UNIVERSIDADE DE ÉVORA

1º Trabalho de Sistemas Operativos

2020/2021

Engenharia Informática

Trabalho realizado por:

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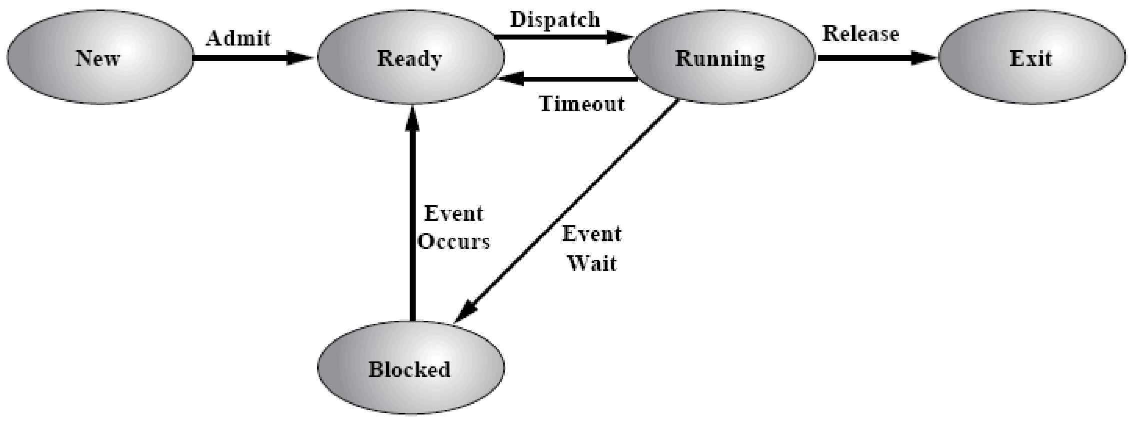
Introdução

Este trabalho tem como objetivo implementar em C, um programa com o intuito de simular o funcionamento de um sistema operativo, neste caso baseado num modelo de 5 estados para lidar com determinadas execuções de processos (figura abaixo a ilustrar este modelo), em que são utilizadas filas de espera de acordo com o protocolo FIFO (first in first out). Para a manipulação destes processos foi-nos desafiado fazer esta implementação utilizando dois algoritmos diferentes, Round Robin e Virtual Round Robin.



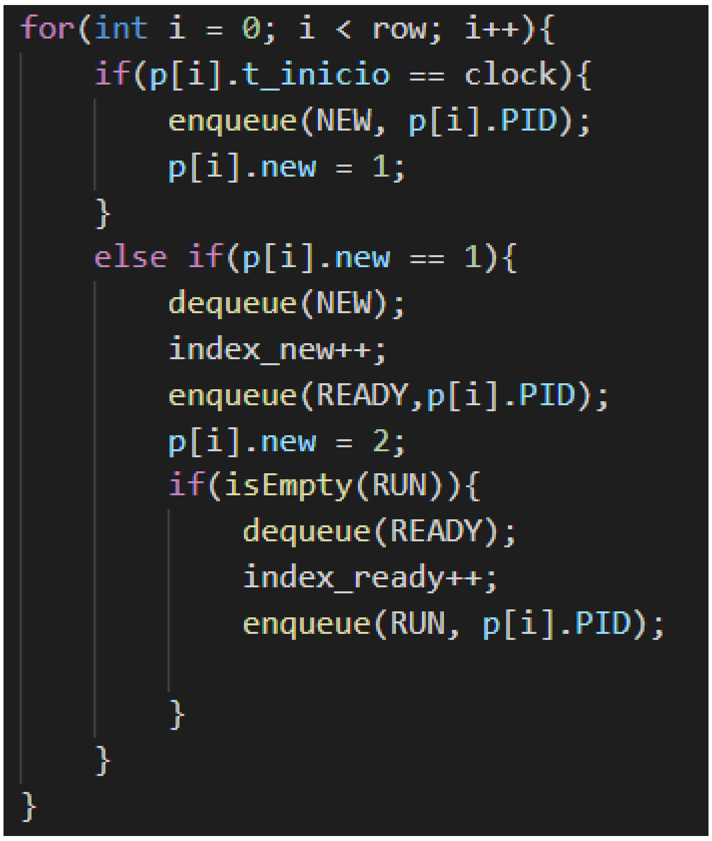
Implementação

Para a implementação deste programa começámos por implementar o funcionamento de queues em C, que guardámos num ficheiro à parte com o nome "queue.c" sendo este importado para o ficheiro principal do trabalho.

Depois foi criada uma struct processo para guardar as informações de cada processo (tempos de entrada, run times e blocked times), bem como vários index para auxiliar na leitura destas estruturas.

