Embedded Operating Systems

Circular buffer

protoCore 0.00001

Prof. Otávio Gomes

otavio.gomes@unifei.edu.br

in /otavio-gomes

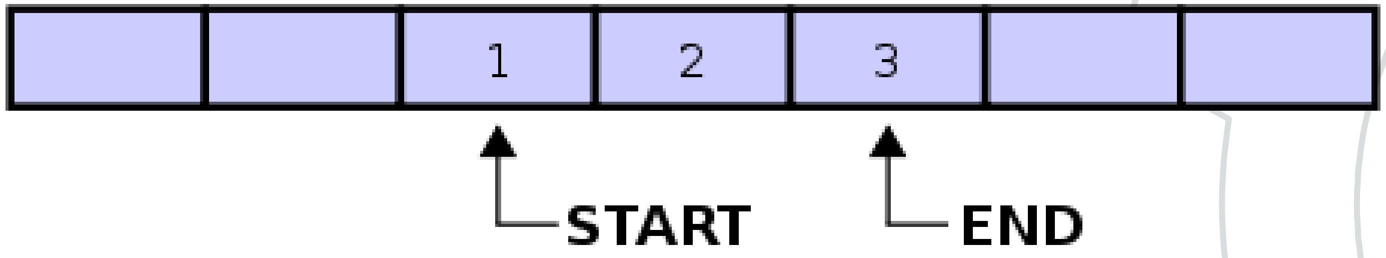
Circular buffers

Circular Buffers

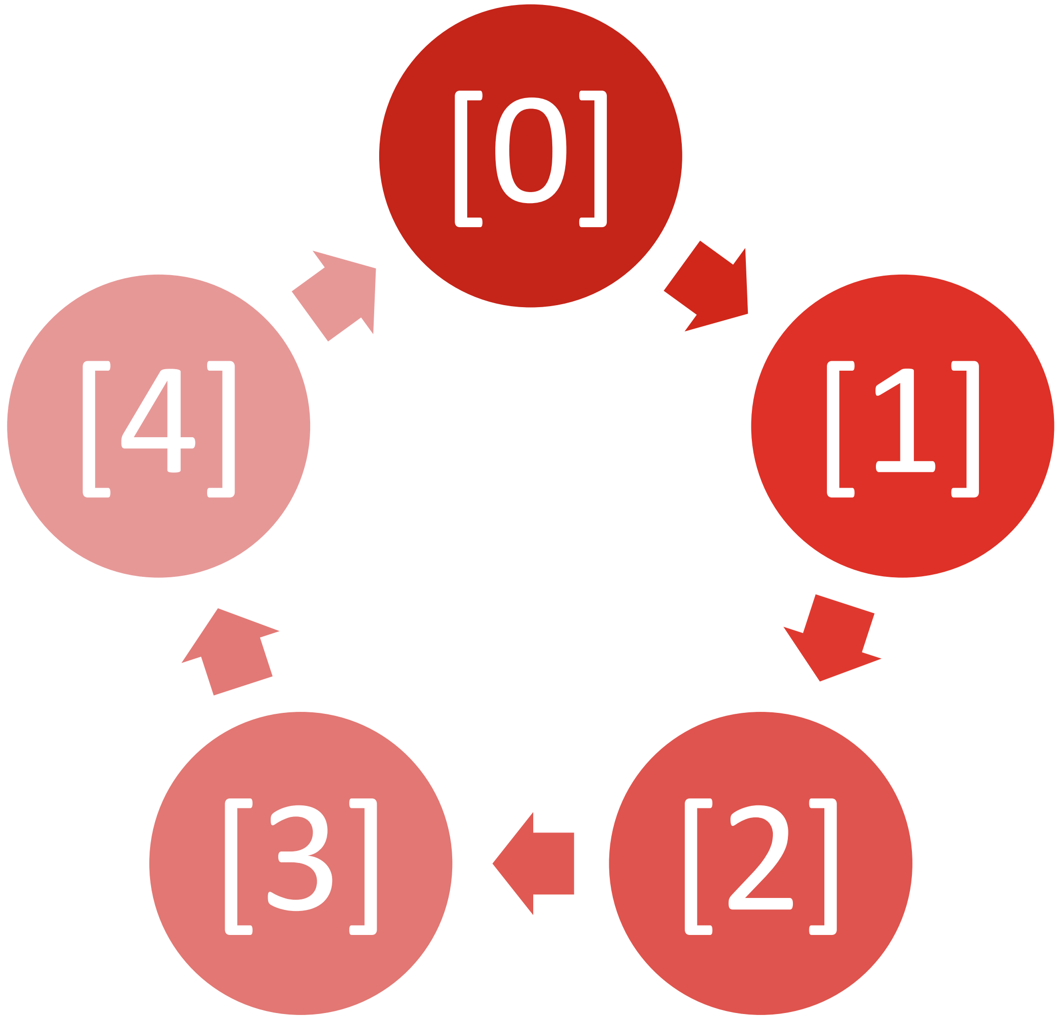
- “Endless” memory spaces
- Use FIFO aproach
- Store temporary data
- Can implemented using vectors or linked-lists

Circular Buffers

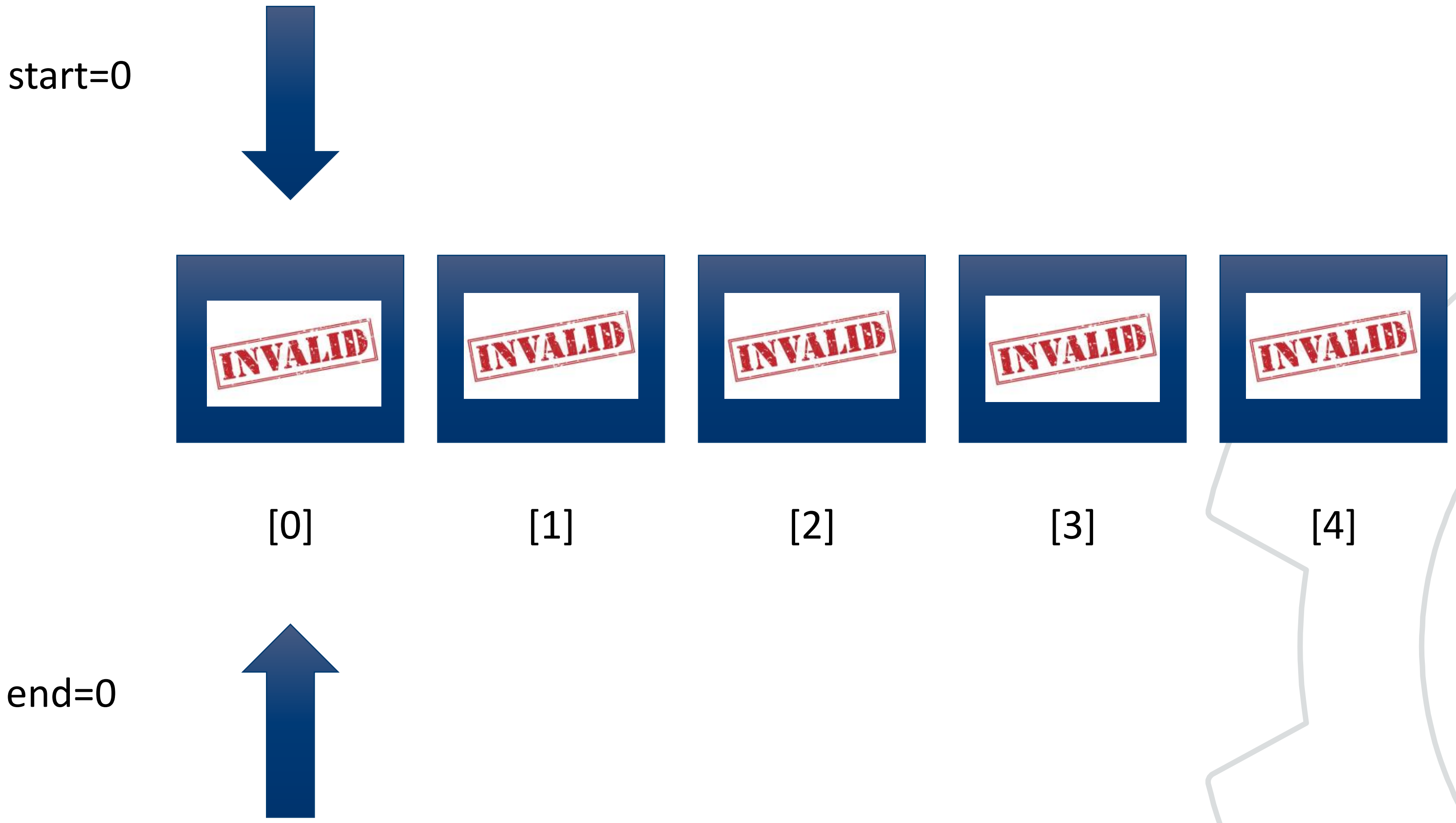
- Vector implementation
  - Uses less space
  - Need special caution when cycling
  - Problem to differentiate full from empty



