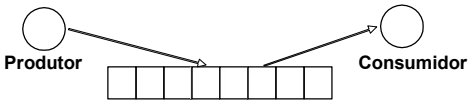
Problema do(s) Produtor(es) / Consumidor(es)

```
Var
 ElemType Buffer[N] = ...
 Semaphore full, empty, mutex;

Inicialização:
   full.value  = 0;
   empty.value = N;
   mutex.value = 1;
```




```
Process Producer
...
Repeat
...
Produce(Item);
Wait(Empty);
Wait(Mutex);
Append(Item);
Signal(Mutex);
Signal(Full);
...
Until ...;
```

```
Process Consumer
...
Repeat
...
Wait(Full);
Wait(Mutex);
Item=Take();
Signal(Mutex);
Signal(Empty);
Consume(Item);
...
Until ...;
```

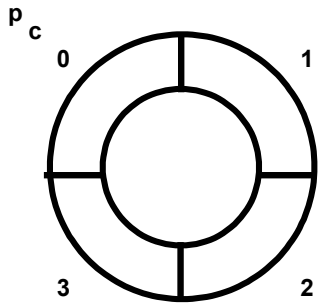
- **full**
  - p/ sincronizar os 2 processos;
  - não significa *buffer* cheio mas que tem pelo menos 1 item.
- **empty**
  - p/ sincronizar os 2 processos;
  - não significa *buffer* vazio mas que há espaço no *buffer*
- **mutex**
  - p/implementar a exclusão mútua.

1

Problema do(s) Produtor(es) / Consumidor(es)

```
char buffer[4];
Semaphore full, empty, mutex;

semInit(full,0);
semInit(empty,N);
semInit(mutex,1);
int p = c = 0;
int count = 0;
```

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```


2

Problema do(s) Produtor(es) / Consumidor(es)

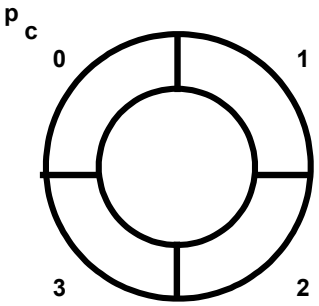
item

full 0
empty 4
mutex 1

p 0
c 0

item

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```


3

Problema do(s) Produtor(es) / Consumidor(es)

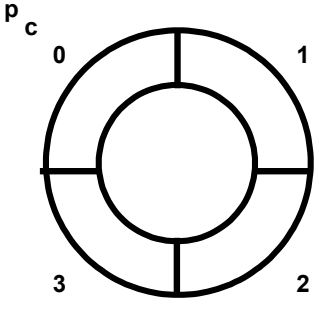
item A

full 0
empty 4
mutex 1

p 0
c 0

item

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```


4

Problema do(s) Produtor(es) / Consumidor(es)

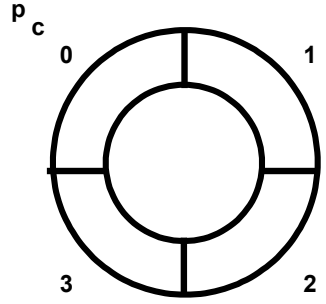
item A

full 0
empty 4
mutex 1

p 0
c 0

item

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```


5

Problema do(s) Produtor(es) / Consumidor(es)

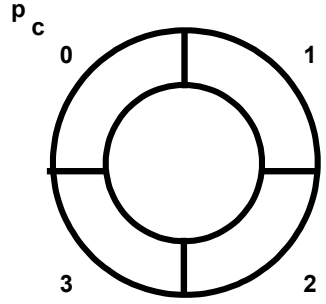
item A

full 0
empty 3
mutex 1

p 0
c 0

item

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```


6

Problema do(s) Produtor(es) / Consumidor(es)

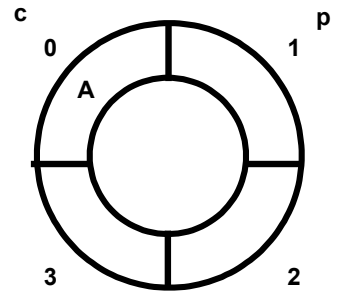
item A

full 0
empty 3
mutex 0

p 1
c 0

item

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```


7

Problema do(s) Produtor(es) / Consumidor(es)