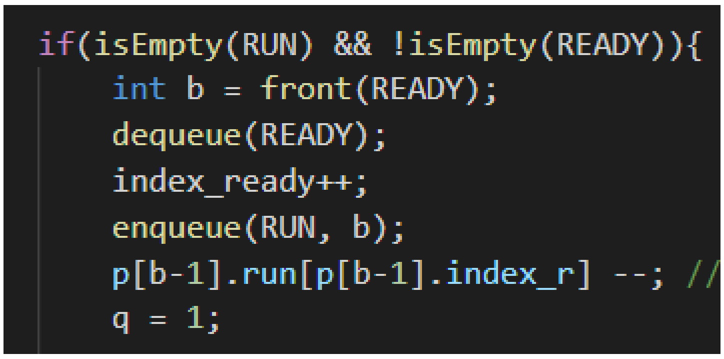
Em seguida, dentro da própria função main implementámos o "scan" do input que corresponde à lista de processos juntamente com os seus respetivos tempos de início, run e blocked.

Passamos então à implementação dos algoritmos em si. Começando pelo Round Robin, começamos por criar as queues NEW, READY, RUN, BLOCKED, EXIT e AUX (para ajudar na manipulação da queue blocked). Toda a estrutura está situada dentro de um for que funciona como um clock, que define os vários instantes de tempo. Primeiramente um if e um if else para colocar os processos novos em NEW, passá-los para READY caso já tenham passado 1 instante em NEW e caso READY e RUN estejam ambos vazios um processo pode passar instantaneamente para o CPU (estado RUN).



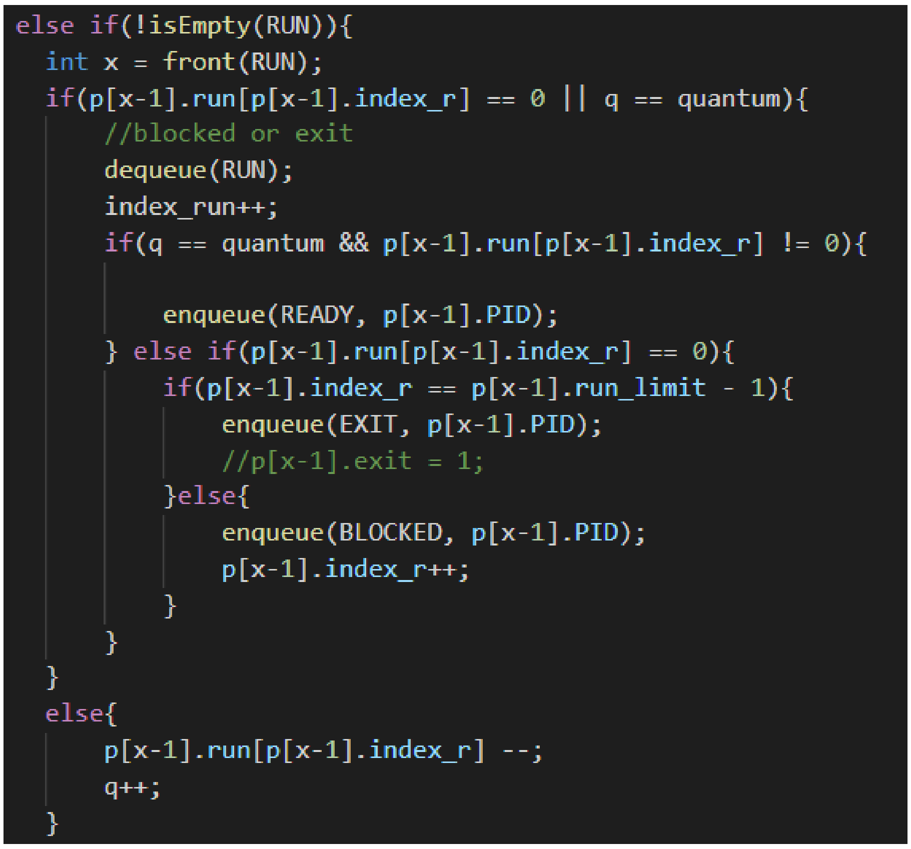
```c
for(int i = 0; i < row; i++){
    if(p[i].t_inicio == clock){
        enqueue(NEW, p[i].PID);
        p[i].new = 1;
    }
    else if(p[i].new == 1){
        dequeue(NEW);
        index_new++;
        enqueue(READY,p[i].PID);
        p[i].new = 2;
        if(isEmpty(RUN)){
            dequeue(READY);
            index_ready++;
            enqueue(RUN, p[i].PID);

        }
    }
}
```

Em seguida um if para passar o primeiro processo da fila READY para a fila RUN, caso esta esteja vazia.



