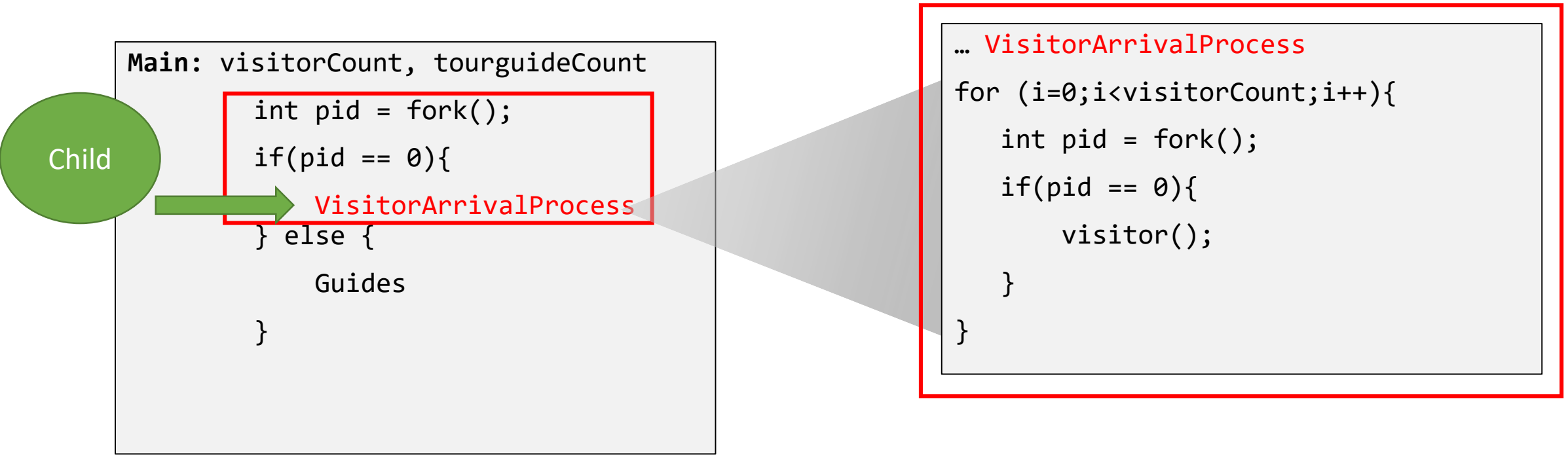
Child has a full copy of the parent's variables and up to the moment that the fork was called

```
Main: visitorCount, tourguideCount
        int pid = fork();
        if(pid == 0){
            VisitorArrivalProcess
        } else {
            Guides
        }
```

```
Main: visitorCount, tourguideCount
        int pid = fork();
        if(pid == 0){
            VisitorArrivalProcess
        } else {
            Guides
        }
```

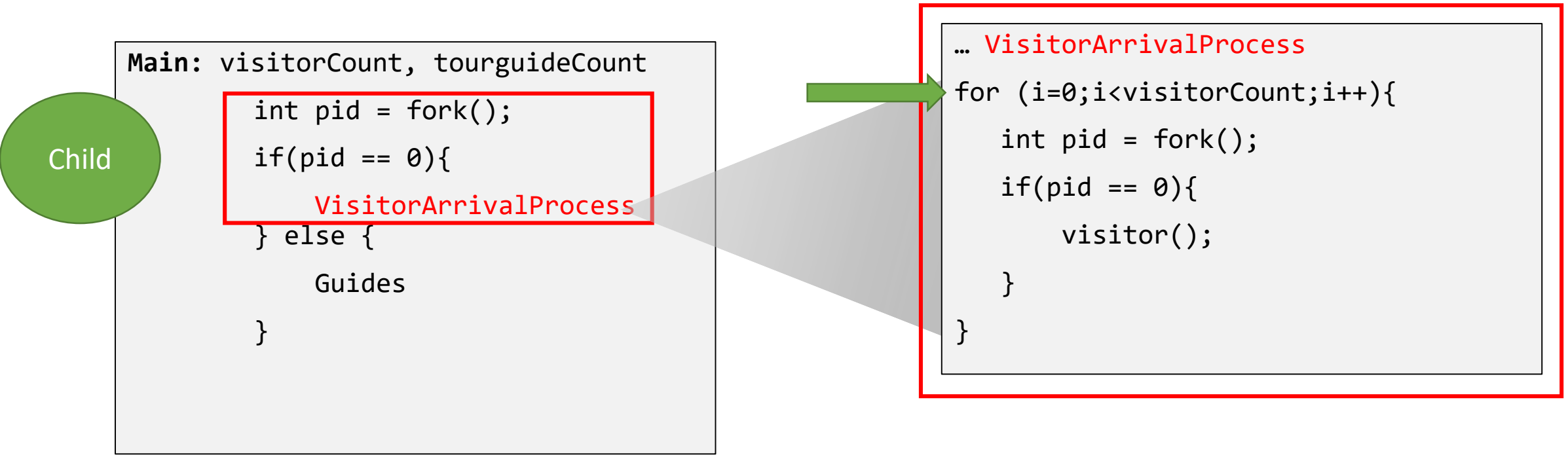
Project 2 - Safe Museum Tour Problem

- The visitor **process** (Program Parameter)
- The tour guide **process** (Program Parameter)
- Two processes to simulate guides and visitor's arrival



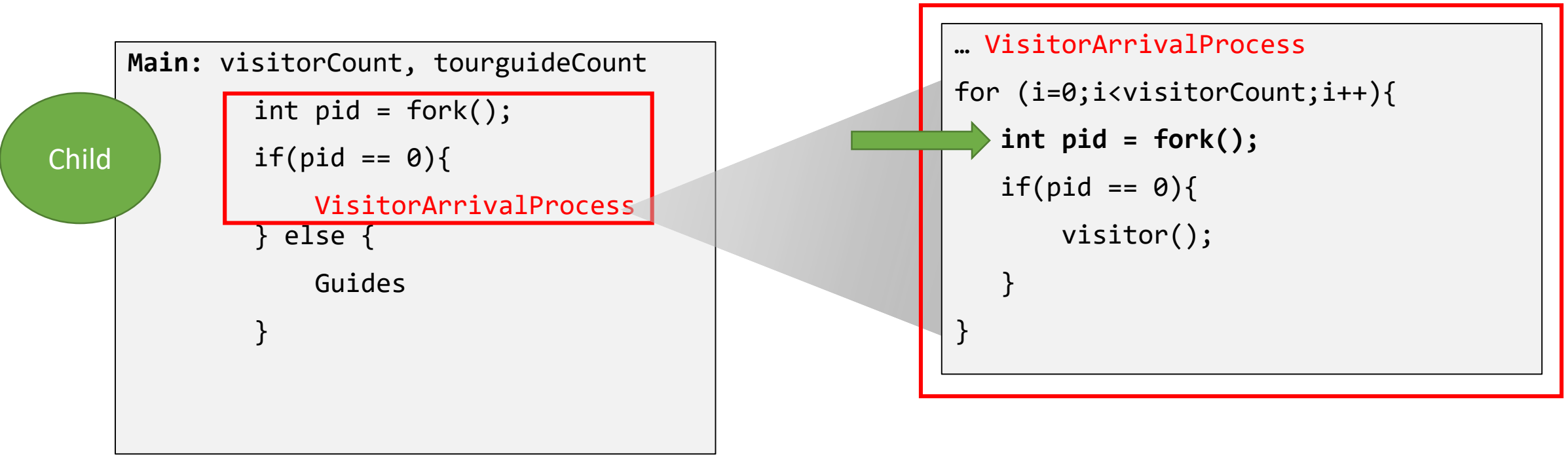
Project 2 - Safe Museum Tour Problem

- The visitor **process** (Program Parameter)
- The tour guide **process** (Program Parameter)
- Two processes to simulate guides and visitor's arrival