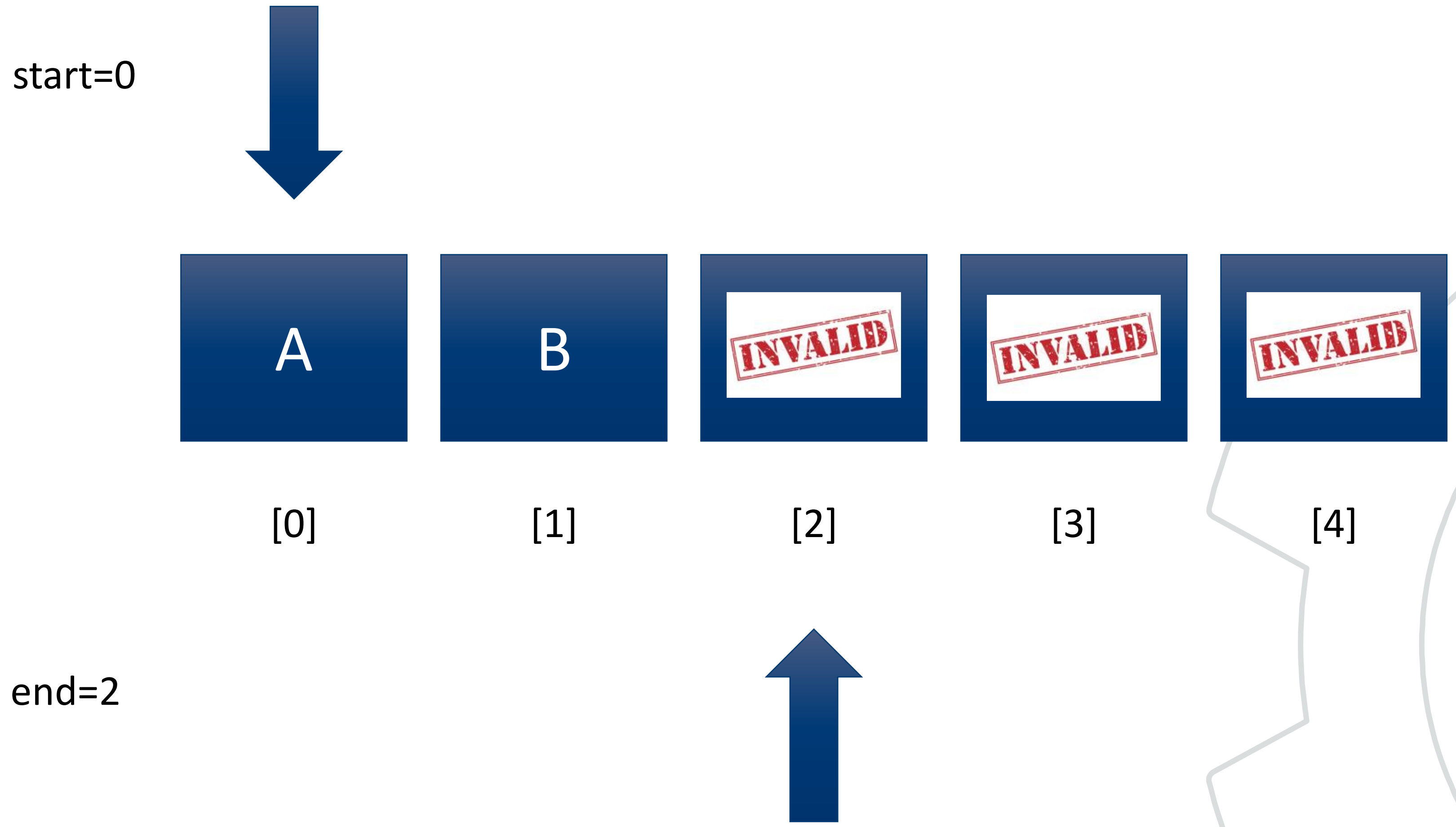
Circular Buffers



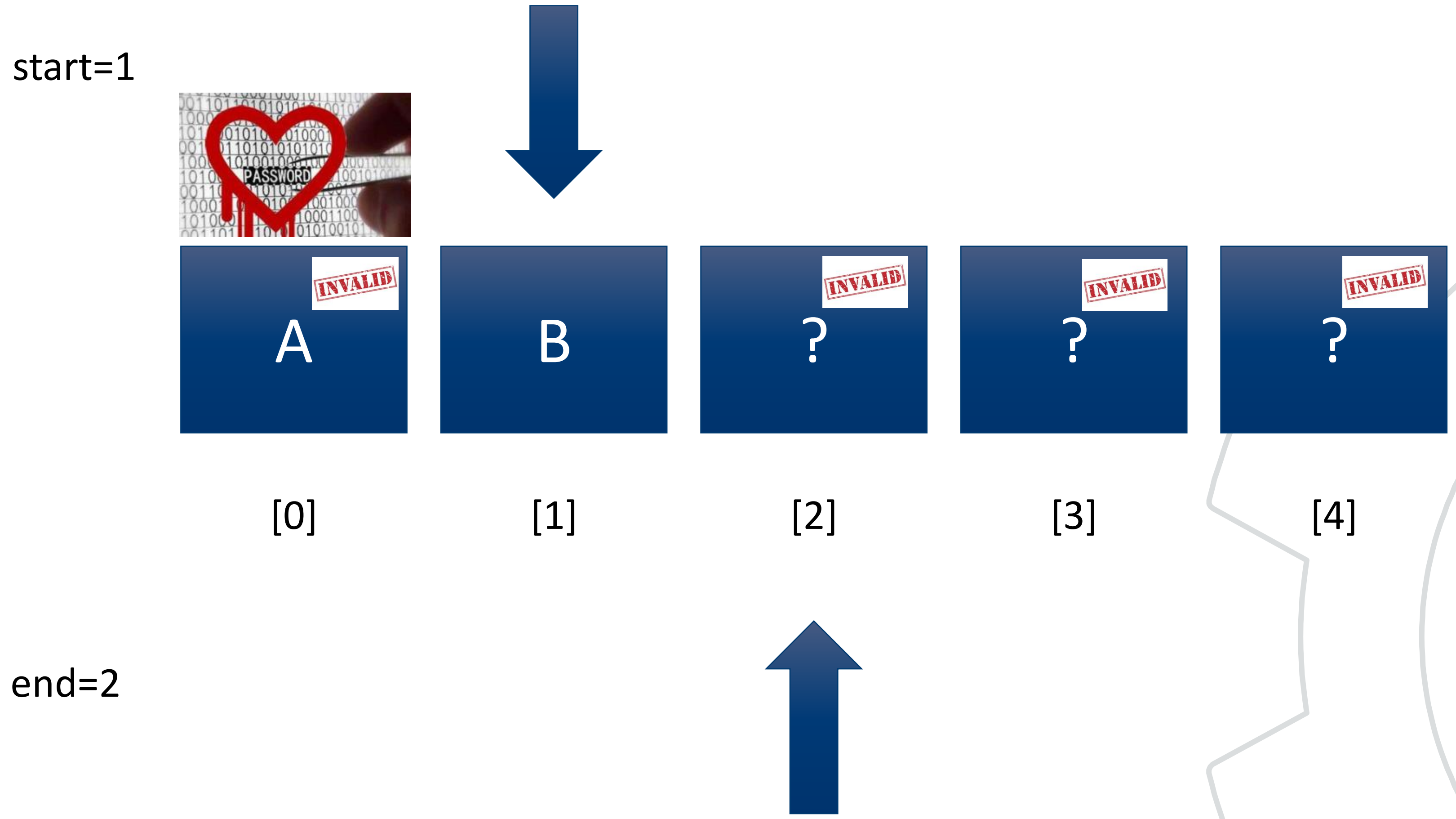
Empty Buffer



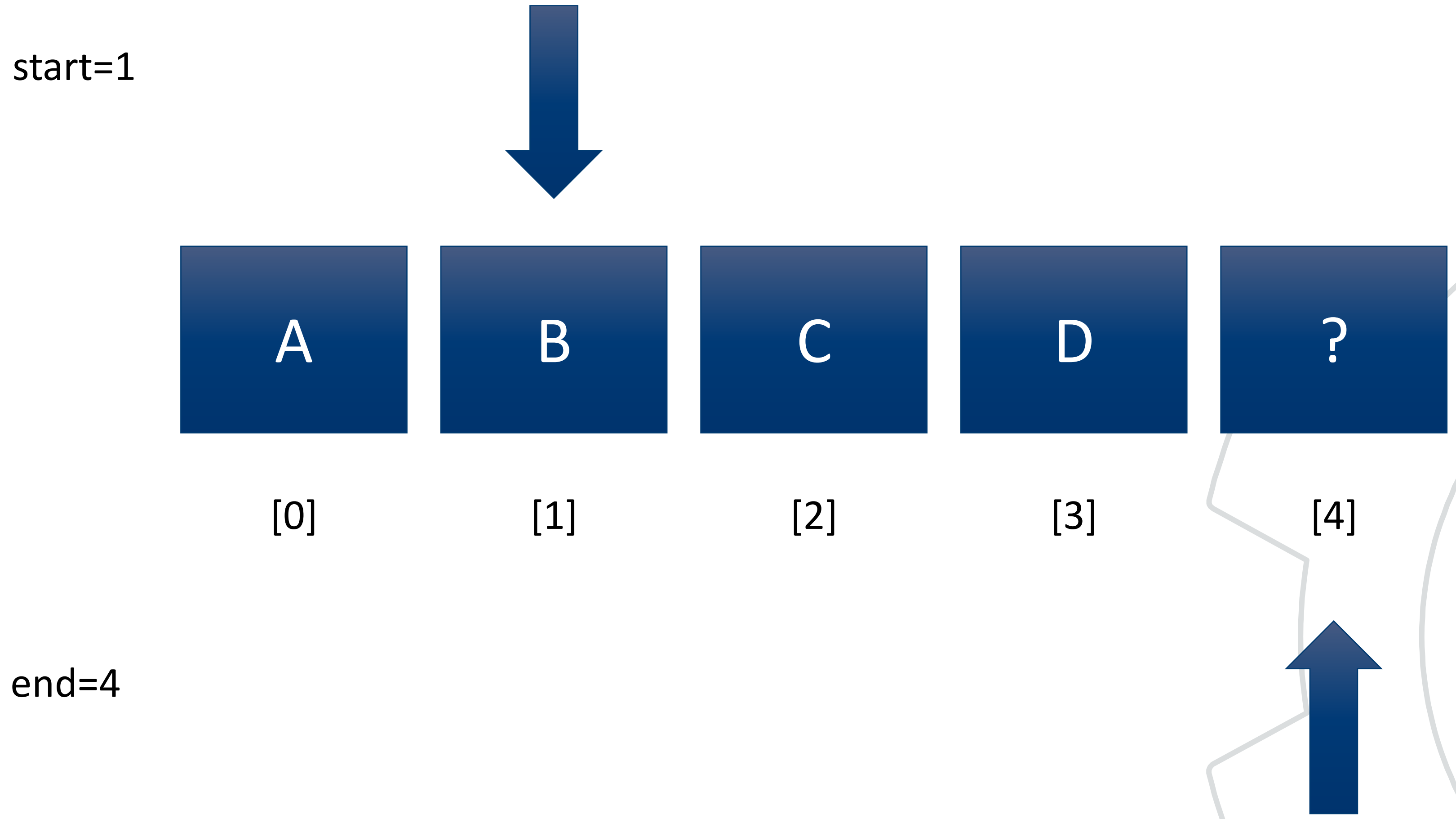
Adding 2 elements



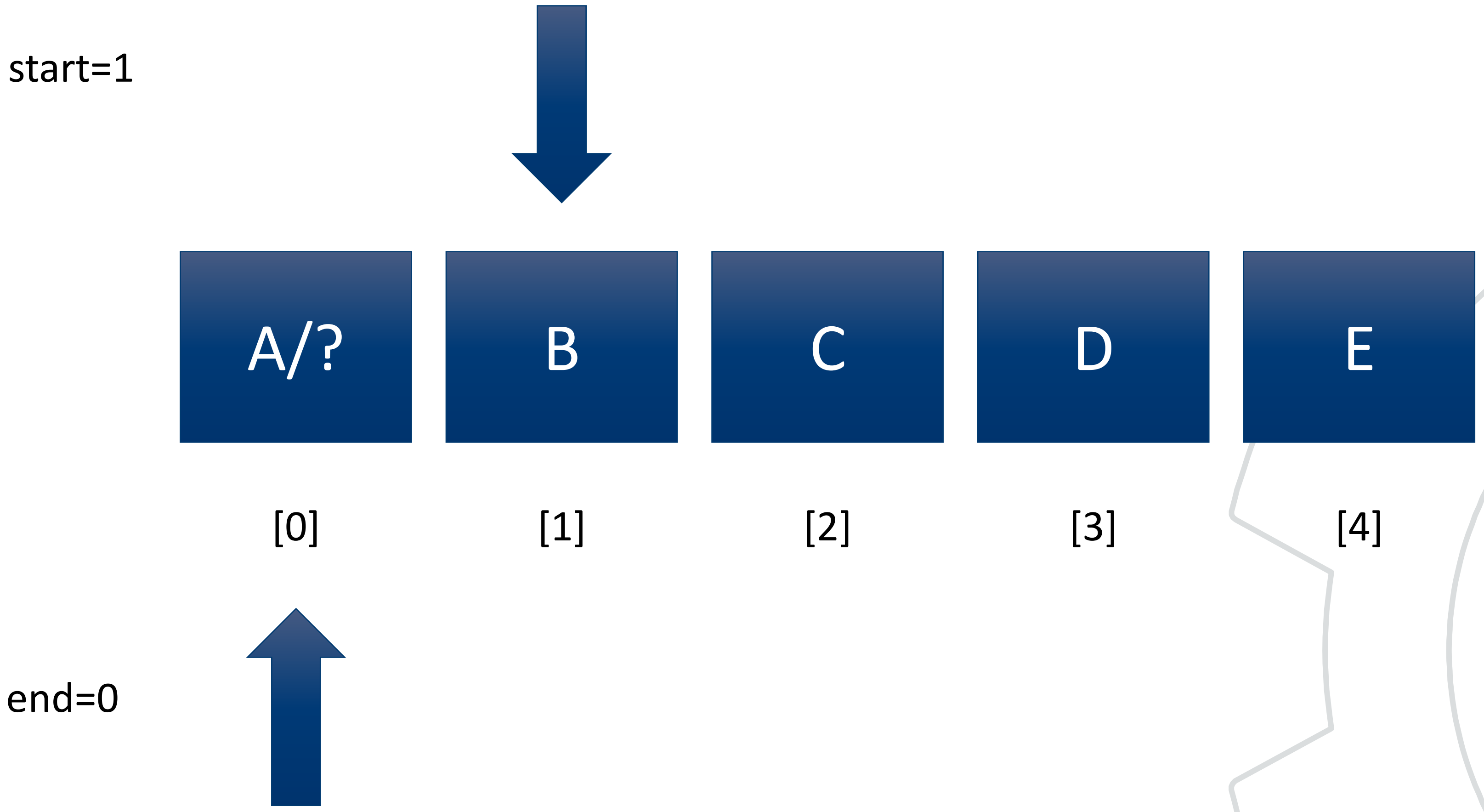
Removing 1 element



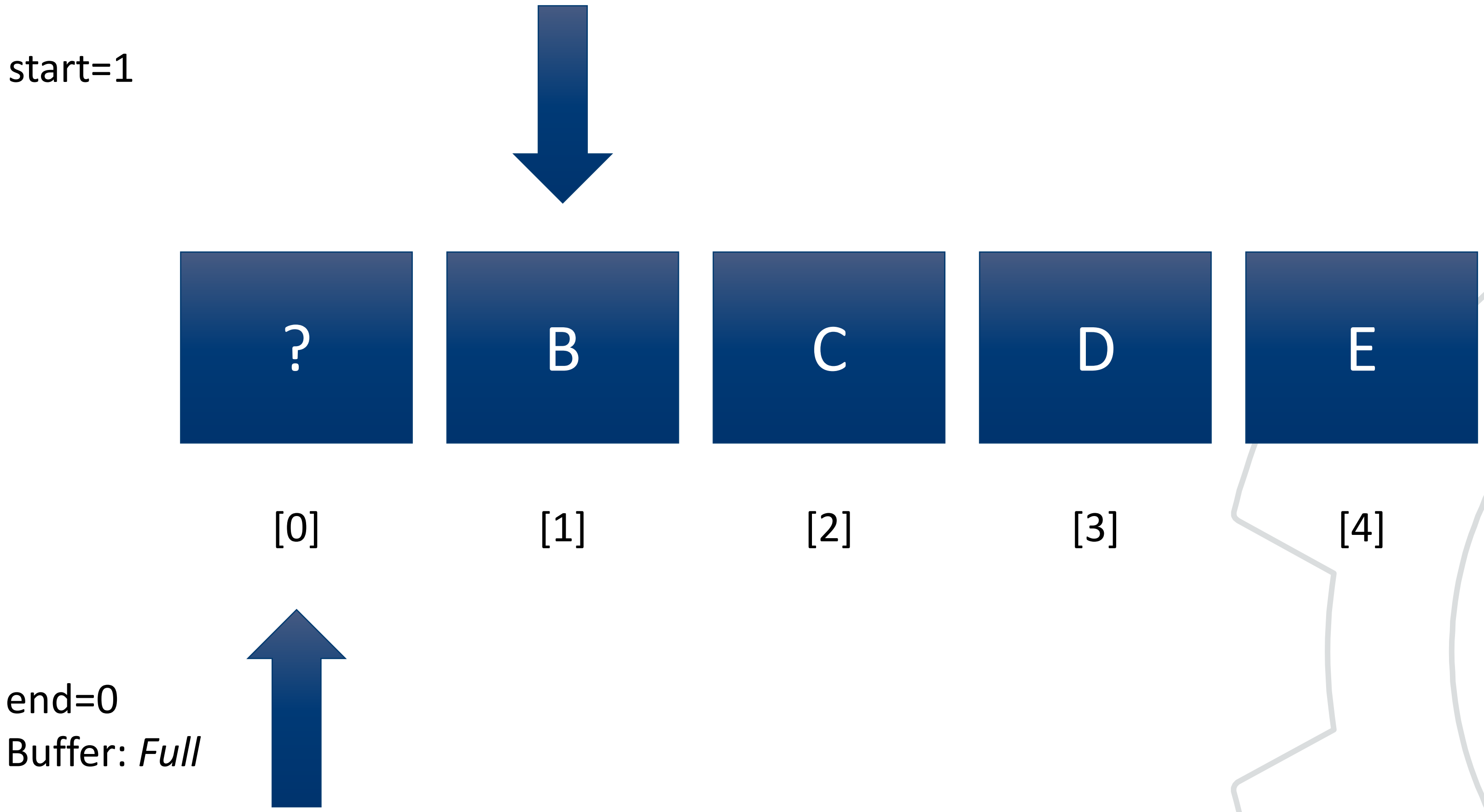
Adding 2 elements



Adding 1 element



Full Buffer



```
#define CB_SIZE 10

int circular_buffer[CB_SIZE];

int index=0;

for(;;){
    //do anything with the buffer
    circular_buffer[index] = index;
    //increment the index
    index = (index+1)%CB_SIZE;
}
```

Circular buffers

```c
#define CB_SIZE 10

int circular_buffer[CB_SIZE];

int index=0;