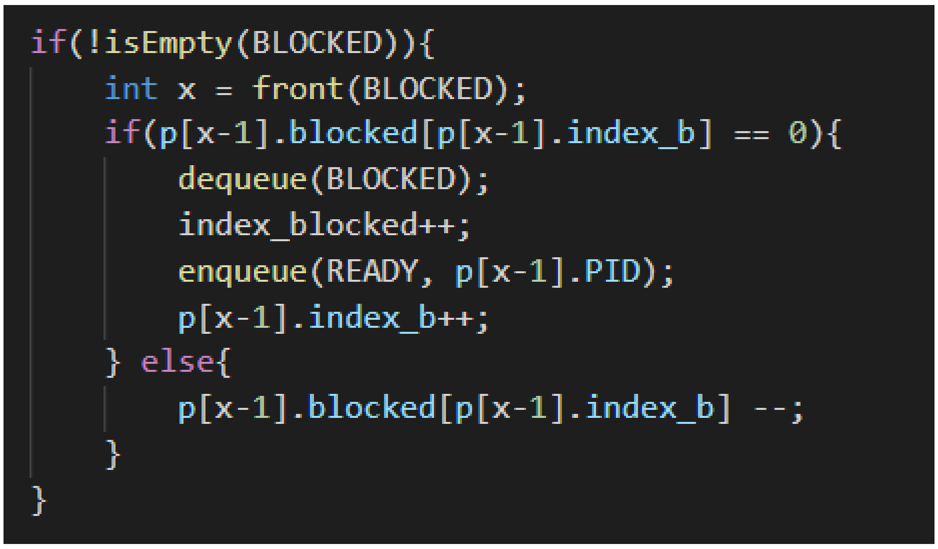
```
if(isEmpty(RUN) && !isEmpty(READY)){
    int b = front(READY);
    dequeue(READY);
    index_ready++;
    enqueue(RUN, b);
    p[b-1].run[p[b-1].index_r] --; //
    q = 1;
```

Depois deste if, um else if para controlar os processos que estão na fase RUN verificando se já acabou o seu tempo de RUN ou se o quantum de 3 já foi igualado. Caso tenha acabado o tempo de RUN, o processo sai de RUN e vai para BLOCKED, caso o quantum tenha sido igualado o processo passa para READY à espera de entrar novamente no cpu para acabar o tempo de RUN. Caso nenhum destes acontecimentos se verifique é decrementado o valor do array run de modo a chegar a um dos cenários acima. Quando um processo chega ao seu último run, este é enviado para a fila EXIT ficando lá 1 instante antes de sair da lista de processos.



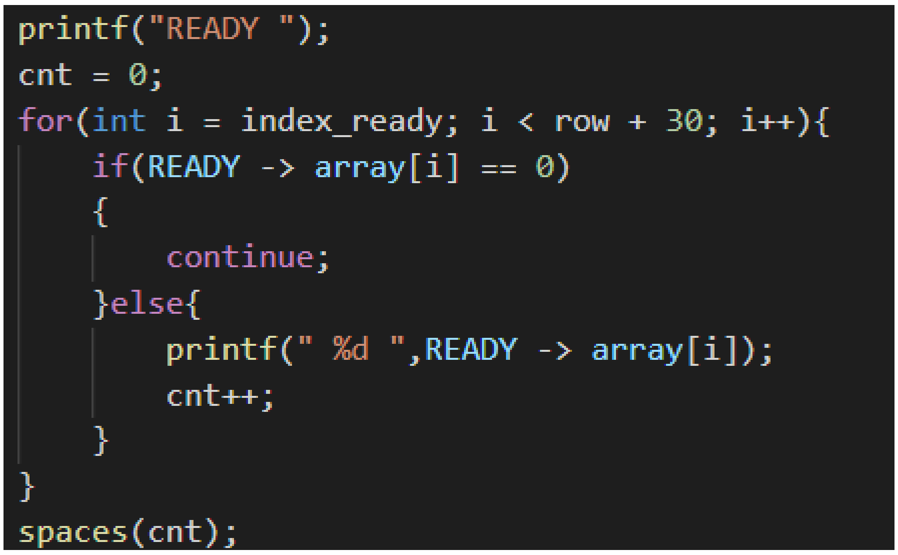
```
else if(!isEmpty(RUN)){
  int x = front(RUN);
  if(p[x-1].run[p[x-1].index_r] == 0 || q == quantum){
      //blocked or exit
      dequeue(RUN);
      index_run++;
      if(q == quantum && p[x-1].run[p[x-1].index_r] != 0){

          enqueue(READY, p[x-1].PID);
      } else if(p[x-1].run[p[x-1].index_r] == 0){
          if(p[x-1].index_r == p[x-1].run_limit - 1){
              enqueue(EXIT, p[x-1].PID);
              //p[x-1].exit = 1;
          }else{
              enqueue(BLOCKED, p[x-1].PID);
              p[x-1].index_r++;
          }
      }
  }
  else{
      p[x-1].run[p[x-1].index_r] --;
      q++;
  }
```

Depois, um if para gerir os tempos de BLOCKED, decrementando os tempos do array blocked apenas para o primeiro processo da fila e caso o tempo tenha chegado a 0 o processo é enviado novamente para READY.



```c
if(!isEmpty(BLOCKED)){
    int x = front(BLOCKED);
    if(p[x-1].blocked[p[x-1].index_b] == 0){
        dequeue(BLOCKED);
        index_blocked++;
        enqueue(READY, p[x-1].PID);
        p[x-1].index_b++;
    } else{
        p[x-1].blocked[p[x-1].index_b] --;
    }
}
```