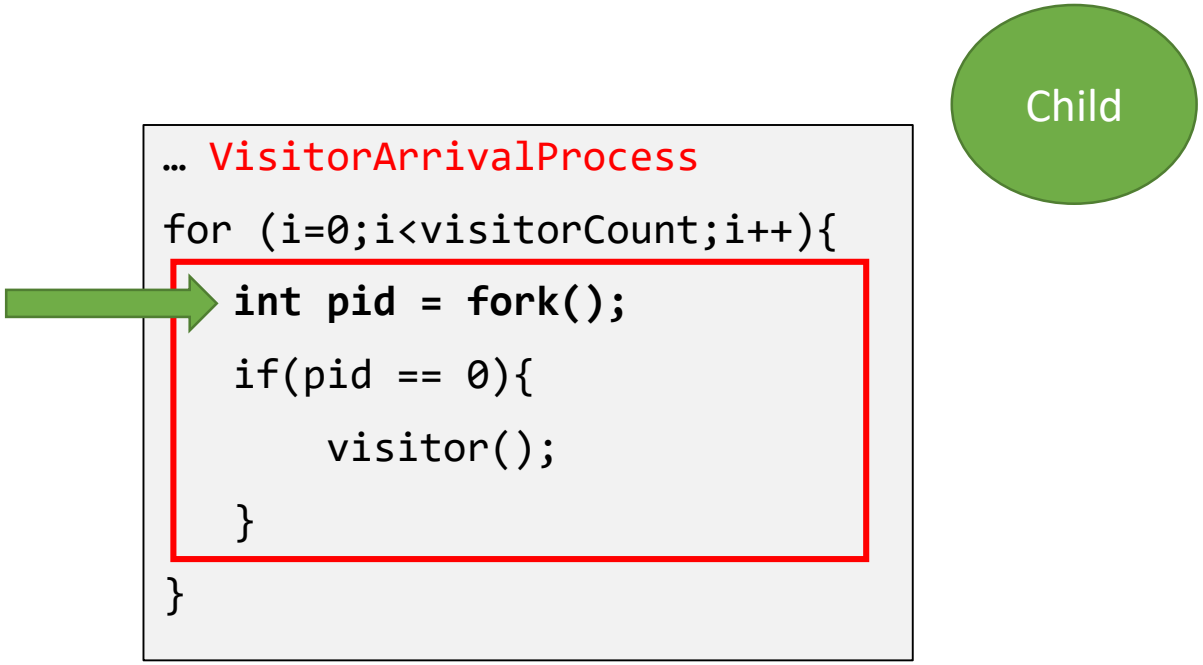
Project 2 - Safe Museum Tour Problem

- The visitor **process** (Program Parameter)
- The tour guide **process** (Program Parameter)
- Two processes to simulate guides and visitor's arrival



Project 2 - Safe Museum Tour Problem

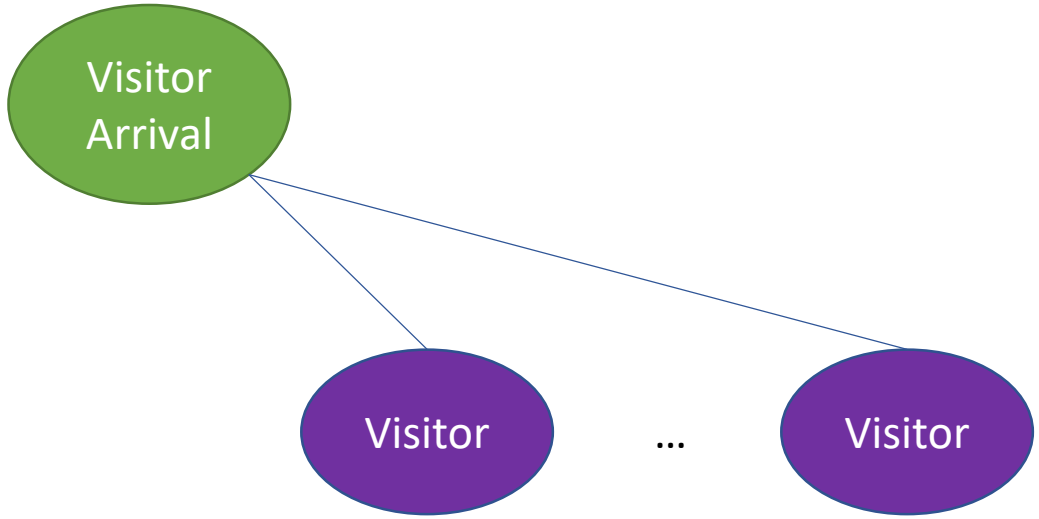
- The visitor **process** (Program Parameter)
- The tour guide **process** (Program Parameter)
- Two processes to simulate guides and visitor's arrival



Project 2 - Safe Museum Tour Problem

- The visitor **process** (Program Parameter)
- The tour guide **process** (Program Parameter)
- Two processes to simulate guides and visitor's arrival

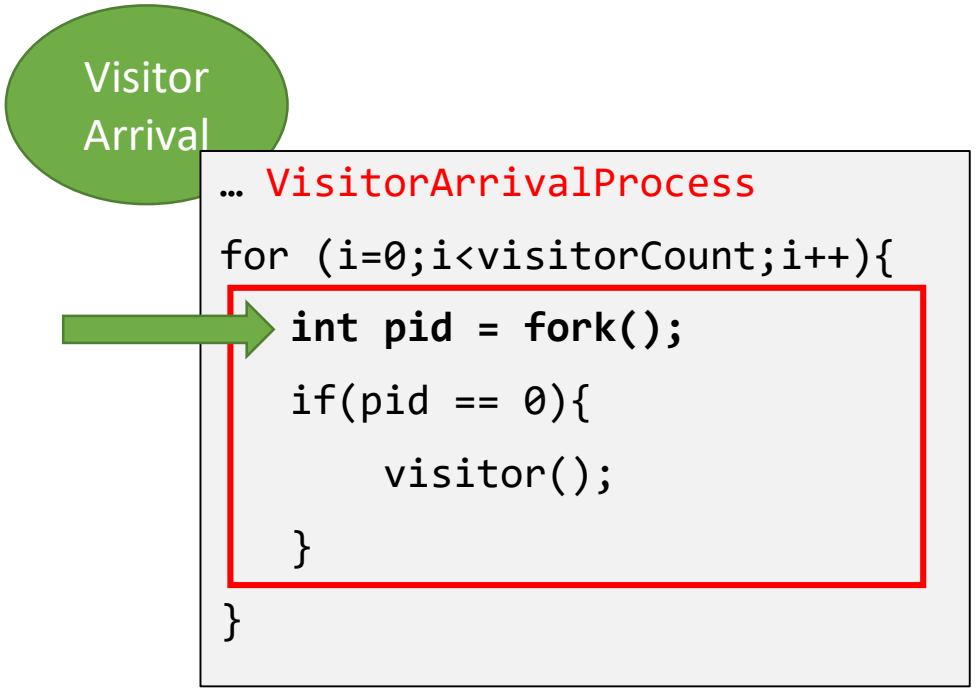
```
… VisitorArrivalProcess
for (i=0;i<visitorCount;i++){
    int pid = fork();
    if(pid == 0){
        visitor();
    }
}
```

