TP3 - Sistemas Digitais 23.1

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O Objetivo desse trabalho é projetar e implementar o algoritmo centralizado de exclusão mútua distribuída.

O Servidor

A implementação do servidor foi feita na linguagem de programação Go, com ajuda da biblioteca de RPC (remote procedure call) chamada gRPC. Debaixo dos panos essa biblioteca nos ajuda à criar múltiplas threads que escutam os clientes em diferentes sockets, e reage às suas mensagens.

Tal biblioteca permite a criação de um "contrato de comunicação": o PROTOBUFF, escrito em linguagem neutra, gera automaticamente o código para tratar as mensagens entre diferentes linguagens através de stubs e do marshalling.

O servidor possui um semáforo que controla o acesso dos clientes ao arquivo de escrita. Uma mensagem de 'GRANT' significa que o semáforo foi corretamente adquirido e ele só é solto por uma mensagem de 'RELEASE' vinda daquele processo que possui o 'GRANT'.

Outros processos que tentarem escrever no arquivo estarão aguardando até que o acquire desse semáforo retorne, indicando que é a vez dele de escrever. A implementação desse semáforo possui um outro semáforo para controle da fila de requisições.

Não implementamos temporizadores ou maneiras robustas de tratar falhas, se o processo que possui o 'GRANT' falhar e não retornar o 'RELEASE', o servidor se vê impossibilitado de continuar à tratar os clientes (o que acontece na prática ao parar o script dos Clientes no meio, ao reiniciar, o servidor está esperando ainda um Release de um processo que não existe mais, é necessário parar e recomeçar também o processo do servidor).

Os Clientes

Para ver a biblioteca de RPC do Go em ação, foi decidido escrever o código dos clientes em python, e se utilizar dos stubs e do marshalling para traduzir de uma linguagem para outra na prática.

O código recebe como argumento os valores de **n** (número de processos), **r** (número de vezes que cada processo precisa acessar a zona crítica), e **k** (número de segundos cada processo espera antes de começar um novo pedido). Para **n** vezes, começa um processo que roda a função *clientRequest*s que efetivamente envia as requisições de acesso e age quando recebe as notificações de GRANT.

```
def main():
   if len(sys.argv) != 4:
        print(
            "Usage: python3 main.py <no0fProcesses> <no0fRequestsPerProcess> <secondsToSleep>"
        sys.exit(1)
    n_processes, r_requests, k_seconds = [int(x) for x in sys.argv[1:]]
    processes = []
    for i in range(n_processes):
        p = multiprocessing.Process(
            target=clientRequests, args=(r_requests, k_seconds, i, write)
        processes.append(p)
    for p in processes:
        p.start()
    for p in processes:
        p.join()
    print("done")
//---
def clientRequests(requests, seconds, id, writefunc):
    with grpc.insecure_channel("localhost:50051") as channel:
        stub = tp3_pb2_grpc.Tp3RPCStub(channel)
        for _ in range(requests):
            message = tp3_pb2.ClientMessage(ProcessId=id)
            granted = stub.Request(message)
            if granted.granted:
                print(f"Pid {id} granted message received")
                writefunc(f"Process Id: {id} - {datetime.datetime.now()}\n")
                time.sleep(seconds)
                stub.Release(message)
```

Resultados

Primeira rodada de testes.

▼ Teste 0 de funcionamento.

n = 2, r = 10, e k = 2

```
PS C:\Users\Filipe P\Documents\_Pessoal\_UFRJ\DistributedSystems\TP3> go run server/main/main.go Initializing server
Please choose the corresponding command:
1: Print the current queue
2: Print how many times each process has been served
3: Forcefully stop the server: Cancels all RPCs and open connections and stops the server
What would you like to do?

PS C:\Users\Filipe P\Documents\_Pessoal\_UFRJ\DistributedSystems\TP3> python client/main.py 2 10 2
Pid 0 granted message received
Pid 1 granted message received
Pid 0 granted message received
Pid 1 granted message received
Pid 0 granted message received
Pid 1 granted message received
Pid 0 granted message received
```