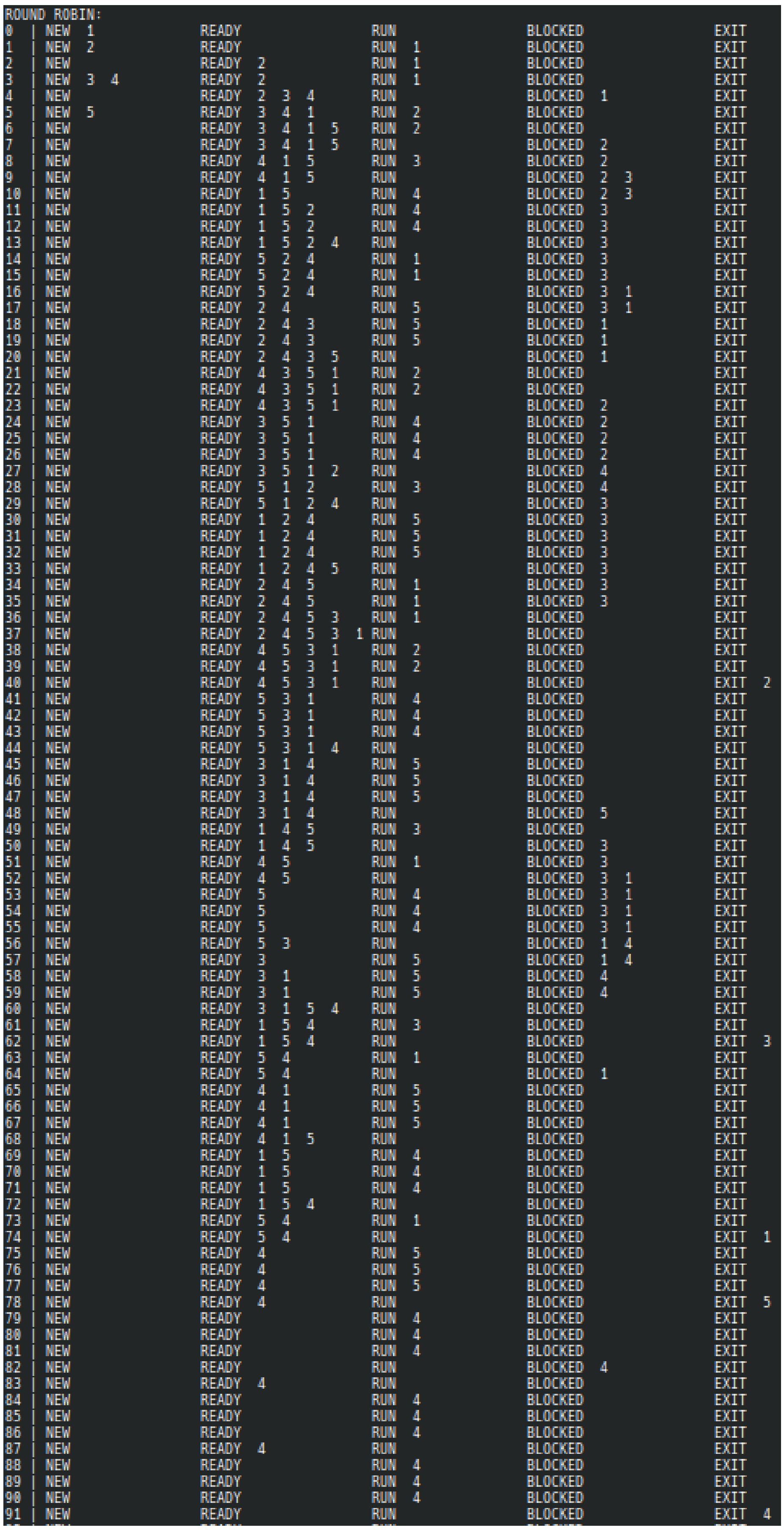
Finalmente, para o output, é criado um for para dar print aos vários valores de cada queue, utilizando depois a função spaces para espaçar os prints na consola.