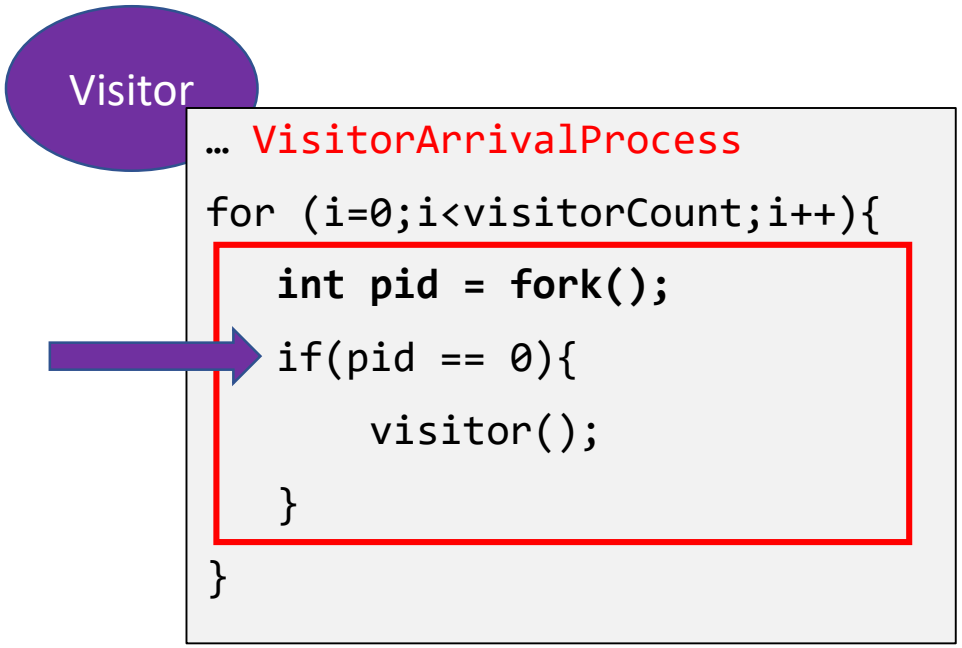


visitorCount Visitor processes

Project 2 - Safe Museum Tour Problem

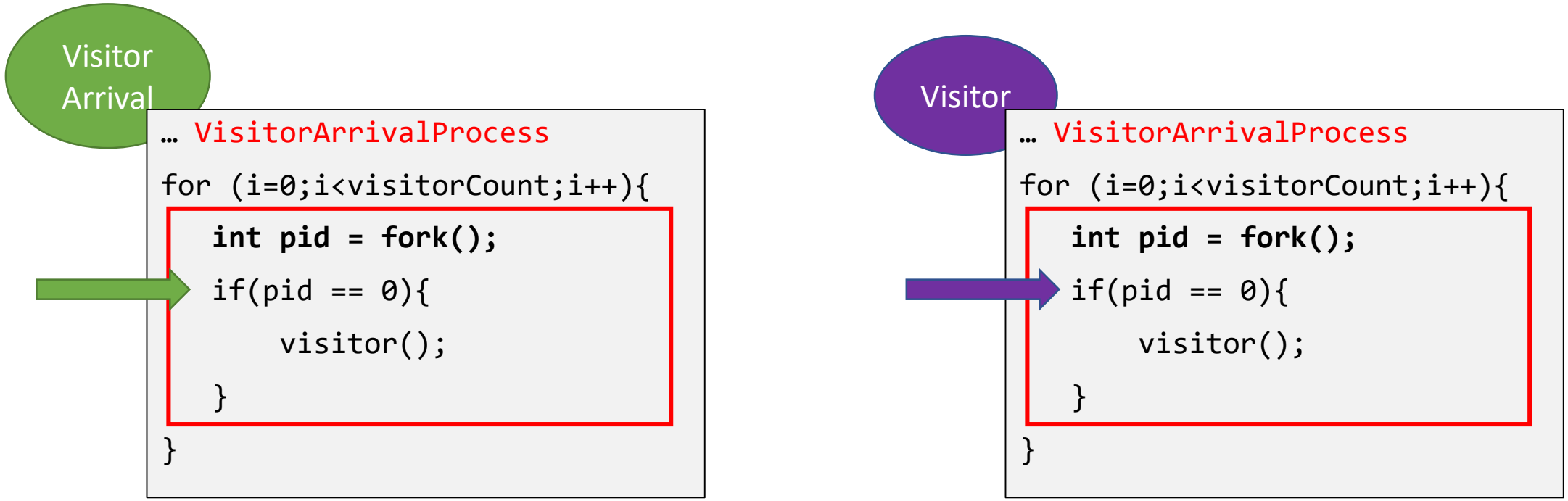
- The visitor **process** (Program Parameter)
- The tour guide **process** (Program Parameter)
- Two processes to simulate guides and visitor's arrival





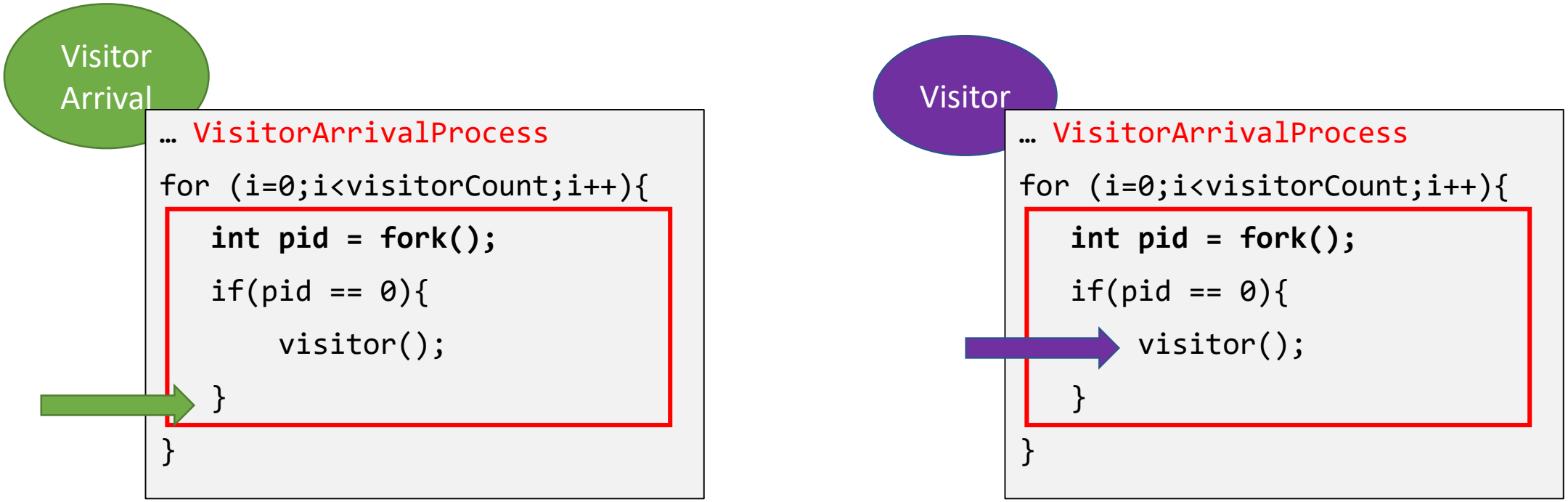
Project 2 - Safe Museum Tour Problem

- The visitor **process** (Program Parameter)
- The tour guide **process** (Program Parameter)
- Two processes to simulate guides and visitor's arrival



Project 2 - Safe Museum Tour Problem

- The visitor **process** (Program Parameter)
- The tour guide **process** (Program Parameter)
- Two processes to simulate guides and visitor's arrival



Project 2 - Safe Museum Tour Problem

Visitor Arrival

```
… VisitorArrivalProcess
for (i=0;i<visitorCount;i++){
    int pid = fork();
    if(pid == 0){
        visitor();
    }
}
```

Project 2 - Safe Museum Tour Problem

Visitor Arrival

```
… VisitorArrivalProcess
srand(seed);
for (i=0;i<visitorCount;i++){
   int pid = fork();
   if(pid == 0){
       visitor();
   }else {
       int value = rand() % 100 + 1;  //random number between 1-100
       if (value > 50){sleep(delay)};
}
```

The visitor has to sleep for some **time** with 50% probability

Project 2 - Safe Museum Tour Problem

Visitor Arrival

```
… VisitorArrivalProcess
srand(seed);
for (i=0;i<visitorCount;i++){
   int pid = fork();
   if(pid == 0){
       visitor();
   }else {
       int value = rand() % 100 + 1;  //random number between 1-100
       if (value > 50){sleep(delay)};
}
for (i=0;i<visitorCount;i++){
    wait(Null);
}
```

Then after creating all the visitors it will **wait** for them to finish.