▼ results.txt (20 linhas 2x10) - 38,250 segundos

```
Process Id: 0 - 2023-07-16 19:08:14.385568
Process Id: 1 - 2023-07-16 19:08:16.402866
Process Id: 0 - 2023-07-16 19:08:18.413894
Process Id: 1 - 2023-07-16 19:08:20.431095
Process Id: 0 - 2023-07-16 19:08:22.444128
Process Id: 1 - 2023-07-16 19:08:24.464769
Process Id: 0 - 2023-07-16 19:08:26.477323
Process Id: 1 - 2023-07-16 19:08:28.484966
Process Id: 0 - 2023-07-16 19:08:30.499585
Process Id: 1 - 2023-07-16 19:08:32.515594
Process Id: 0 - 2023-07-16 19:08:34.533208
Process Id: 1 - 2023-07-16 19:08:36.548476
Process Id: 0 - 2023-07-16 19:08:38.556950
Process Id: 1 - 2023-07-16 19:08:40.564181
Process Id: 0 - 2023-07-16 19:08:42.571313
Process Id: 1 - 2023-07-16 19:08:44.588313
Process Id: 0 - 2023-07-16 19:08:46.604815
Process Id: 1 - 2023-07-16 19:08:48.611219
Process Id: 0 - 2023-07-16 19:08:50.623412
Process Id: 1 - 2023-07-16 19:08:52.635794
```

```
Message Process ID Time

REQUEST 0 2023-07-16 19:08:08.381834

GRANTED 0 2023-07-16 19:08:08.384220

REQUEST 1 2023-07-16 19:08:08.396634

RELEASED 0 2023-07-16 19:08:08.401868

GRANTED 1 2023-07-16 19:08:08.401868

REQUEST 0 2023-07-16 19:08:08.402866
```

```
RELEASED 1 2023-07-16 19:08:08.413311
GRANTED 0 2023-07-16 19:08:08.413311
REQUEST 1 2023-07-16 19:08:08.414475
GRANTED 1 2023-07-16 19:08:08.430001
RELEASED 0 2023-07-16 19:08:08.430001
REQUEST 0 2023-07-16 19:08:08.431637
RELEASED 1 2023-07-16 19:08:08.442910
GRANTED 0 2023-07-16 19:08:08.442910
REQUEST 1 2023-07-16 19:08:08.444676
RELEASED 0 2023-07-16 19:08:08.459947
GRANTED 1 2023-07-16 19:08:08.460505
REQUEST 0 2023-07-16 19:08:08.464769
RELEASED 1 2023-07-16 19:08:08.474907
GRANTED 0 2023-07-16 19:08:08.475548
REQUEST 1 2023-07-16 19:08:08.477323
GRANTED 1 2023-07-16 19:08:08.481631
RELEASED 0 2023-07-16 19:08:08.481631
REQUEST 0 2023-07-16 19:08:08.485544
GRANTED 0 2023-07-16 19:08:08.497685
RELEASED 1 2023-07-16 19:08:08.497071
REQUEST 1 2023-07-16 19:08:08.499585
GRANTED 1 2023-07-16 19:08:08.514464
RELEASED 0 2023-07-16 19:08:08.513929
REQUEST 0 2023-07-16 19:08:08.516389
GRANTED 0 2023-07-16 19:08:08.531756
RELEASED 1 2023-07-16 19:08:08.531756
REQUEST 1 2023-07-16 19:08:08.533208
RELEASED 0 2023-07-16 19:08:08.546908
GRANTED 1 2023-07-16 19:08:08.547326
REQUEST 0 2023-07-16 19:08:08.548527
RELEASED 1 2023-07-16 19:08:08.553658
GRANTED 0 2023-07-16 19:08:08.554464
REQUEST 1 2023-07-16 19:08:08.556950
RELEASED 0 2023-07-16 19:08:08.563677
GRANTED 1 2023-07-16 19:08:08.563677
REQUEST 0 2023-07-16 19:08:08.564181
GRANTED 0 2023-07-16 19:08:08.570241
RELEASED 1 2023-07-16 19:08:08.569755
REQUEST 1 2023-07-16 19:08:08.571313
GRANTED 1 2023-07-16 19:08:08.587254
RELEASED 0 2023-07-16 19:08:08.586807
REQUEST 0 2023-07-16 19:08:08.588313
RELEASED 1 2023-07-16 19:08:08.601735
GRANTED 0 2023-07-16 19:08:08.601735
REQUEST 1 2023-07-16 19:08:08.604815
GRANTED 1 2023-07-16 19:08:08.609860
RELEASED 0 2023-07-16 19:08:08.609860
REQUEST 0 2023-07-16 19:08:08.611319
GRANTED 0 2023-07-16 19:08:08.622853
RELEASED 1 2023-07-16 19:08:08.622328
REQUEST 1 2023-07-16 19:08:08.623412
RELEASED 0 2023-07-16 19:08:08.634212
GRANTED 1 2023-07-16 19:08:08.634681
RELEASED 1 2023-07-16 19:08:08.642940
```

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Minimamente funcional.