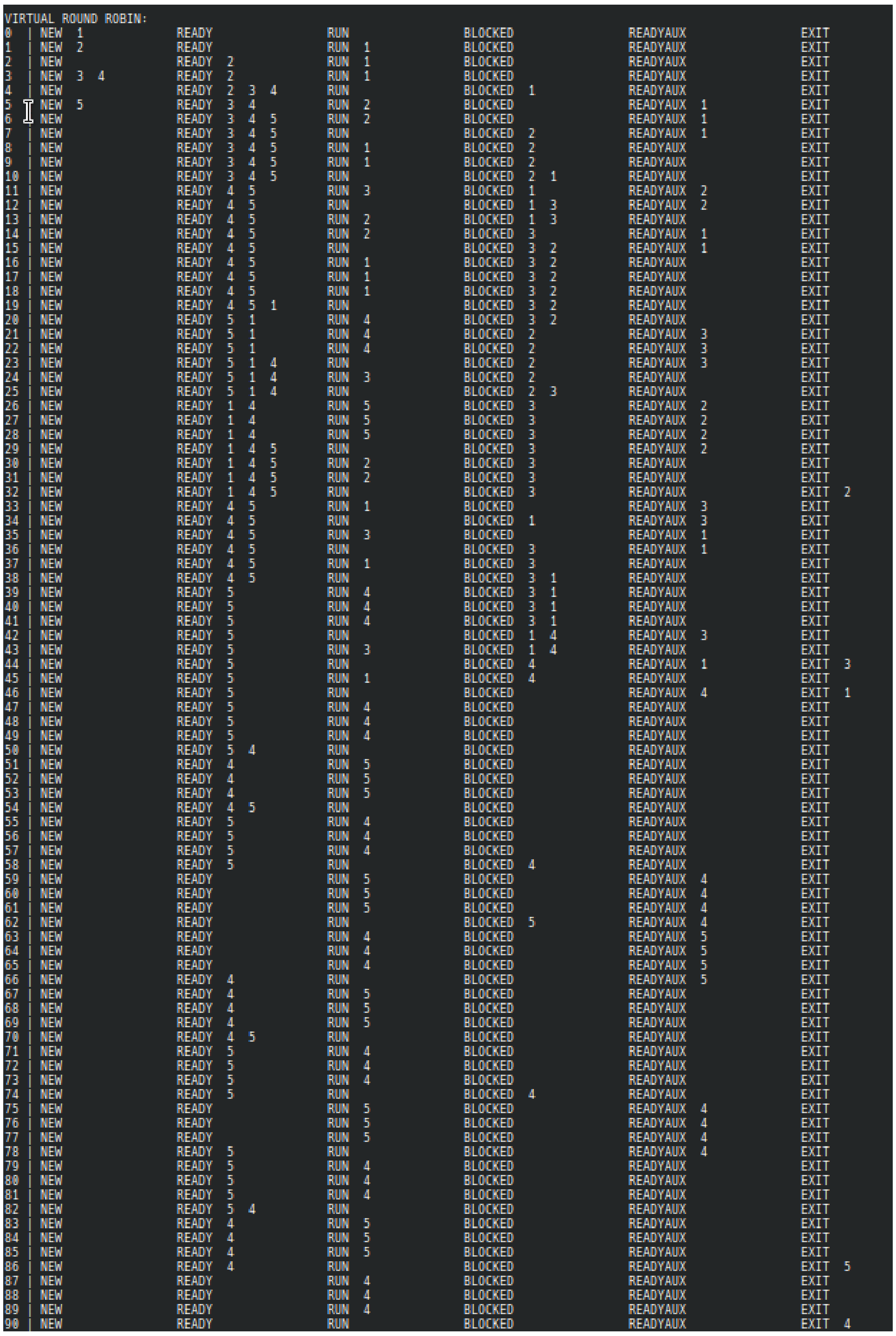
```c
printf("READY ");
cnt = 0;
for(int i = index_ready; i < row + 30; i++){
    if(READY -> array[i] == 0)
    {
        continue;
    }else{
        printf(" %d ",READY -> array[i]);
        cnt++;
    }
}
spaces(cnt);
```

Para Virtual Round Robin, o funcionamento é bastante semelhante ao Round Robin mudando apenas a adição de uma fila READYAUX que serve para alojar os processos que saem de BLOCKED, tendo prioridade sobre os processos que saem da fila READY “normal”.