Project 2 - Safe Museum Tour Problem

- The visitor **process** (Program Parameter)
- The tour guide **process** (Program Parameter)
- Two processes to simulate guides and visitor's arrival

Project 2 - Safe Museum Tour Problem

- The visitor **process** (Program Parameter)
- The tour guide **process** (Program Parameter)
- Two processes to **simulate guides** and visitor's arrival

Project 2 - Safe Museum Tour Problem

- Two processes to **simulate guides** and visitor's arrival

Main

```
int pid = fork();
if(pid == 0){
    VisitorArrivalProcess
} else {
    for (i=0; i<guideCount; i++){
        int pid = fork();
        if(pid == 0){
           guides();
        }
 }}
```

The parent will **create child processes** for the guide **directly**

Project 2 - Safe Museum Tour Problem

- Two processes to **simulate guides** and visitor's arrival

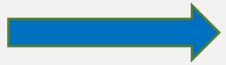
Main

```
int pid = fork();
if(pid == 0){
    VisitorArrivalProcess
} else {
    for (i=0; i<guideCount; i++){
        int pid = fork();
        if(pid == 0){
            guides();
        }
 }}
```

Project 2 - Safe Museum Tour Problem

Main

```
int pid = fork();
if(pid == 0){
    VisitorArrivalProcess
} else {
    srand(seed);
    for (i=0; i<guideCount; i++){
        int pid = fork();
        if(pid == 0){
           guides();
        }
        int value = rand() % 100 + 1;
        if (value > 50){sleep(delay)};
 }}
```



However, he also **must** sleep with **50% chance**

Project 2 - Safe Museum Tour Problem

Main

```
int pid = fork();
if(pid == 0){
    VisitorArrivalProcess
} else {
    srand(seed);
    for (i=0; i<guideCount; i++){
        int pid = fork();
        if(pid == 0){
           guides();
        }
        int value = rand() % 100 + 1;
        if (value > 50){sleep(delay)};
 }}
```

Child Guide

```
int pid = fork();
if(pid == 0){
    VisitorArrivalProcess
} else {
    srand(seed);
    for (i=0; i<guideCount; i++){
        int pid = fork();
        if(pid == 0){
           guides();
           exit()
        }
        int value = rand() % 100 + 1;
        if (value > 50){sleep(delay)};
 }}
```

Project 2 - Safe Museum Tour Problem

Main

```
int pid = fork();
if(pid == 0){
    VisitorArrivalProcess
} else {
    srand(seed);
    for (i=0; i<guideCount; i++){
        int pid = fork();
        if(pid == 0){
            guides();
        }
        int value = rand() % 100 + 1;
        if (value > 50){sleep(delay)};
 }}
```

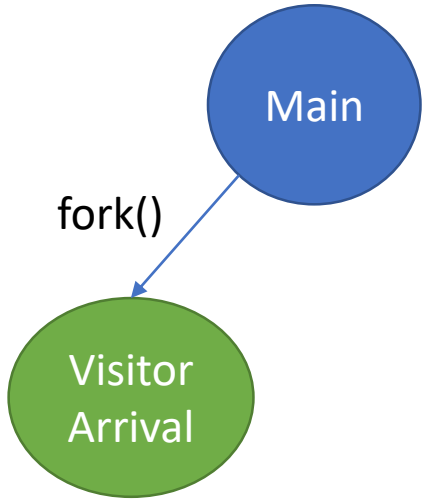
Child Guide

```
int pid = fork();
if(pid == 0){
    VisitorArrivalProcess
} else {
    srand(seed);
    for (i=0; i<guideCount; i++){
        int pid = fork();
        if(pid == 0){
            guides();
            exit();
        }
        int value = rand() % 100 + 1;
        if (value > 50){sleep(delay)};
 }}
```

Project 2 - Safe Museum Tour Problem

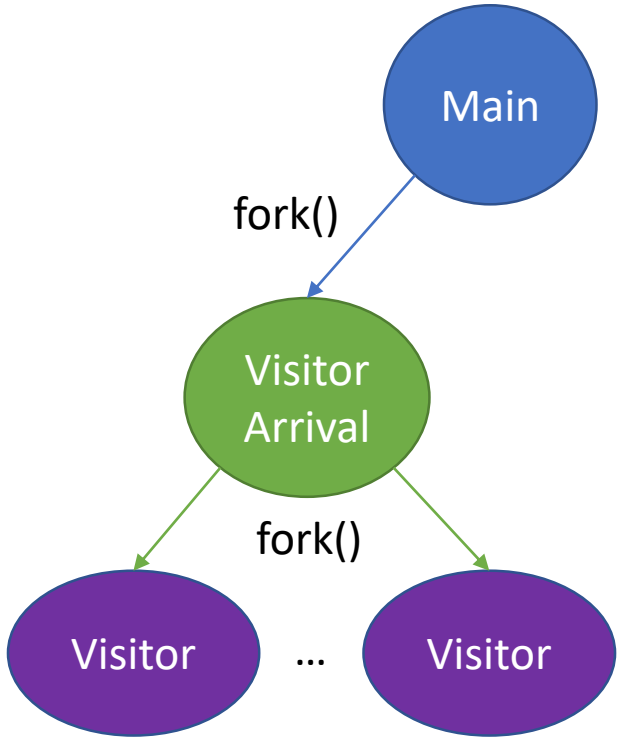
- The visitor **process** (Program Parameter)
- The tour guide **process** (Program Parameter)
- Two processes to simulate guides and visitor's arrival