▼ Teste 1 de escalabilidade do sistema.

n = 2, r = 10, e k = 2	38,250 segundos
n = 4, r = 10, e k = 2	78,484 segundos
n = 8, r = 10, e k = 2	158,932 segundos
n = 16, r = 10, e k = 2	320,285 segundos
n = 32, r = 10, e k = 2	640,785 segundos

▼ Test 2 de escalabilidade do sistema.

n = 2, r = 5, e k = 1	9,121 segundos
n = 4, r = 5, e k = 1	19,237 segundos
n = 8, r = 5, e k = 1	39,559 segundos
n = 16, r = 5, e k = 1	79,964 segundos
n = 32, r = 5, e k = 1	161,150 segundos
n = 64, r = 5, e k = 1	322,934 segundos

exemplo de log (não passou na validação)

▼ results.txt (10 linhas 2x5) - 9,121 segundos

```
Process Id: 0 - 2023-07-16 20:05:42.273171

Process Id: 1 - 2023-07-16 20:05:43.279929

Process Id: 0 - 2023-07-16 20:05:44.298874

Process Id: 1 - 2023-07-16 20:05:45.309819

Process Id: 0 - 2023-07-16 20:05:46.324346

Process Id: 1 - 2023-07-16 20:05:47.338246

Process Id: 0 - 2023-07-16 20:05:48.350782

Process Id: 1 - 2023-07-16 20:05:49.365274

Process Id: 0 - 2023-07-16 20:05:50.375657

Process Id: 1 - 2023-07-16 20:05:51.394341
```

```
Message Process ID Time
REQUEST 0 2023-07-16 20:05:05.270908
GRANTED 0 2023-07-16 20:05:05.271947
REQUEST 1 2023-07-16 20:05:05.301246
RELEASED 0 2023-07-16 20:05:05.279353
```

```
GRANTED 1 2023-07-16 20:05:05.279353
REQUEST 0 2023-07-16 20:05:05.279929
RELEASED 1 2023-07-16 20:05:05.297664
GRANTED 0 2023-07-16 20:05:05.297664
REQUEST 1 2023-07-16 20:05:05.298874
GRANTED 1 2023-07-16 20:05:05.309238
RELEASED 0 2023-07-16 20:05:05.309238
REQUEST 0 2023-07-16 20:05:05.310323
RELEASED 1 2023-07-16 20:05:05.323318
GRANTED 0 2023-07-16 20:05:05.323318
REQUEST 1 2023-07-16 20:05:05.324346
RELEASED 0 2023-07-16 20:05:05.337227
GRANTED 1 2023-07-16 20:05:05.337227
REQUEST 0 2023-07-16 20:05:05.338246
GRANTED 0 2023-07-16 20:05:05.350275
RELEASED 1 2023-07-16 20:05:05.350275
REQUEST 1 2023-07-16 20:05:05.351425
RELEASED 0 2023-07-16 20:05:05.363207
GRANTED 1 2023-07-16 20:05:05.363207
REQUEST 0 2023-07-16 20:05:05.365274
GRANTED 0 2023-07-16 20:05:05.375152
RELEASED 1 2023-07-16 20:05:05.375152
REQUEST 1 2023-07-16 20:05:05.375657
RELEASED 0 2023-07-16 20:05:05.391792
GRANTED 1 2023-07-16 20:05:05.391792
RELEASED 1 2023-07-16 20:05:05.400547
```

▼ Test 3 de escalabilidade do sistema.

n = 2, r = 3, e k = 0	0,053 segundos
n = 4, r = 3, e k = 0	0,087 segundos
n = 8, r = 3, e k = 0	0,181 segundos
n = 16, r = 3, e k = 0	0,618 segundos
n = 32, r = 3, e k = 0	1,726 segundos
n = 64, r = 3, e k = 0	3,335 segundos
n = 128, r = 3, e k = 0	11,911 segundos