Outputs:



```
ROUND ROBIN:
0  | NEW  1                   READY                RUN                 BLOCKED                EXIT
1  | NEW  2                   READY                RUN  1              BLOCKED                EXIT
2  | NEW                      READY  2             RUN  1              BLOCKED                EXIT
3  | NEW  3  4                READY  2             RUN  1              BLOCKED                EXIT
4  | NEW                      READY  2  3  4       RUN                 BLOCKED  1             EXIT
5  | NEW  5                   READY  3  4  1       RUN  2              BLOCKED                EXIT
6  | NEW                      READY  3  4  1  5    RUN  2              BLOCKED                EXIT
7  | NEW                      READY  3  4  1  5    RUN                 BLOCKED  2             EXIT
8  | NEW                      READY  4  1  5       RUN  3              BLOCKED  2             EXIT
9  | NEW                      READY  4  1  5       RUN                 BLOCKED  2  3          EXIT
10 | NEW                      READY  1  5          RUN  4              BLOCKED  2  3          EXIT
11 | NEW                      READY  1  5  2       RUN  4              BLOCKED  3             EXIT
12 | NEW                      READY  1  5  2       RUN  4              BLOCKED  3             EXIT
13 | NEW                      READY  1  5  2  4    RUN                 BLOCKED  3             EXIT
14 | NEW                      READY  5  2  4       RUN  1              BLOCKED  3             EXIT
15 | NEW                      READY  5  2  4       RUN  1              BLOCKED  3             EXIT
16 | NEW                      READY  5  2  4       RUN                 BLOCKED  3  1          EXIT
17 | NEW                      READY  2  4          RUN  5              BLOCKED  3  1          EXIT
18 | NEW                      READY  2  4  3       RUN  5              BLOCKED  1             EXIT
19 | NEW                      READY  2  4  3       RUN  5              BLOCKED  1             EXIT
20 | NEW                      READY  2  4  3  5    RUN                 BLOCKED  1             EXIT
21 | NEW                      READY  4  3  5  1    RUN  2              BLOCKED                EXIT
22 | NEW                      READY  4  3  5  1    RUN  2              BLOCKED                EXIT
23 | NEW                      READY  4  3  5  1    RUN                 BLOCKED  2             EXIT
24 | NEW                      READY  3  5  1       RUN  4              BLOCKED  2             EXIT
25 | NEW                      READY  3  5  1       RUN  4              BLOCKED  2             EXIT
26 | NEW                      READY  3  5  1       RUN  4              BLOCKED  2             EXIT
27 | NEW                      READY  3  5  1  2    RUN                 BLOCKED  4             EXIT
28 | NEW                      READY  5  1  2       RUN  3              BLOCKED  4             EXIT
29 | NEW                      READY  5  1  2  4    RUN                 BLOCKED  3             EXIT
30 | NEW                      READY  1  2  4       RUN  5              BLOCKED  3             EXIT
31 | NEW                      READY  1  2  4       RUN  5              BLOCKED  3             EXIT
32 | NEW                      READY  1  2  4       RUN  5              BLOCKED  3             EXIT
33 | NEW                      READY  1  2  4  5    RUN                 BLOCKED  3             EXIT
34 | NEW                      READY  2  4  5       RUN  1              BLOCKED  3             EXIT
35 | NEW                      READY  2  4  5       RUN  1              BLOCKED  3             EXIT
36 | NEW                      READY  2  4  5  3    RUN  1              BLOCKED                EXIT
37 | NEW                      READY  2  4  5  3  1 RUN                 BLOCKED                EXIT
38 | NEW                      READY  4  5  3  1    RUN  2              BLOCKED                EXIT
39 | NEW                      READY  4  5  3  1    RUN  2              BLOCKED                EXIT
40 | NEW                      READY  4  5  3  1    RUN                 BLOCKED                EXIT  2
41 | NEW                      READY  5  3  1       RUN  4              BLOCKED                EXIT
42 | NEW                      READY  5  3  1       RUN  4              BLOCKED                EXIT
43 | NEW                      READY  5  3  1       RUN  4              BLOCKED                EXIT
44 | NEW                      READY  5  3  1  4    RUN                 BLOCKED                EXIT
45 | NEW                      READY  3  1  4       RUN  5              BLOCKED                EXIT
46 | NEW                      READY  3  1  4       RUN  5              BLOCKED                EXIT
47 | NEW                      READY  3  1  4       RUN  5              BLOCKED                EXIT
48 | NEW                      READY  3  1  4       RUN                 BLOCKED  5             EXIT
49 | NEW                      READY  1  4  5       RUN  3              BLOCKED                EXIT
50 | NEW                      READY  1  4  5       RUN                 BLOCKED  3             EXIT
51 | NEW                      READY  4  5          RUN  1              BLOCKED  3             EXIT
52 | NEW                      READY  4  5          RUN                 BLOCKED  3  1          EXIT
53 | NEW                      READY  5             RUN  4              BLOCKED  3  1          EXIT
54 | NEW                      READY  5             RUN  4              BLOCKED  3  1          EXIT
55 | NEW                      READY  5             RUN  4              BLOCKED  3  1          EXIT
56 | NEW                      READY  5  3          RUN                 BLOCKED  1  4          EXIT
57 | NEW                      READY  3             RUN  5              BLOCKED  1  4          EXIT
58 | NEW                      READY  3  1          RUN  5              BLOCKED  4             EXIT
59 | NEW                      READY  3  1          RUN  5              BLOCKED  4             EXIT
60 | NEW                      READY  3  1  5  4    RUN                 BLOCKED                EXIT
61 | NEW                      READY  1  5  4       RUN  3              BLOCKED                EXIT
62 | NEW                      READY  1  5  4       RUN                 BLOCKED                EXIT  3
63 | NEW                      READY  5  4          RUN  1              BLOCKED                EXIT
64 | NEW                      READY  5  4          RUN                 BLOCKED  1             EXIT
65 | NEW                      READY  4  1          RUN  5              BLOCKED                EXIT