Each node **is a process**



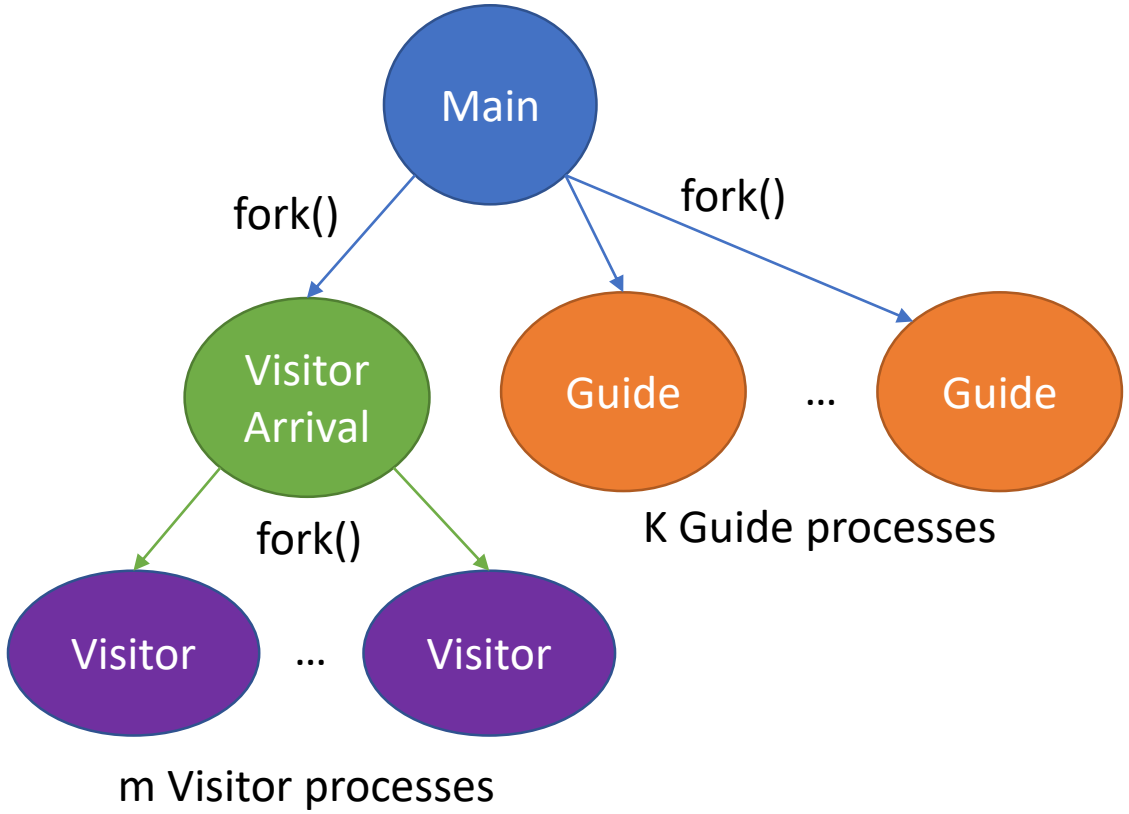
Each node **is a process**

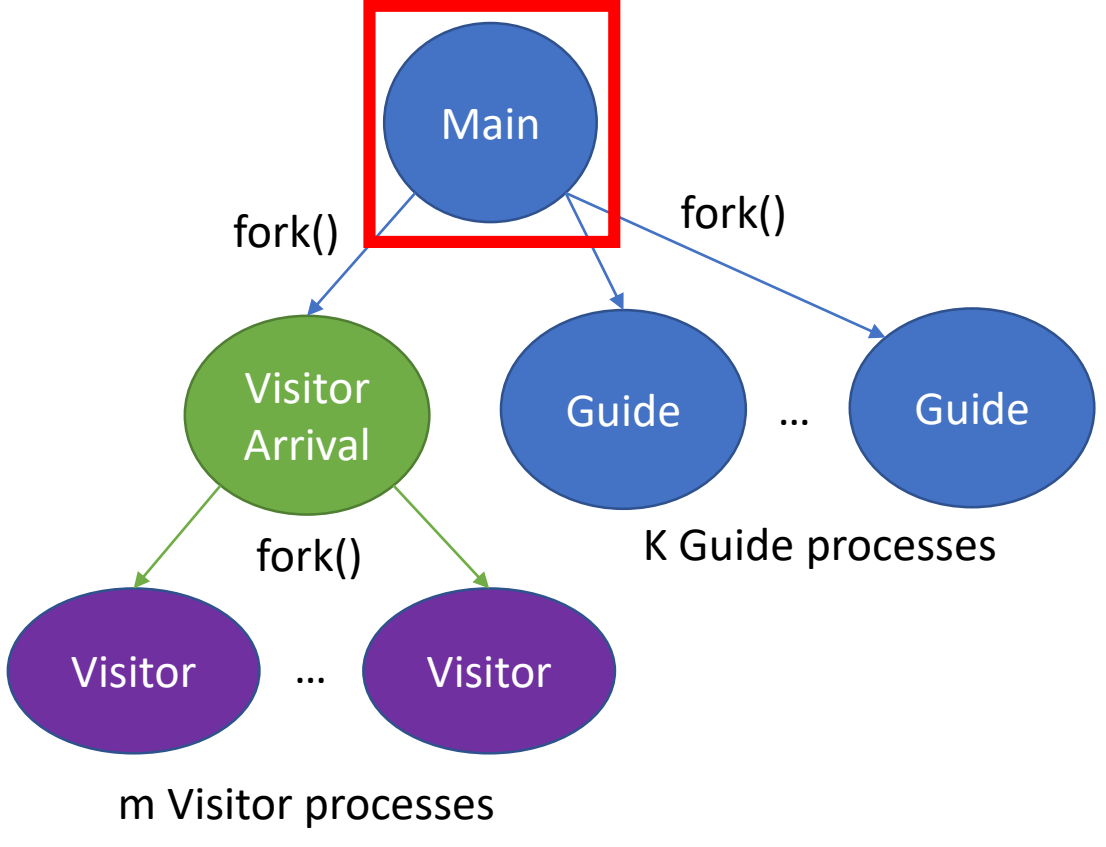
Each node **is a process**

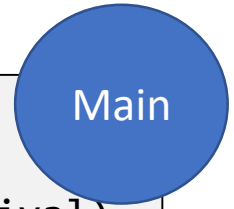


m Visitor processes

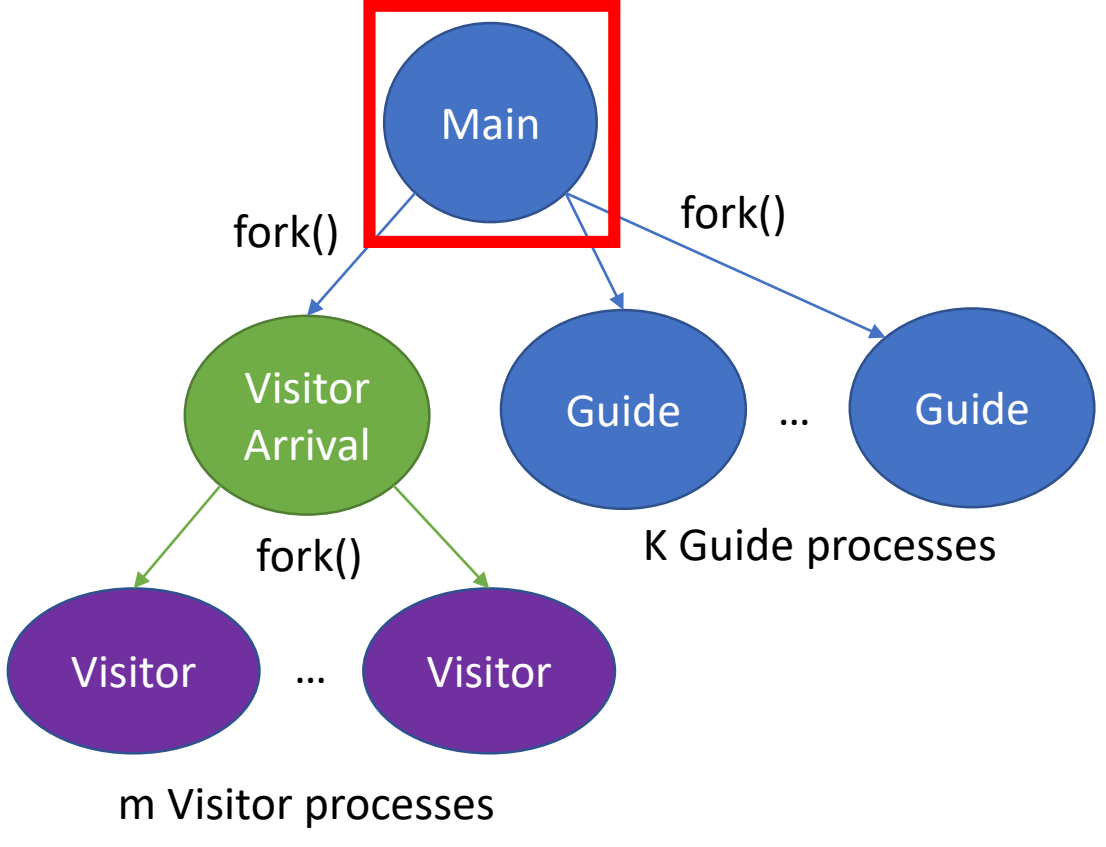
Each node **is a process**



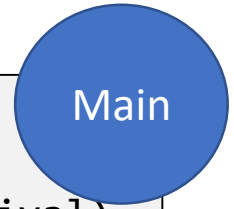





```
Main:
  int t0 = getTimeOfDay(); //1. get initial time stamp
  int pid = fork();        // 2. create child process (visitor arrival)
  if(pid == 0){            //child process when pid == 0
    VisitorArrivalProcess  //visitor arrival process
  } else {                 //original process when pid != 0
    GuideCriations         //3. create following child process(guides)
  }
```




```
Main:
  int t0 = getTimeOfDay(); //1. get initial time stamp
  int pid = fork();        // 2. create child process (visitor arrival)
  if(pid == 0){            //child process when pid == 0
    VisitorArrivalProcess  //visitor arrival process
  } else {                 //original process when pid != 0
    GuideCriations         //3. create following child process(guides)
  }
```