for(;;){
    //do anything with the buffer
    circular_buffer[index] = index;
    //increment the index
    index = (index+1)%CB_SIZE; //index++;
}
```

Circular buffers

```c
#define CB_SIZE 10
int circular_buffer[CB_SIZE];
int start=0, end=0;

char AddBuff(int newData)
{
  //check if there is space to add a number
  if ( ((end+1)%CB_SIZE) != start)
  {
    circular_buffer[end] = newData;
    end = (end+1)%CB_SIZE;
    return SUCCESS;
  }
  return FAIL;
}
```

Circular buffers

```
#define CB_SIZE 10
int circular_buffer[CB_SIZE];
int start=0, end=0;

char AddBuff(int newData)
{
  //check if there is space to add a number
  if ( ((end+1)%CB_SIZE) != start)
  {
    circular_buffer[end] = newData;
    end = (end+1)%CB_SIZE;
    return SUCCESS;
  }
  return FAIL;
}
```

Exercise

- Implement a circular buffer
  - Use a 10-position vector
- Each element of the vector is a structure with two variables
  - `char * ProcessName;`
  - `int Time;`

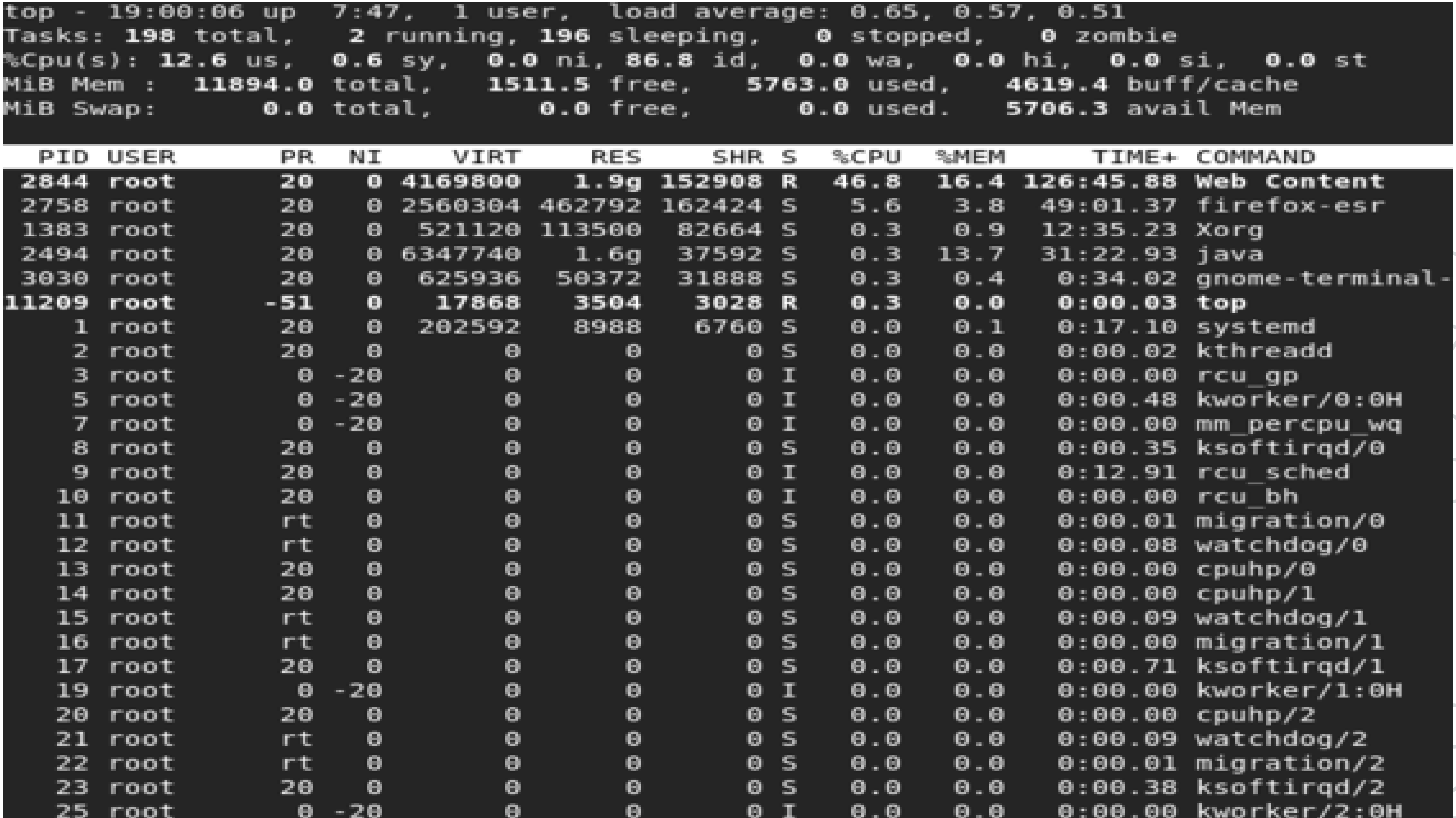
- Create one function to add new elements and one to remove the oldest elements.

```c
typedef struct {
    char* processName;
    int time;
}process;

//circular buffer declaration
#define BUFFERSIZE  10
process buffer[BUFFERSIZE];

//Declaration of access pointers
int start=0, end=0;
```