66 | NEW                      READY  4  1          RUN  5              BLOCKED                EXIT
67 | NEW                      READY  4  1          RUN  5              BLOCKED                EXIT
68 | NEW                      READY  4  1  5       RUN                 BLOCKED                EXIT
69 | NEW                      READY  1  5          RUN  4              BLOCKED                EXIT
70 | NEW                      READY  1  5          RUN  4              BLOCKED                EXIT
71 | NEW                      READY  1  5          RUN  4              BLOCKED                EXIT
72 | NEW                      READY  1  5  4       RUN                 BLOCKED                EXIT
73 | NEW                      READY  5  4          RUN  1              BLOCKED                EXIT
74 | NEW                      READY  5  4          RUN                 BLOCKED                EXIT  1
75 | NEW                      READY  4             RUN  5              BLOCKED                EXIT
76 | NEW                      READY  4             RUN  5              BLOCKED                EXIT
77 | NEW                      READY  4             RUN  5              BLOCKED                EXIT
78 | NEW                      READY  4             RUN                 BLOCKED                EXIT  5
79 | NEW                      READY                RUN  4              BLOCKED                EXIT
80 | NEW                      READY                RUN  4              BLOCKED                EXIT
81 | NEW                      READY                RUN  4              BLOCKED                EXIT
82 | NEW                      READY                RUN                 BLOCKED  4             EXIT
83 | NEW                      READY  4             RUN                 BLOCKED                EXIT
84 | NEW                      READY                RUN  4              BLOCKED                EXIT
85 | NEW                      READY                RUN  4              BLOCKED                EXIT
86 | NEW                      READY                RUN  4              BLOCKED                EXIT
87 | NEW                      READY  4             RUN                 BLOCKED                EXIT
88 | NEW                      READY                RUN  4              BLOCKED                EXIT
89 | NEW                      READY                RUN  4              BLOCKED                EXIT
90 | NEW                      READY                RUN  4              BLOCKED                EXIT
91 | NEW                      READY                RUN                 BLOCKED                EXIT  4
```



```
VIRTUAL ROUND ROBIN:
0  | NEW  1             READY                RUN                BLOCKED                READYAUX                EXIT
1  | NEW  2             READY                RUN  1             BLOCKED                READYAUX                EXIT
2  | NEW                READY  2             RUN  1             BLOCKED                READYAUX                EXIT
3  | NEW  3  4          READY  2             RUN  1             BLOCKED                READYAUX                EXIT
4  | NEW                READY  2  3  4       RUN                BLOCKED  1             READYAUX                EXIT
5  | NEW  5             READY  3  4          RUN  2             BLOCKED                READYAUX  1             EXIT
6  | NEW                READY  3  4  5       RUN  2             BLOCKED                READYAUX  1             EXIT
7  | NEW                READY  3  4  5       RUN                BLOCKED  2             READYAUX  1             EXIT
8  | NEW                READY  3  4  5       RUN  1             BLOCKED  2             READYAUX                EXIT
9  | NEW                READY  3  4  5       RUN  1             BLOCKED  2             READYAUX                EXIT
10 | NEW                READY  3  4  5       RUN                BLOCKED  2  1          READYAUX                EXIT
11 | NEW                READY  4  5          RUN  3             BLOCKED  1             READYAUX  2             EXIT
12 | NEW                READY  4  5          RUN                BLOCKED  1  3          READYAUX  2             EXIT
13 | NEW                READY  4  5          RUN  2             BLOCKED  1  3          READYAUX                EXIT
14 | NEW                READY  4  5          RUN  2             BLOCKED  3             READYAUX  1             EXIT
15 | NEW                READY  4  5          RUN                BLOCKED  3  2          READYAUX  1             EXIT
16 | NEW                READY  4  5          RUN  1             BLOCKED  3  2          READYAUX                EXIT
17 | NEW                READY  4  5          RUN  1             BLOCKED  3  2          READYAUX                EXIT
18 | NEW                READY  4  5          RUN  1             BLOCKED  3  2          READYAUX                EXIT
19 | NEW                READY  4  5  1       RUN                BLOCKED  3  2          READYAUX                EXIT
20 | NEW                READY  5  1          RUN  4             BLOCKED  3  2          READYAUX                EXIT
21 | NEW                READY  5  1          RUN  4             BLOCKED  2             READYAUX  3             EXIT
22 | NEW                READY  5  1          RUN  4             BLOCKED  2             READYAUX  3             EXIT
23 | NEW                READY  5  1  4       RUN                BLOCKED  2             READYAUX  3             EXIT
24 | NEW                READY  5  1  4       RUN  3             BLOCKED  2             READYAUX                EXIT
25 | NEW                READY  5  1  4       RUN                BLOCKED  2  3          READYAUX                EXIT
26 | NEW                READY  1  4          RUN  5             BLOCKED  3             READYAUX  2             EXIT
27 | NEW                READY  1  4          RUN  5             BLOCKED  3             READYAUX  2             EXIT
28 | NEW                READY  1  4          RUN  5             BLOCKED  3             READYAUX  2             EXIT
29 | NEW                READY  1  4  5       RUN                BLOCKED  3             READYAUX  2             EXIT
30 | NEW                READY  1  4  5       RUN  2             BLOCKED  3             READYAUX                EXIT
31 | NEW                READY  1  4  5       RUN  2             BLOCKED  3             READYAUX                EXIT
32 | NEW                READY  1  4  5       RUN                BLOCKED  3             READYAUX                EXIT  2
33 | NEW                READY  4  5          RUN  1             BLOCKED                READYAUX  3             EXIT