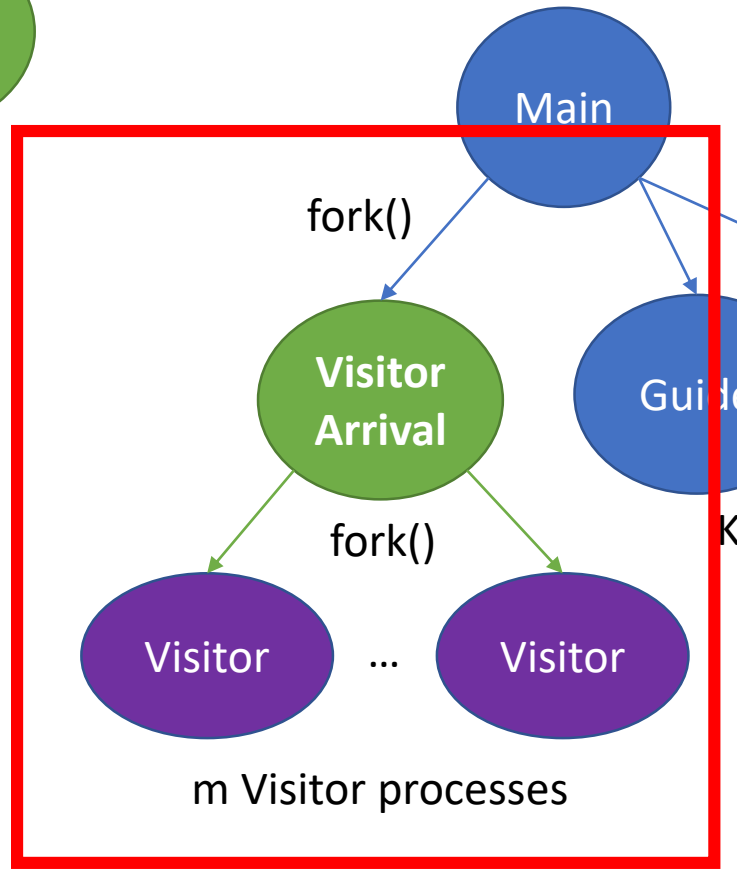


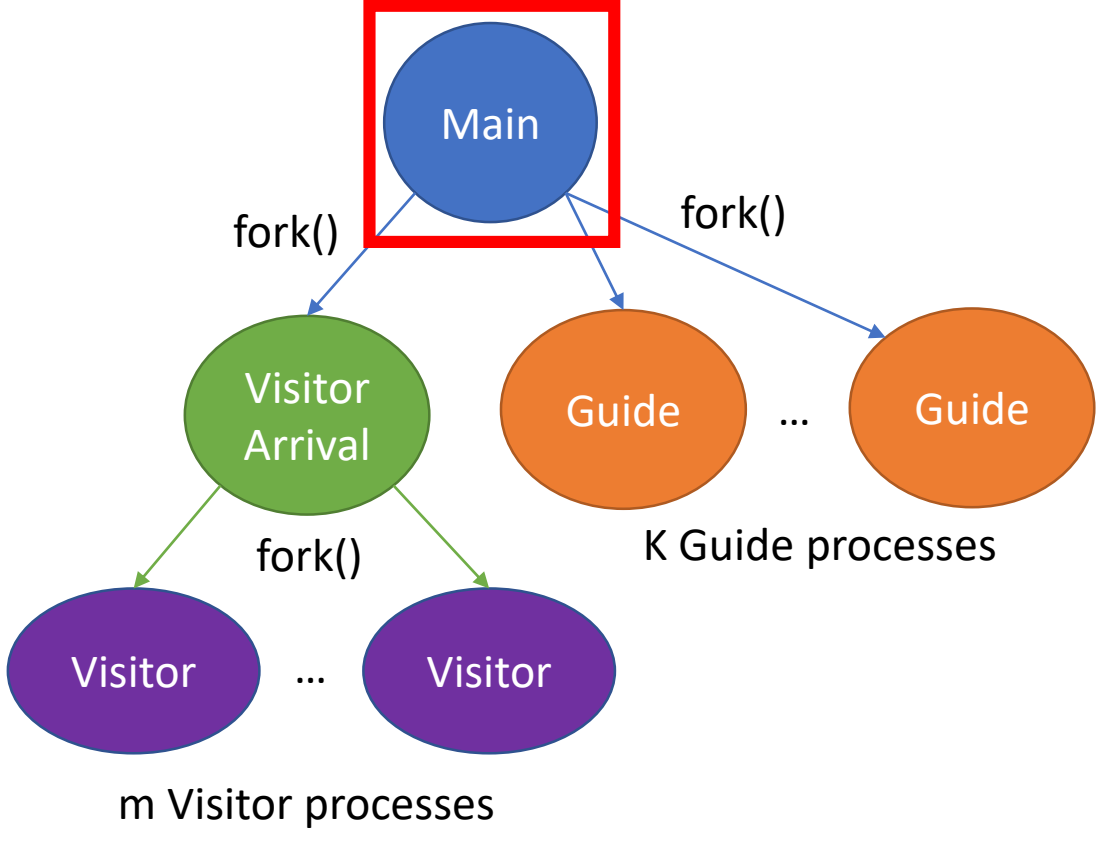
```
VisitorArrivalProcess :

  srand(seed); //1. setup random seed for random arrival
  for (int i = 0; i < m; i++){ //2. fork child processes by flip a coin
    int pid2 = fork();          //fork child processes (visitors)
    if(pid2==0){                //child process (visitors) when pid2==0
       visitors();
       exit();
    } else {     //original process(VIsitorArrivalProcess) when pid2!=0
       int value = rand() % 100 + 1;  //random number between 1-100
       if (value > 50){sleep(delay)};
    }
  }
  for (int i = 0; i < m; i++){ //3. wait until all children finished
     wait(Null);
  }
```

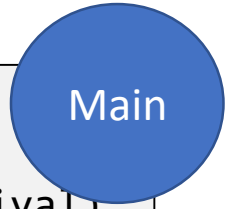
Visitor Arrival

Visitor






```
Main:
  int t0 = getTimeOfDay(); //1. get initial time stamp
  int pid = fork();        // 2. create child process (visitor arrival)
  if(pid == 0){            //child process when pid == 0
    VisitorArrivalProcess  //visitor arrival process
  } else {                 //original process when pid != 0
    GuideCriations         //3. create following child process(guides)
  }
```

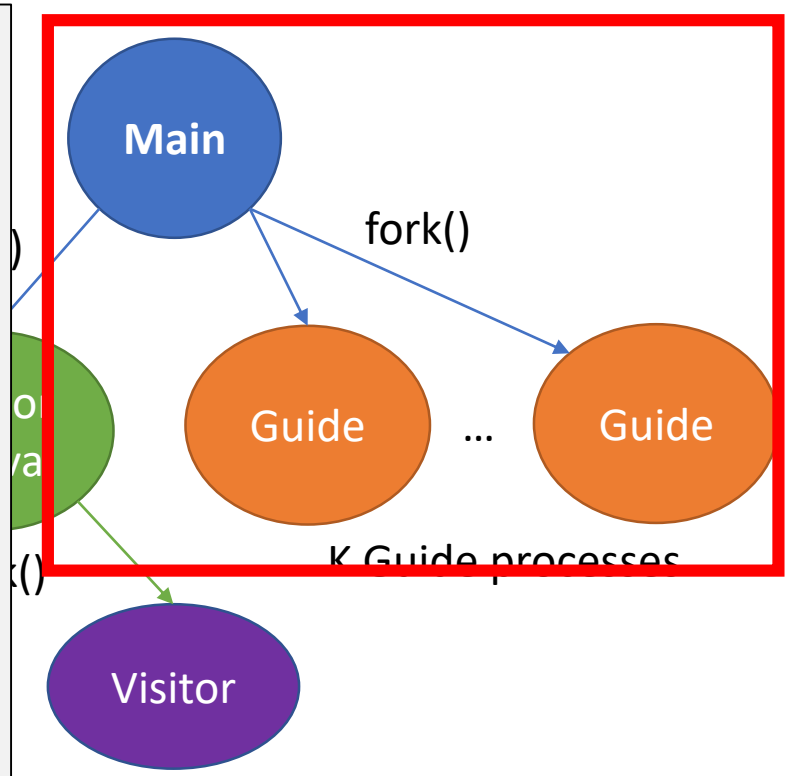


```
GuideCriations :

  srand(seed); //1. setup random seed for random arrival
  for (int i = 0; i < m; i++){ //2. fork child processes by flip a coin
    int pid2 = fork();          //fork child processes (visitors)
    if(pid2==0){                //child process (visitors) when pid2==0
       guide();
       exit();
    } else {     //original process(VIsitorArrivalProcess) when pid2!=0
       int value = rand() % 100 + 1;  //random number between 1-100
       if (value > 50){sleep(delay)};
    }
  }
  for (int i = 0; i < m; i++){ //3. wait until all children finished
     wait(Null);
  }
  wait(Null)
```