Exercise



```
top - 19:00:06 up  7:47,  1 user,  load average: 0.65, 0.57, 0.51
Tasks: 198 total,   2 running, 196 sleeping,   0 stopped,   0 zombie
%Cpu(s): 12.6 us,  0.6 sy,  0.0 ni, 86.8 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem :  11894.0 total,   1511.5 free,   5763.0 used,   4619.4 buff/cache
MiB Swap:      0.0 total,      0.0 free,      0.0 used.   5706.3 avail Mem

  PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
 2844 root      20   0 4169800   1.9g 152908 R  46.8  16.4 126:45.88 Web Content
 2758 root      20   0 2560304 462792 162424 S   5.6   3.8  49:01.37 firefox-esr
 1383 root      20   0  521120 113500  82664 S   0.3   0.9  12:35.23 Xorg
 2494 root      20   0 6347740   1.6g  37592 S   0.3  13.7  31:22.93 java
 3030 root      20   0  625936  50372  31888 S   0.3   0.4   0:34.02 gnome-terminal-
11209 root     -51   0   17868   3504   3028 R   0.3   0.0   0:00.03 top
    1 root      20   0  202592   8988   6760 S   0.0   0.1   0:17.10 systemd
    2 root      20   0       0      0      0 S   0.0   0.0   0:00.02 kthreadd
    3 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 rcu_gp
    5 root       0 -20       0      0      0 I   0.0   0.0   0:00.48 kworker/0:0H
    7 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 mm_percpu_wq
    8 root      20   0       0      0      0 S   0.0   0.0   0:00.35 ksoftirqd/0
    9 root      20   0       0      0      0 I   0.0   0.0   0:12.91 rcu_sched
   10 root      20   0       0      0      0 I   0.0   0.0   0:00.00 rcu_bh
   11 root      rt   0       0      0      0 S   0.0   0.0   0:00.01 migration/0
   12 root      rt   0       0      0      0 S   0.0   0.0   0:00.08 watchdog/0
   13 root      20   0       0      0      0 S   0.0   0.0   0:00.00 cpuhp/0
   14 root      20   0       0      0      0 S   0.0   0.0   0:00.00 cpuhp/1
   15 root      rt   0       0      0      0 S   0.0   0.0   0:00.09 watchdog/1
   16 root      rt   0       0      0      0 S   0.0   0.0   0:00.00 migration/1
   17 root      20   0       0      0      0 S   0.0   0.0   0:00.71 ksoftirqd/1
   19 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/1:0H
   20 root      20   0       0      0      0 S   0.0   0.0   0:00.00 cpuhp/2
   21 root      rt   0       0      0      0 S   0.0   0.0   0:00.09 watchdog/2
   22 root      rt   0       0      0      0 S   0.0   0.0   0:00.01 migration/2
   23 root      20   0       0      0      0 S   0.0   0.0   0:00.38 ksoftirqd/2
   25 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker/2:0H
```

```
//Function to add process to buffer
void addProc(char *nname, int ntime){

  //Verification of position (full?)
  if ( ((end+1)%BUFFERSIZE) != start){
    //Current position update
     buffer[end].processName = nname;
     buffer[end].time = ntime;
    //increment circular buffer position
     end = (end+1)%(BUFFERSIZE);
  }
}
```

Exercise

```c
//Function to add process to buffer
void addProc(char *nname, int ntime){

  //Verification of position (full?)
  if ( ((end+1)%BUFFERSIZE) != start){
    //Current position update
    buffer[end].processName = nname;
    buffer[end].time = ntime;
    //increment circular buffer position
    end = (end+1)%(BUFFERSIZE);
  }
}
```

Exercise

```c
//Function to add process to buffer
void addProc(char *nname, int ntime){

  //Verification of position (full?)
   if ( ((end+1)%BUFFERSIZE) != start){
    //Current position update
     buffer[end].processName = nname;
     buffer[end].time = ntime;
    //increment circular buffer position
     end = (end+1)%(BUFFERSIZE);
   }
}
```

Exercise

TO DO: Try/Catch or SUCCESS/FAIL

```
//Function to remove process from buffer
void removeProc (void){

  //Verification of position (empty?)
   if (end != start){
     //increment circular buffer start position
       start = (start +1)%(BUFFERSIZE);
   }

}
```

Exercise

```c
#include "stdio.h"
void main (void){
  addProc("proc1", 0);
  addProc("proc2", 1);
  addProc("proc3", 2);
  removeProc();
  removeProc();
  removeProc();
}
```

Exercise

Software engines

Kernel – abstraction and management

Software engines

- **Goal:**
  - Make an image editor that can choose the right function to call
- 1st Implementation
  - Use a option parameter as a switch operator

```
image Blur(image nImg){}
image Sharpen(image nImg){}

image imageEditorEngine(image nImg, int opt){
  image temp;
  switch(opt){
    case 1:
      temp = Sharpen(nImg);
      break;
    case 2:
      temp = Blur(nImg);
      break;
  }
  return temp;
}
```

Software engines

Software engines

```
image Blur(image nImg){}
image Sharpen(image nImg){}

image imageEditorEngine(image nImg, int opt){
  image temp;
  switch(opt){
    case 1:
      temp = Sharpen(nImg);
      break;
    case 2:
      temp = Blur(nImg);
      break;
  }
  return temp;
}
```

Why not?

```
Sharpen(nImg);
      or
Blur(nImg);
```

```
image Blur(image nImg){}
image Sharpen(image nImg){}

image imageEditorEngine(image nImg, int opt){
  image temp;
  switch(opt){
    case 1:
      temp = Sharpen(nImg);
      break;
    case 2:
      temp = Blur(nImg);
      break;
  }
  return temp;
}
```

Software engines

GET and **SET** methods

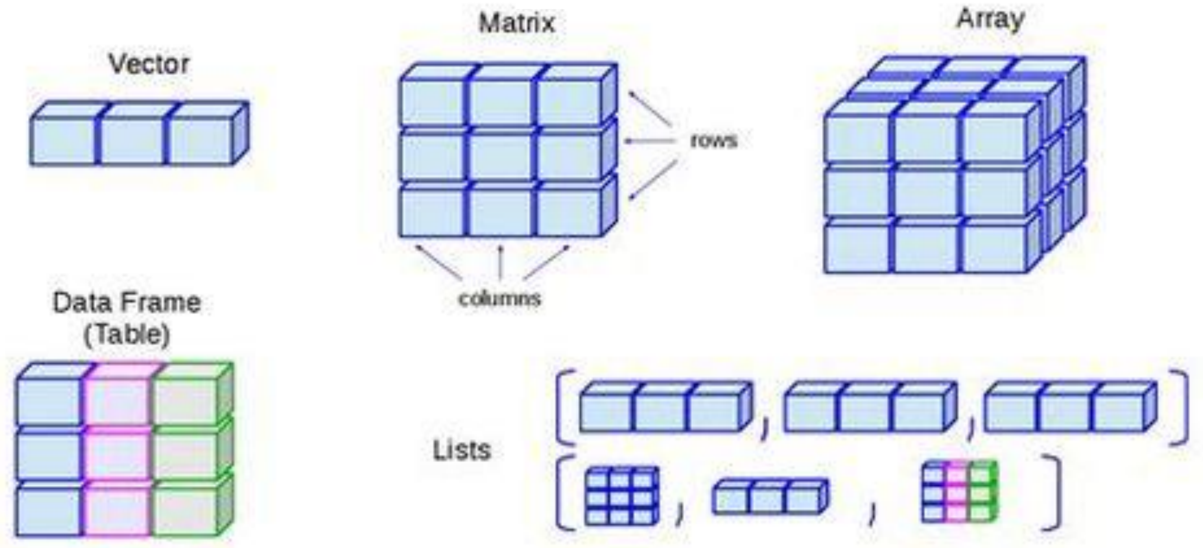
- Permissions
- Img Resolution
- File Type

Variables
Versus
Circular buffer

```
image Blur(image nImg){}
image Sharpen(image nImg){}

image imageEditorEngine(image nImg, int opt){
  image temp;
  switch(opt){
    case 1:
      temp = Sharpen(nImg);
      break;
    case 2:
      temp = Blur(nImg);
      break;
  }
  return temp;
}
```