34 | NEW                READY  4  5          RUN                BLOCKED  1             READYAUX  3             EXIT
35 | NEW                READY  4  5          RUN  3             BLOCKED                READYAUX  1             EXIT
36 | NEW                READY  4  5          RUN                BLOCKED  3             READYAUX  1             EXIT
37 | NEW                READY  4  5          RUN  1             BLOCKED  3             READYAUX                EXIT
38 | NEW                READY  4  5          RUN                BLOCKED  3  1          READYAUX                EXIT
39 | NEW                READY  5             RUN  4             BLOCKED  3  1          READYAUX                EXIT
40 | NEW                READY  5             RUN  4             BLOCKED  3  1          READYAUX                EXIT
41 | NEW                READY  5             RUN  4             BLOCKED  3  1          READYAUX                EXIT
42 | NEW                READY  5             RUN                BLOCKED  1  4          READYAUX  3             EXIT
43 | NEW                READY  5             RUN  3             BLOCKED  1  4          READYAUX                EXIT
44 | NEW                READY  5             RUN                BLOCKED  4             READYAUX  1             EXIT  3
45 | NEW                READY  5             RUN  1             BLOCKED  4             READYAUX                EXIT
46 | NEW                READY  5             RUN                BLOCKED                READYAUX  4             EXIT  1
47 | NEW                READY  5             RUN  4             BLOCKED                READYAUX                EXIT
48 | NEW                READY  5             RUN  4             BLOCKED                READYAUX                EXIT
49 | NEW                READY  5             RUN  4             BLOCKED                READYAUX                EXIT
50 | NEW                READY  5  4          RUN                BLOCKED                READYAUX                EXIT
51 | NEW                READY  4             RUN  5             BLOCKED                READYAUX                EXIT
52 | NEW                READY  4             RUN  5             BLOCKED                READYAUX                EXIT
53 | NEW                READY  4             RUN  5             BLOCKED                READYAUX                EXIT
54 | NEW                READY  4  5          RUN                BLOCKED                READYAUX                EXIT
55 | NEW                READY  5             RUN  4             BLOCKED                READYAUX                EXIT
56 | NEW                READY  5             RUN  4             BLOCKED                READYAUX                EXIT
57 | NEW                READY  5             RUN  4             BLOCKED                READYAUX                EXIT
58 | NEW                READY  5             RUN                BLOCKED  4             READYAUX                EXIT
59 | NEW                READY                RUN  5             BLOCKED                READYAUX  4             EXIT
60 | NEW                READY                RUN  5             BLOCKED                READYAUX  4             EXIT
61 | NEW                READY                RUN  5             BLOCKED                READYAUX  4             EXIT
62 | NEW                READY                RUN                BLOCKED  5             READYAUX  4             EXIT
63 | NEW                READY                RUN  4             BLOCKED                READYAUX  5             EXIT
64 | NEW                READY                RUN  4             BLOCKED                READYAUX  5             EXIT
65 | NEW                READY                RUN  4             BLOCKED                READYAUX  5             EXIT
66 | NEW                READY  4             RUN                BLOCKED                READYAUX  5             EXIT
67 | NEW                READY  4             RUN  5             BLOCKED                READYAUX                EXIT
68 | NEW                READY  4             RUN  5             BLOCKED                READYAUX                EXIT
69 | NEW                READY  4             RUN  5             BLOCKED                READYAUX                EXIT
70 | NEW                READY  4  5          RUN                BLOCKED                READYAUX                EXIT
71 | NEW                READY  5             RUN  4             BLOCKED                READYAUX                EXIT
72 | NEW                READY  5             RUN  4             BLOCKED                READYAUX                EXIT
73 | NEW                READY  5             RUN  4             BLOCKED                READYAUX                EXIT
74 | NEW                READY  5             RUN                BLOCKED  4             READYAUX                EXIT
75 | NEW                READY                RUN  5             BLOCKED                READYAUX  4             EXIT
76 | NEW                READY                RUN  5             BLOCKED                READYAUX  4             EXIT
77 | NEW                READY                RUN  5             BLOCKED                READYAUX  4             EXIT
78 | NEW                READY  5             RUN                BLOCKED                READYAUX  4             EXIT
79 | NEW                READY  5             RUN  4             BLOCKED                READYAUX                EXIT
80 | NEW                READY  5             RUN  4             BLOCKED                READYAUX                EXIT
81 | NEW                READY  5             RUN  4             BLOCKED                READYAUX                EXIT
82 | NEW                READY  5  4          RUN                BLOCKED                READYAUX                EXIT
83 | NEW                READY  4             RUN  5             BLOCKED                READYAUX                EXIT
84 | NEW                READY  4             RUN  5             BLOCKED                READYAUX                EXIT
85 | NEW                READY  4             RUN  5             BLOCKED                READYAUX                EXIT
86 | NEW                READY  4             RUN                BLOCKED                READYAUX                EXIT  5
87 | NEW                READY                RUN  4             BLOCKED                READYAUX                EXIT
88 | NEW                READY                RUN  4             BLOCKED                READYAUX                EXIT
89 | NEW                READY                RUN  4             BLOCKED                READYAUX                EXIT
90 | NEW                READY                RUN                BLOCKED                READYAUX                EXIT  4
```