Main

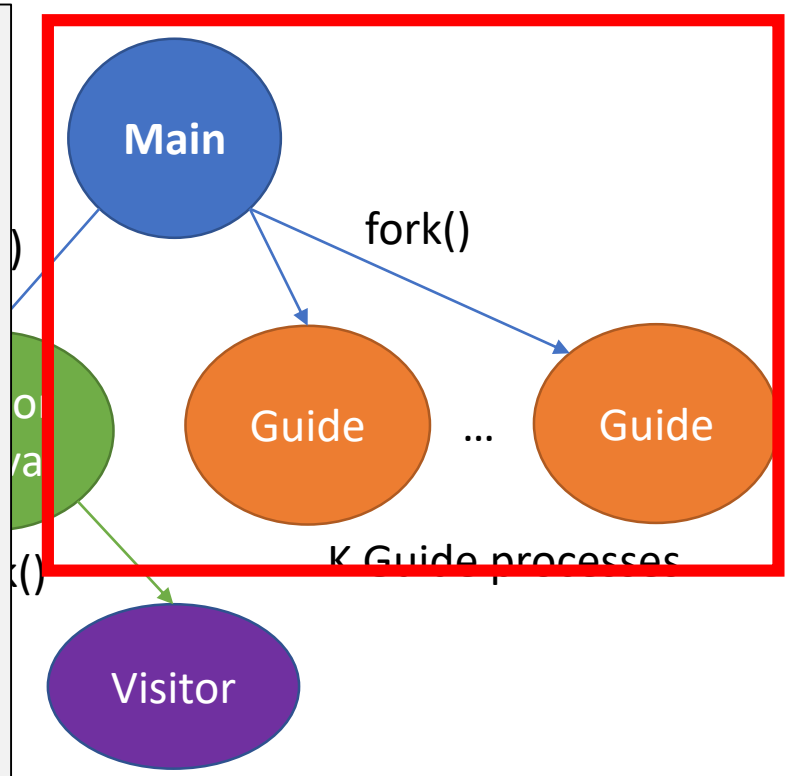
Guide

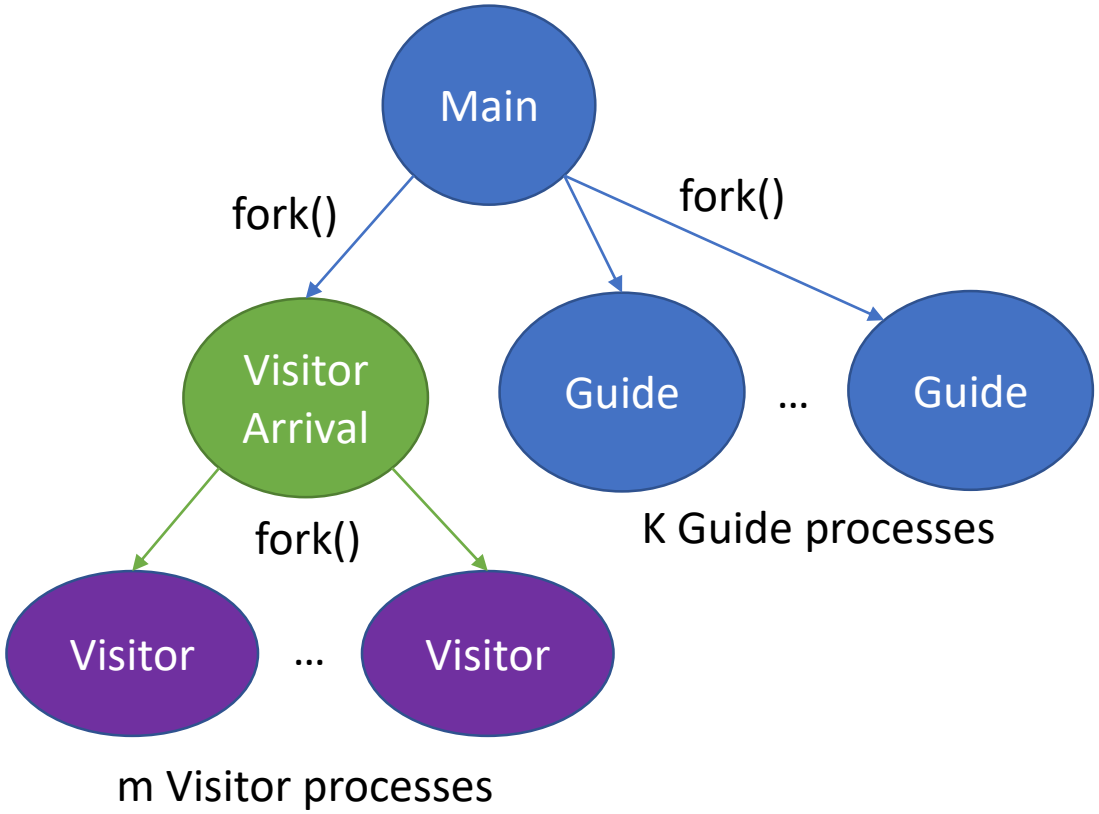


GuideCriations :

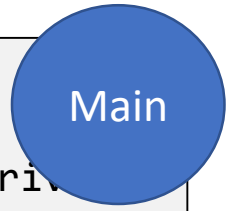
```
  srand(seed); //1. setup random seed for random arrival
  for (int i = 0; i < m; i++){ //2. fork child processes by flip a coin
     int pid2 = fork();          //fork child processes (visitors)
     if(pid2==0){                //child process (visitors) when pid2==0
        guide();
        exit();
    } else {     //original process(VIsitorArrivalProcess) when pid2!=0
        int value = rand() % 100 + 1;  //random number between 1-100
        if (value > 50){sleep(delay)};
    }
  }
  for (int i = 0; i < m; i++){ //3. wait until all children finished
     wait(Null);
  }
```

wait(Null) Parent has to wait for the VisitorArrivalProcess






```
Main:
  int t0 = getTimeOfDay(); //1. get initial time stamp
  int pid = fork();        // 2. create child process (visitor arri
  if(pid == 0){            //child process when pid == 0
    VisitorArrivalProcess  //visitor arrival process
  } else {                 //original process when pid != 0
    GuideCriations         //3. create following child process(guides)
  }
  wait(Null)
```



Project 2 - Safe Museum Tour Problem

- The visitor **process** (Program Parameter)
- The tour guide **process** (Program Parameter)
- Two processes to simulate guides and visitor's arrival
- Six functions called by these processes
  - visitorArrives()
  - tourMuseum()
  - visitorLeaves()
  - tourguideArrives()
  - openMuseum()
  - tourGuideLeaves()

Project 2 - Safe Museum Tour Problem

- For the museum to open
  - 1 tour guide
  - 1 Visitor
  - visitorArrives() is called by **visitor process**
  - tourGuideArrives() is called by **tour guide**

Project 2 - Safe Museum Tour Problem

- A **visitor** must wait if
  - Museum is closed
  - Max visitors is reached

Project 2 - Safe Museum Tour Problem

- A visitor must wait if
  - Museum is closed
  - Max visitors is reached
- An arriving tour guide **must wait if**
  - Museum is closed and no visitor is waiting, **or**
  - Museum is open, and **two tour guides** are inside the museum

Project 2 - Safe Museum Tour Problem

- A visitor must wait if
  - Museum is closed
  - Max visitors is reached
- An arriving tour guide must wait if
  - Museum is closed and no visitor is waiting, **or**
  - Museum is open, and two tour guides are inside the museum
- While only **one tour guide** is inside the museum
  - Up to ten visitors may arrive (i.e., calling visitorArrives())
  - Second tour guide may open the museum (i.e., call openMuseum())

Project 2 - Safe Museum Tour Problem

- When a tour arrives you should print
  - **Tour guide %d arrives at time d%**
- When a visitor arrives you print
  - **Visitor %d arrives at time %d**
- Remember to use these calls to print:

```
fprintf(stderr,<print content here>)
```

OR

```
printf(<print content here>);
fflush(stdout);
```

Project 2 - Safe Museum Tour Problem

- Memory allocation

  #include <sys/mman.h>

  void *mmap(void ***_addr_, size_t** _length_**, int** _prot_**, int** _flags_**, int** _fd_**, off_t** _offset_**);**

Project 2 - Safe Museum Tour Problem

- Memory allocation

  #include <sys/mman.h>

  void *mmap(void ***_addr_, size_t** _length_**, int** _prot_**, int** _flags_**, int** _fd_**, off_t** _offset_**);**