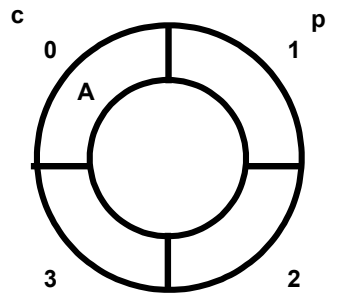
item A

full 0
empty 3
mutex 1

p 1
c 0

item

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```


8

Problema do(s) Produtor(es) / Consumidor(es)

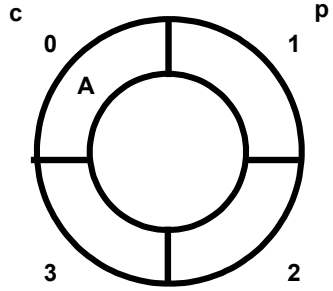
item A

full 1
empty 3
mutex 1

p 1
c 0

item

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```


9

Problema do(s) Produtor(es) / Consumidor(es)

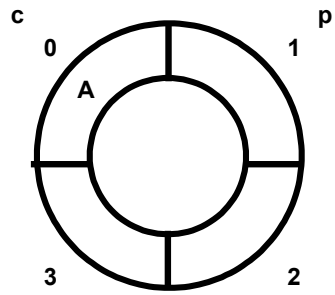
item B

full 1
empty 3
mutex 1

p 1
c 0

item

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```


10

Problema do(s) Produtor(es) / Consumidor(es)

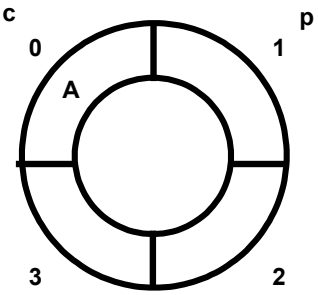
item B

full 1
empty 3
mutex 1

p 1
c 0

item

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```


11

Problema do(s) Produtor(es) / Consumidor(es)

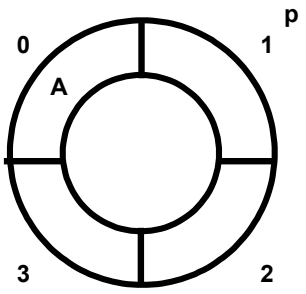
item B

full 1
empty 2
mutex 1

p 1
c 0

item

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```


12

Problema do(s) Produtor(es) / Consumidor(es)

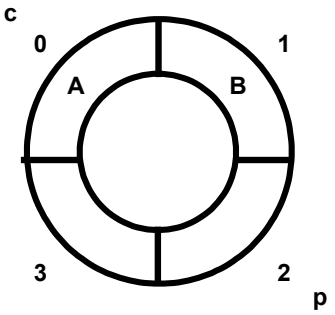
item B

full 1
empty 2
mutex 0

p 1
c 0

item

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```


13

Problema do(s) Produtor(es) / Consumidor(es)

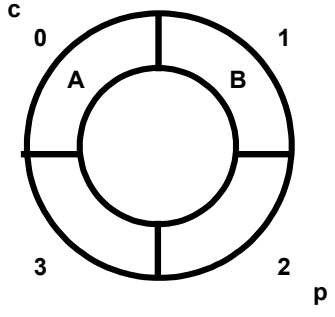
item B

full 1
empty 2
mutex 1

p 1
c 0

item

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```


14

Problema do(s) Produtor(es) / Consumidor(es)

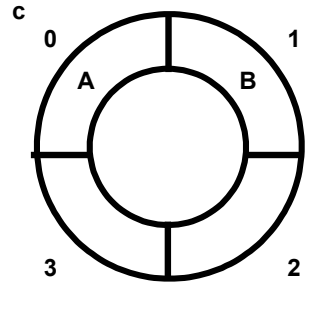
item B

full 2
empty 2
mutex 1

p 1
c 0

item

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```


15

Problema do(s) Produtor(es) / Consumidor(es)