Variables
Versus



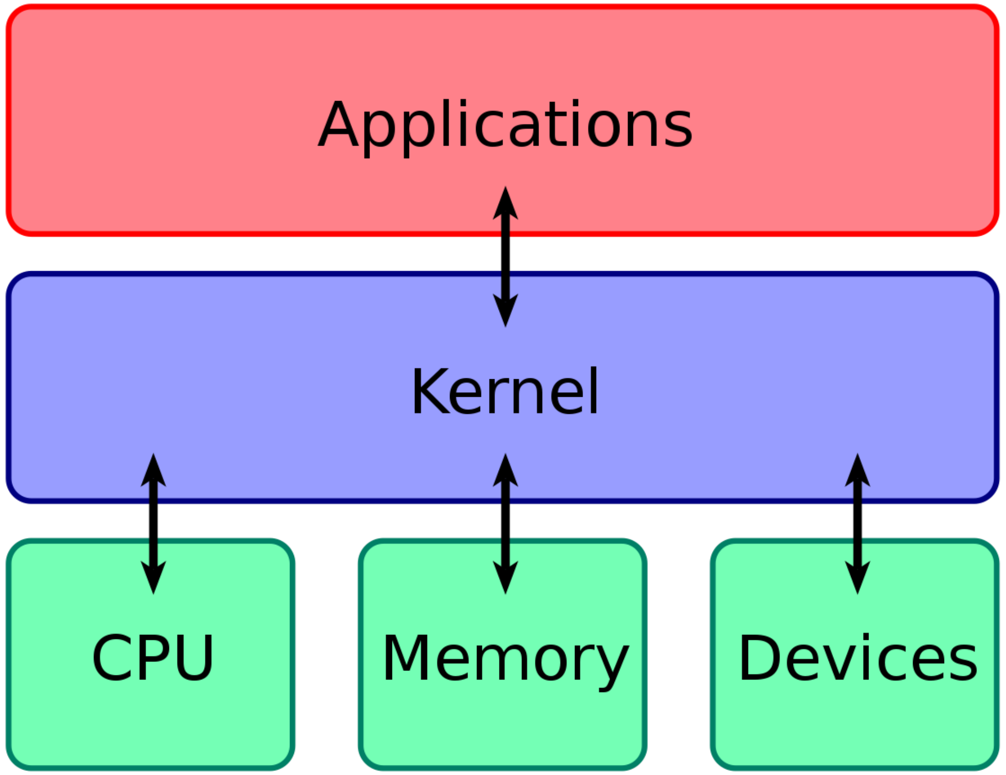
Easy to handle with a lot of data

Software engines

Function pointers

Problem

How to execute a function that **is not known at compile time**?



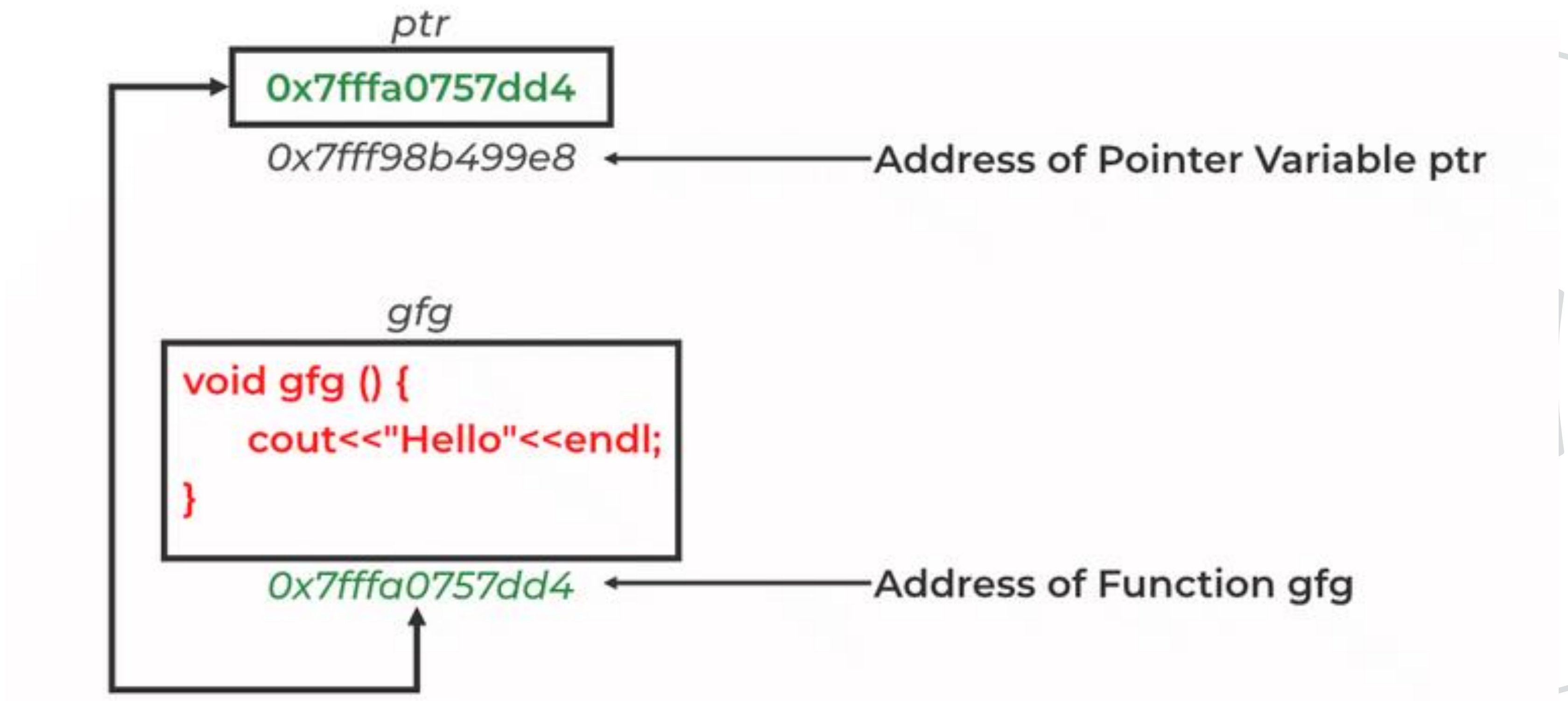
Problem

How to execute a function that **is not known at compile time**?

- Know the address of the function at runtime.
- Stack the parameters correctly that the function needs
- Make a function call to this address

Function pointers

- Work *almost* as a normal pointer
- Its manipulation obeys all pointer manipulation rules
- Hold the address of a function start point instead the address of a variable



```
void gfg () {
    cout<<"Hello"<<endl;
}
```

Function pointers

- Work *almost* as a normal pointer
- Its manipulation obeys all pointer manipulation rules
- Hold the address of a function start point instead the address of a variable
- The compiler <u>need no known the function signature</u> to pass the correct parameters and the return value.
- Awkard declaration (it is best to <u>**use a typedef**</u>)

Function pointers

```c
//defining the type pointerTest
//it is a pointer to function that:
//   receives no parameter
//   returns no parameter
void (*pointerTest)(void);
```

Function pointers

```
//defining the type pointerTest
//it is a pointer to function that:
//   receives no parameter
//   returns no parameter
void (*pointerTest)(void);

//Function to be called
void nop (void){ __asm NOP __endasm }

//creating an pointerTest variable;
(*pointerTest)(void) foo;
foo = nop; //foo receives the address of nop
(*foo)(); //calling the function via pointer
// or foo();
```

Function pointers

```
//defining the type pointerTest
//it is a pointer to function that:
//   receives no parameter
//   returns no parameter
// ~~void (*pointerTest)(void);~~
typedef void (*pointerTest)(void);
```

Function pointers

```
//defining the type pointerTest
//it is a pointer to function that:
//   receives no parameter
//   returns no parameter
typedef void (*pointerTest)(void);

//Function to be called
void nop (void){ __asm NOP __endasm }

//creating an pointerTest variable;
pointerTest foo;
foo = nop; //foo receives the address of nop
(*foo)(); //calling the function via pointer
// or foo();
```

Function pointers

Re-code the image editor engine using function pointers

Function pointers

```
image Blur(image nImg){}

image Sharpen(image nImg){}

typedef image (*ptrFunc)(image nImg);

//image editor engine
image imageEditorEngine(ptrFunc function,
                        image nImg){
    image temp;
    temp = (*function)(nImg);
    return temp;
}
```

Function pointers

```
image Blur(image nImg){}

image Sharpen(image nImg){}

typedef image (*ptrFunc)(image nImg);

//image editor engine
image imageEditorEngine(ptrFunc function,
                        image nImg){
    image temp;
    temp = (*function)(nImg);
    return temp;
}
```

Receive:
functionPtr & image

It executes the function with the image
Function returns the result

Returns:
image

Function pointers

- **Good**
  - New function additions do **not alter the engine**
  - The engine only needs to be tested once
  - Can change the function implementations **dynamically**
- **Bad**
  - **More complex** code (function pointers are not easy to understand for beginners)
  - Probable *bugs*
  - Lack of **compile time guarantees** (function signature)