  - set flags=**MAP_SHARED** when allocating shared memory

Project 2 - Safe Museum Tour Problem

- Memory allocation

  #include <sys/mman.h>

  void *mmap(void ****addr*, size_t** *length*, **int** *prot*, **int** *flags*, **int** *fd*, **off_t** *offset*);**

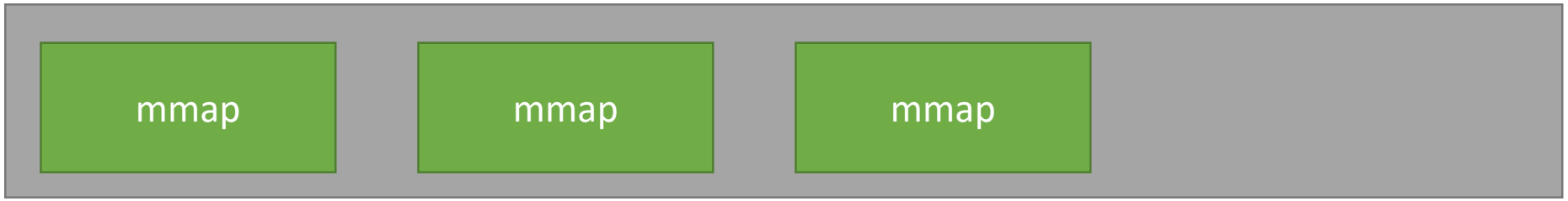
  - set flags=**MAP_SHARED** when allocating shared memory
  - Usage e.g.:

    int* const = (int*) mmap(NULL, sizeof(int), PROT_READ|PROT_WRITE, MAP_SHARED|MAP_ANONYMOUS, 0, 0);

  - More info: http://man7.org/linux/man-pages/man2/mmap.2.html

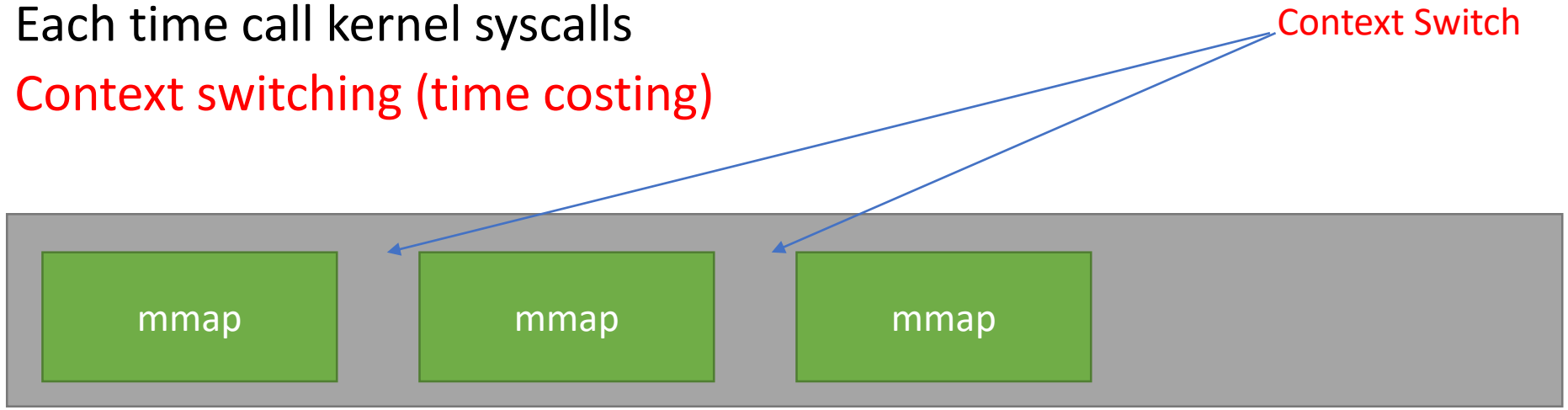
Project 2 - Safe Museum Tour Problem

- Memory allocation
  - Each time call kernel syscalls



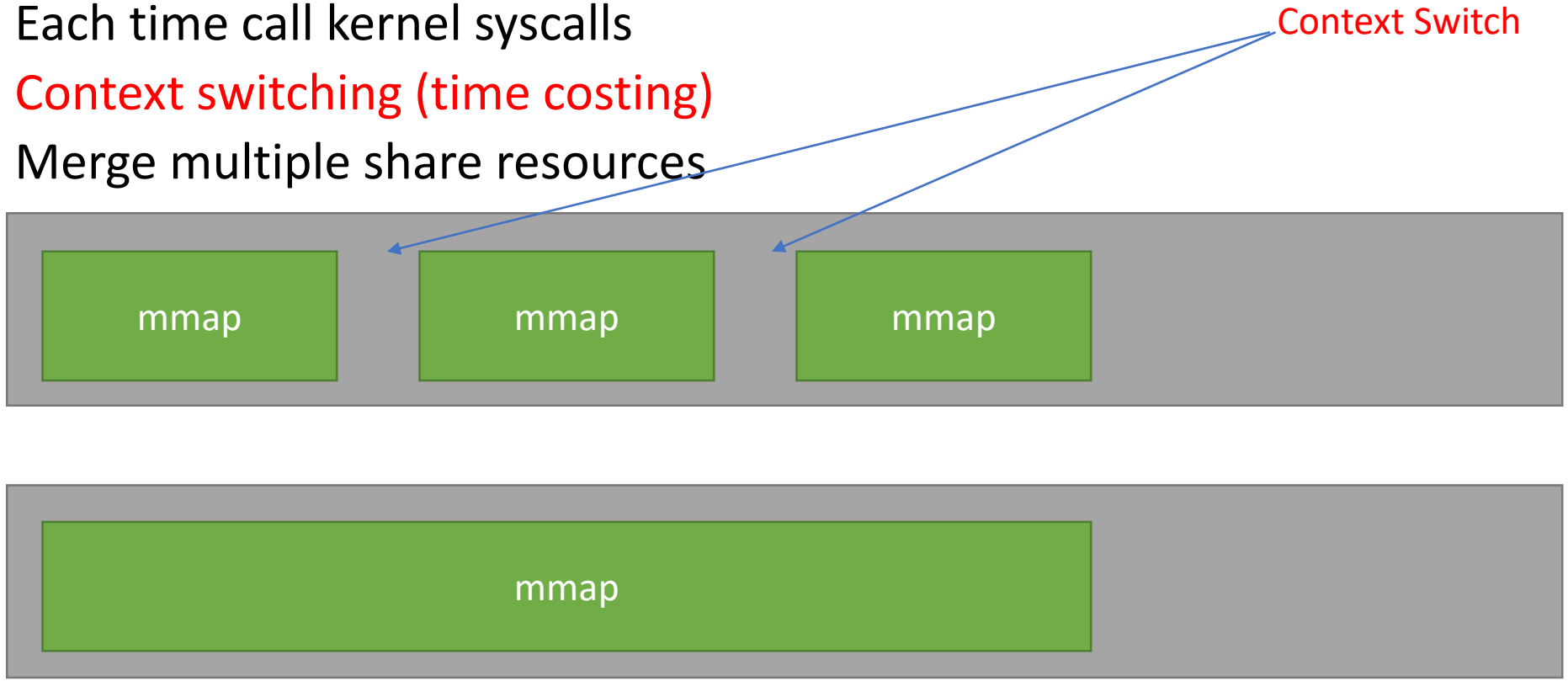
Project 2 - Safe Museum Tour Problem

- Memory allocation
  - Each time call kernel syscalls
  - Context switching (time costing)



Project 2 - Safe Museum Tour Problem

- Memory allocation
  - Each time call kernel syscalls
  - Context switching (time costing)
  - Merge multiple share resources



Project 2 - Safe Museum Tour Problem

- Memory allocation
  - Each time call kernel syscalls
  - Context switching (time costing)
  - Merge multiple share resources

```
struct shared_mem{
        int visitors;
        int guides;
        struct cs1550_sem sem1;
        …
}
```

CS 1550

Week 7 - Project 2 Discussion

Teaching Assistant

Henrique Potter