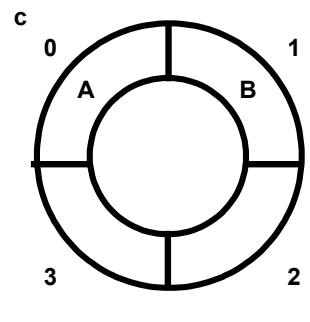
item B

full 2
empty 2
mutex 1

p 1
c 0

item

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```


16

Problema do(s) Produtor(es) / Consumidor(es)

item B

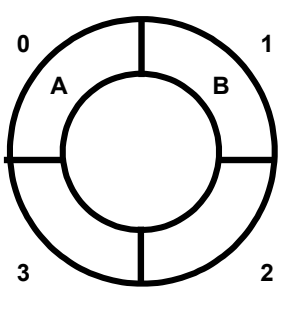
full 1
empty 2
mutex 1

p 1
c 0

item

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```

```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```



17

Problema do(s) Produtor(es) / Consumidor(es)

item B

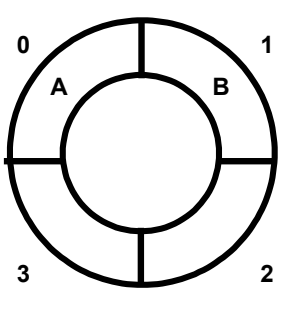
full 1
empty 2
mutex 0

p 1
c 1

item B

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```

```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```



18

Problema do(s) Produtor(es) / Consumidor(es)

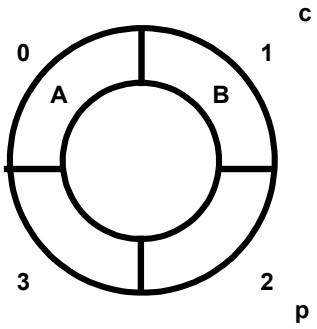
item B

full 1
empty 2
mutex 1

p 1
c 1

item B

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```


19

Problema do(s) Produtor(es) / Consumidor(es)

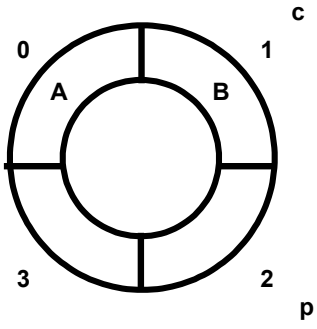
item B

full 1
empty 3
mutex 1

p 1
c 1

item B

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```


20

Problema do(s) Produtor(es) / Consumidor(es)

21

Problema do(s) Produtor(es) / Consumidor(es)

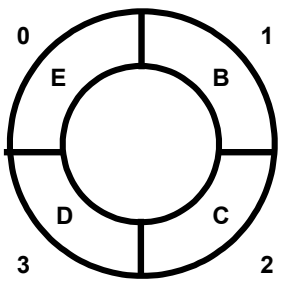
item F

full 3
empty 0
mutex 0

p 1
c 2

item B

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```


22

Problema do(s) Produtor(es) / Consumidor(es)

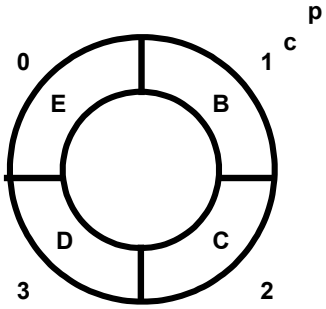
item F

full 3
empty 1
mutex 1

p 1
c 2

item B

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```


23

Problema do(s) Produtor(es) / Consumidor(es)

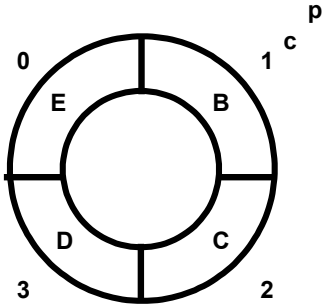
item F

full 3
empty 1
mutex 1

p 1
c 2

item B

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```

Jorge Silva MIEIC / FEUP

24

Problema do(s) Produtor(es) / Consumidor(es)

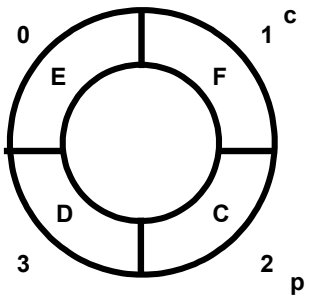
item F

full 3
empty 0
mutex 0

p 1
c 2

item B

```
Process Producer
...
Repeat
...
Produce(item);
Wait(Empty);

Wait(Mutex);
buffer[p] = item;
p = (p+1) % 4;
Signal(Mutex);

Signal(Full);
...
Until ...;
```




```
Process Consumer
...
Repeat
...
Wait(Full);

Wait(Mutex);
item=buffer[c];
c = (c+1) % 4;
Signal(Mutex);

Signal(Empty);
Consume(item);
...
Until ...;
```


25

Problema do(s) Produtor(es) / Consumidor(es)

26