Function pointers

```
int plus(int a, int b) { return a+b; }
int minus(int a, int b) { return a-b; }




int main() {
  int (*func)(int, int);
  func = plus;
  printf("%d\n", func(2,5));
  return 0;
}
```

Function pointers

```
int plus(int a, int b) { return a+b; }
int minus(int a, int b) { return a-b; }
int times(int a, int b) { return a*b; }
int divide(int a, int b) { return a/b; }

int main() {
  int (*func)(int, int);
  func = plus;
  printf("%d\n", func(2,5));
  return 0;
}
```

Function pointers

```c
int plus(int a, int b) { return a+b; }
int minus(int a, int b) { return a-b; }
int times(int a, int b) { return a*b; }
int divide(int a, int b) { return a/b; }

int main() {
  int (*func)(int, int);
  func = plus;
  printf("%d\n", func(2,5));
  return 0;
}
```

Only new features/functions must to be tested

Exercise

Using function pointers

Exercise

- Update last class structure to include a function pointer as one of its members.
- Create a function (ExecProc) that executes the pointer stored in the "first" filled position of the circular buffer.
- Create a main that executes the commands to the side:
- Create the three different functions, each printing a different phrase.

```
#include "stdio.h"
void main (void){
    addProc(p1);
    addProc(p2);
    addProc(p3);
    ExeProc();
    RemoveProc();
    ExeProc();
    RemoveProc();
    ExeProc();
    RemoveProc();
}
```

```
#include "stdio.h"
void main (void){
   addProc("proc1", 0);
   addProc("proc2", 1);
   addProc("proc3", 2);
   removeProc();
   removeProc();
   removeProc();
}
```

Exercise

Exercise

- Update last class structure to include a function pointer as one of its members.
- Create a function (ExecProc) that executes the pointer stored in the "first" filled position of the circular buffer.
- Create a main that executes the commands to the side:
- Create the three different functions, each printing a different phrase.

```
#include "stdio.h"
void main (void){
    addProc(p1);
    addProc(p2);
    addProc(p3);
    ExeProc();
    RemoveProc();
    ExeProc();
    RemoveProc();
    ExeProc();
    RemoveProc();
}
```

```c
typedef int (*ptrFunc)(void);

typedef struct {
    char name;
    int time;
    ptrFunc func;
}process;

#define BUFFERSIZE  10
process buffer[BUFFERSIZE];

int start=0, end=0;
```

Exercise

```c
void addProc(process *nProcess, int nTime, ptrFunc
fPointer){
  if ( ((end+1)%BUFFERSIZE) != start){
    buffer[end].name = nProcess;
    buffer[end].time = nTime;
    buffer[end].pFunc = fPointer;
    end = (end+1)%(BUFFERSIZE);
  }
}
```

Exercise

```
void removeProc (void){
  if ( start != end){
    start = (start +1)%(BUFFERSIZE);
  }
}

void exec(void){
  if (start != end){
    buffer[start].func();
  }
}
```

Exercise

```
void func1(void){printf("f1 \n");}

void func2(void){printf("f2 \n");}

void func3(void){printf("f3 \n");}
```

Exercise

```c
#include "stdio.h"
void main (void){
   addProc("Proc1", 1, func1);
   addProc("Proc2", 2, func2);
   addProc("Proc3", 3, func3);
   exec();
   removeProc();
   exec();
   removeProc();
   exec();
   removeProc();
}
```

Exercise

```c
#include "stdio.h"
void main (void){
   addProc("Proc1", 1, func1);
   addProc("Proc2", 2, func2);
   addProc("Proc3", 3, func3);
   exec();
   removeProc();
   exec();
   removeProc();
   exec();
   removeProc();
}
```

```c
/* Similar to:
  f1();
  f2();
  f3();
 */
```

Exercise

Exercise

Step-by-step

```c
typedef int (*ptrFunc)(void);

typedef struct {
    char name;
    int time;
    ptrFunc func;
}process;

#define BUFFERSIZE  10
process buffer[BUFFERSIZE];

int start=0, end=0;
```

Exercise

buffer

	name	**time**	**func**
	char	int	ptrFunc
0	?	?	?
1	?	?	?
2	?	?	?
3	?	?	?
4	?	?	?
5	?	?	?
6	?	?	?
7	?	?	?
8	?	?	?
9	?	?	?

start	0
end	0

```
#include "stdio.h"
void main (void){
   addProc("Proc1", 1, func1);
   addProc("Proc2", 2, func2);
   addProc("Proc3", 3, func3);
   exec();
   removeProc();
   exec();
   removeProc();
   exec();
   removeProc();
}
```

Exercise

buffer

	name char	time int	func ptrFunc
0	?	?	?
1	?	?	?
2	?	?	?
3	?	?	?
4	?	?	?
5	?	?	?
6	?	?	?
7	?	?	?
8	?	?	?
9	?	?	?

start	0
end	0

```
void addProc(process *nProcess, int nTime,
ptrFunc fPointer){
  if ( ((end+1)%BUFFERSIZE) != start){
    buffer[end].name = nProcess;
    buffer[end].time = nTime;
    buffer[end].func = fPointer;
    end = (end+1)%(BUFFERSIZE);
  }
}
```

Exercise

buffer

	name char	**time** int	**func** ptrFunc
0	?	?	?
1	?	?	?
2	?	?	?
3	?	?	?
4	?	?	?
5	?	?	?
6	?	?	?
7	?	?	?
8	?	?	?
9	?	?	?

start	0
end	0

```
void addProc(process *nProcess, int nTime,
ptrFunc ponteiro){
  if ( ((end+1)%BUFFERSIZE) != start){
    buffer[end].name = nProcess;
    buffer[end].time = nTime;
    buffer[end].func = ponteiro;
    end = (end+1)%(BUFFERSIZE);
  }
}
```

Exercise

buffer

	name char	**time** int	**func** ptrFunc
0	**Proc1**	**1**	**func1**
1	?	?	?
2	?	?	?
3	?	?	?
4	?	?	?
5	?	?	?
6	?	?	?
7	?	?	?
8	?	?	?
9	?	?	?

start	0
end	1

```c
void addProc(process *nProcess, int nTime,
ptrFunc ponteiro){
  if ( ((end+1)%BUFFERSIZE) != start){
    buffer[end].name = nProcess;
    buffer[end].time = nTime;
    buffer[end].func = ponteiro;
    end = (end+1)%(BUFFERSIZE);
  }
}
```

Exercise

buffer

	name char	time int	func ptrFunc
0	**Proc1**	**1**	**func1**
1	**Proc2**	**2**	**func2**
2	?	?	?
3	?	?	?
4	?	?	?
5	?	?	?
6	?	?	?
7	?	?	?
8	?	?	?
9	?	?	?

start	0
end	2

```
void addProc(process *nProcess, int nTime,
ptrFunc ponteiro){
  if ( ((end+1)%BUFFERSIZE) != start){
    buffer[end].name = nProcess;
    buffer[end].time = nTime;
    buffer[end].func = ponteiro;
    end = (end+1)%(BUFFERSIZE);
  }
}
```

Exercise

buffer

	name char	**time** int	**func** ptrFunc
0	**Proc1**	**1**	**func1**
1	**Proc2**	**2**	**func2**
2	**Proc3**	**3**	**func3**
3	?	?	?
4	?	?	?
5	?	?	?
6	?	?	?
7	?	?	?
8	?	?	?
9	?	?	?

start	0
end	3

```c
#include "stdio.h"
void main (void){
   addProc("Proc1", 1, func1);
   addProc("Proc2", 2, func2);
   addProc("Proc3", 3, func3);
   exec();
   removeProc();
   exec();
   removeProc();
   exec();
   removeProc();
}
```

Exercise

buffer

	name char	time int	func ptrFunc
0	**Proc1**	**1**	**func1**
1	**Proc2**	**2**	**func2**
2	**Proc3**	**3**	**func3**
3	?	?	?
4	?	?	?
5	?	?	?
6	?	?	?
7	?	?	?
8	?	?	?
9	?	?	?

start	0
end	3

```
#include "stdio.h"
void main (void){
   addProc("Proc1", 1, func1);
   addProc("Proc2", 2, func2);
   addProc("Proc3", 3, func3);
   exec();
   removeProc();
   exec();
   removeProc();
   exec();
   removeProc();
}
```

Exercise

buffer

	name char	time int	func ptrFunc
0	**Proc1**	**1**	**func1**
1	**Proc2**	**2**	**func2**
2	**Proc3**	**3**	**func3**
3	?	?	?
4	?	?	?
5	?	?	?
6	?	?	?
7	?	?	?
8	?	?	?
9	?	?	?

start	0
end	3

```c
void exec(void){
  if (start != end){
    buffer[start].func();
  }
}
```

1

```c
void removeProc (void){
  if ( start != end){
     start = (start +1)%(BUFFERSIZE);
  }
}
```

```c
void func1(void){printf("f1 \n");}
```

2

```c
void func2(void){printf("f2 \n");}

void func3(void){printf("f3 \n");}
```

Exercise

buffer

	name char	**time** int	**func** ptrFunc
0	**Proc1**	**1**	**func1**
1	**Proc2**	**2**	**func2**
2	**Proc3**	**3**	**func3**
3	?	?	?
4	?	?	?
5	?	?	?
6	?	?	?
7	?	?	?
8	?	?	?
9	?	?	?

start	0
end	3

```c
void exec(void){
  if (start != end){
    buffer[start].func();
  }
}

void removeProc (void){
  if ( start != end){
      start = (start +1)%(BUFFERSIZE);
  }
}

void func1(void){printf("f1 \n");}

void func2(void){printf("f2 \n");}

void func3(void){printf("f3 \n");}
```

3

buffer

	name char	time int	func ptrFunc
0	**Proc1**	**1**	**func1**
1	**Proc2**	**2**	**func2**
2	**Proc3**	**3**	**func3**
3	?	?	?
4	?	?	?
5	?	?	?
6	?	?	?
7	?	?	?
8	?	?	?
9	?	?	?

start	1
end	3

Exercise

```c
#include "stdio.h"
void main (void){
   addProc("Proc1", 1, func1);
   addProc("Proc2", 2, func2);
   addProc("Proc3", 3, func3);
   exec();
   removeProc();
   exec();
   removeProc();
   exec();
   removeProc();
}
```

buffer

	name char	**time** int	**func** ptrFunc
0	**Proc1**	**1**	**func1**
1	**Proc2**	**2**	**func2**
2	**Proc3**	**3**	**func3**
3	?	?	?
4	?	?	?
5	?	?	?
6	?	?	?
7	?	?	?
8	?	?	?
9	?	?	?

start	1
end	3

Exercise

1

```c
void exec(void){
  if (start != end){
    buffer[start].func();
  }
}

void removeProc (void){
  if ( start != end){
     start = (start +1)%(BUFFERSIZE);
  }
}


void func1(void){printf("f1 \n");}

void func2(void){printf("f2 \n");}
```

2

```c
void func3(void){printf("f3 \n");}
```

Exercise

buffer

	name char	**time** int	**func** ptrFunc
0	**Proc1**	**1**	**func1**
1	**Proc2**	**2**	**func2**
2	**Proc3**	**3**	**func3**
3	?	?	?
4	?	?	?
5	?	?	?
6	?	?	?
7	?	?	?
8	?	?	?
9	?	?	?

start	1
end	3

```
void exec(void){
  if (start != end){
     buffer[start].func();
   }
}

void removeProc (void){
   if ( start != end){
       start = (start +1)%(BUFFERSIZE);
   }
}


void func1(void){printf("f1 \n");}

void func2(void){printf("f2 \n");}

void func3(void){printf("f3 \n");}
```

3

Exercise

buffer

	name char	time int	func ptrFunc
0	**Proc1**	**1**	**func1**
1	**Proc2**	**2**	**func2**
2	**Proc3**	**3**	**func3**
3	?	?	?
4	?	?	?
5	?	?	?
6	?	?	?
7	?	?	?
8	?	?	?
9	?	?	?

start	2
end	3

Exercise

```c
#include "stdio.h"
void main (void){
   addProc("Proc1", 1, func1);
   addProc("Proc2", 2, func2);
   addProc("Proc3", 3, func3);
   exec();
   removeProc();
   exec();
   removeProc();
   exec();
   removeProc();
}
```

buffer

	name char	time int	func ptrFunc
0	**Proc1**	**1**	**func1**
1	**Proc2**	**2**	**func2**
2	**Proc3**	**3**	**func3**
3	?	?	?
4	?	?	?
5	?	?	?
6	?	?	?
7	?	?	?
8	?	?	?
9	?	?	?

start	2
end	3

```
void exec(void){
  if (start != end){
     buffer[start].func();
   }
}
```

1

```
void removeProc (void){
   if ( start != end){
        start = (start +1)%(BUFFERSIZE);
   }
}


void func1(void){printf("f1 \n");}

void func2(void){printf("f2 \n");}

void func3(void){printf("f3 \n");}
```

2

Exercise

buffer

	name char	**time** int	**func** ptrFunc
0	**Proc1**	**1**	**func1**
1	**Proc2**	**2**	**func2**
2	**Proc3**	**3**	**func3**
3	?	?	?
4	?	?	?
5	?	?	?
6	?	?	?
7	?	?	?
8	?	?	?
9	?	?	?

start	2
end	3

```
void exec(void){
  if (start != end){
     buffer[start].func();
   }
}

void removeProc (void){
   if ( start != end){
       start = (start +1)%(BUFFERSIZE);
   }
}


void func1(void){printf("f1 \n");}

void func2(void){printf("f2 \n");}

void func3(void){printf("f3 \n");}
```

Exercise

buffer

	name char	**time** int	**func** ptrFunc
0	**Proc1**	**1**	**func1**
1	**Proc2**	**2**	**func2**
2	**Proc3**	**3**	**func3**
3	?	?	?
4	?	?	?
5	?	?	?
6	?	?	?
7	?	?	?
8	?	?	?
9	?	?	?

start	3
end	3

Exercise

```c
#include "stdio.h"
void main (void){
   addProc("Proc1", 1, func1);
   addProc("Proc2", 2, func2);
   addProc("Proc3", 3, func3);
   exec();
   removeProc();
   exec();
   removeProc();
   exec();
   removeProc();
}
```

buffer

	name char	time int	func ptrFunc
0	Proc1	1	func1
1	Proc2	2	func2
2	Proc3	3	func3
3	?	?	?
4	?	?	?
5	?	?	?
6	?	?	?
7	?	?	?
8	?	?	?
9	?	?	?

start	3
end	3

Exercise

Options / Changeovers

Exercise – Option 01

```
void exec(void){
  if (start != end){
    printf("Process - Current ID %d\n", start);
    printf("Process - Last ID %d [null]\n", end);
    printf("<----------------------\n", end);
    buffer[start].func();
    printf("---------------------->\n", end);
  }
}
```

Exercise – Option 02

```c
#include "stdio.h"
void main (void){
   addProc("Proc1", 1, func1);
   addProc("Proc2", 2, func2);
   addProc("Proc3", 3, func3);
   exec();
   exec();
   removeProc();
   exec();
   removeProc();
   exec();
   removeProc();
}
```

Exercise – Option 03

```c
#include "stdio.h"
void main (void){
   addProc("Proc1", 1, func1);
   addProc("Proc2", 2, func2);
   addProc("Proc3", 3, func3);
   exec();
   removeProc();
   addProc("Proc4", 4, func1);
   addProc("Proc5", 5, func2);
   exec();
   removeProc();
   exec();
   addProc("Proc5", 5, func2);
   removeProc();
}
```

Exercise – Option 04

```
#include "stdio.h"
void main (void){
  addProc("Proc1", 1, func1);
  addProc("Proc2", 2, func2);
  addProc("Proc3", 3, func3);
  exec();
  removeProc();
  if (<condition>){
    removeProc();
    addProc("Proc4", 4, func1);
  else{
    addProc("Proc5", 5, func2);
  }
  exec();
  removeProc();
  exec();
  removeProc();
}
```

Linus Torvalds

core 0.01 (1991)

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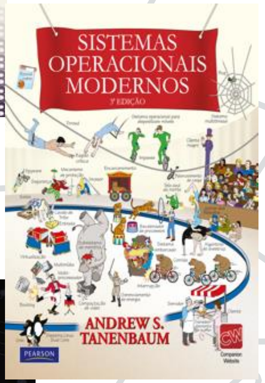

RODRIGO MAXIMIANO A. ALMEIDA
CARLOS HENRIQUE V. MORAES
THATYANA F. PIOLA SERAPHIM
OTÁVIO DE SOUZA M. GOMES
PROGRAMAÇÃO DE
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Prof. Otávio Gomes

otavio.gomes@unifei.edu.br

in /otavio-gomes