Validação dos arquivos

Para validar que o acesso à zona crítica foi sequencial e organizado pelo servidor, olhamos os logs gerados no arquivo serverlog.txt e checamos utilizando o script disponibilizado pelo professor com ligeiras alterações.

```
def validate():
    f = open("serverlog.txt", "r")
    lines = f.readlines()
    requests = []
    grants = []
    releases = []
    for index, line in enumerate(lines):
        if(index == 0): continue
        print(index)
        if ("REQUEST" in line):
            requests.append(int(line.split("-")[1]))
        if ("GRANTED" in line):
            if (len(grants) != len(releases)):
                print(line)
                print(len(grants))
                print(len(releases))
                raise Exception("Invalid log file: invalid grants and releases sequence")
            grants.append(int(line.split("-")[1]))
            continue
        if ("RELEASED" in line):
            if (len(releases) != len(grants) - 1):
                raise Exception("Invalid log file: invalid grants and releases sequence")
            releases.append(int(line.split("-")[1]))
            continue
        print(requests, grants, releases)
    for i in range(len(requests)):
        if (requests[i] != grants[i] or grants[i] != releases[i]):
            raise Exception("Invalid log file: invalid grants and releases sequence")
    print("Log file was successfully validated")
if __name__ == "__main__":
    validate()
```

Todos os arquivos a partir desse momento no relatório passaram com sucesso pelo processo de validação.

```
955
956
957
958
959
960
Log file was successfully validated
```

Após rodar os testes e tentativas de validar os logs, percebemos que a ordem entre escrever no arquivo de log e enviar a mensagem estava equivocada - gerando 'GRANT's antes de 'RELEASE's. Após a correção rodamos novamente os testes.

Fixed order of log messages

37 min

Pedro-genesis committed 2 hours ago

Stowing 1 changed file with 1 addition and 1 deletion.

\$\frac{1}{2} \frac{1}{2} \text{ min } \text{ Tell server steal ATTM semplorer space (\$\frac{1}{2} \text{ min } \text{ min

Segunda Rodada de testes:

▼ Teste 1 de escalabilidade do sistema.

 ∇ n = 2, r = 10, e k = 2 - 38,241 segundos

▼ results.txt (20 linhas 2x10)

```
Process Id: 0 - 2023-07-17 17:16:58.305141
Process Id: 1 - 2023-07-17 17:17:00.319360
Process Id: 0 - 2023-07-17 17:17:02.331801
Process Id: 1 - 2023-07-17 17:17:04.346589
Process Id: 0 - 2023-07-17 17:17:06.349667
Process Id: 1 - 2023-07-17 17:17:08.367794
Process Id: 0 - 2023-07-17 17:17:10.379695
Process Id: 1 - 2023-07-17 17:17:12.385123
Process Id: 0 - 2023-07-17 17:17:14.401655
Process Id: 1 - 2023-07-17 17:17:16.412379
Process Id: 0 - 2023-07-17 17:17:18.426146
Process Id: 1 - 2023-07-17 17:17:20.444785
Process Id: 0 - 2023-07-17 17:17:22.459264
Process Id: 1 - 2023-07-17 17:17:24.463507
Process Id: 0 - 2023-07-17 17:17:26.482144
Process Id: 1 - 2023-07-17 17:17:28.495592
Process Id: 0 - 2023-07-17 17:17:30.505988
Process Id: 1 - 2023-07-17 17:17:32.520653
Process Id: 0 - 2023-07-17 17:17:34.536500
Process Id: 1 - 2023-07-17 17:17:36.546382
```

```
Message Process ID Time
REQUEST 0 2023-07-17 17:16:16.302601
GRANTED 0 2023-07-17 17:16:16.303629
REQUEST 1 2023-07-17 17:16:16.304148
RELEASED 0 2023-07-17 17:17:17.316235
GRANTED 1 2023-07-17 17:17:17.317345
REQUEST 0 2023-07-17 17:17:17.318726
RELEASED 1 2023-07-17 17:17:17.330005
GRANTED 0 2023-07-17 17:17:17.330005
```

```
REQUEST 1 2023-07-17 17:17:17.331801
RELEASED 0 2023-07-17 17:17:17.345627
GRANTED 1 2023-07-17 17:17:17.346084
REQUEST 0 2023-07-17 17:17:17.346589
RELEASED 1 2023-07-17 17:17:17.348710
GRANTED 0 2023-07-17 17:17:17.349163
REQUEST 1 2023-07-17 17:17:17.349667
RELEASED 0 2023-07-17 17:17:17.362672
GRANTED 1 2023-07-17 17:17:17.366726
REQUEST 0 2023-07-17 17:17:17.367268
RELEASED 1 2023-07-17 17:17:17.378115
GRANTED 0 2023-07-17 17:17:17.378664
REQUEST 1 2023-07-17 17:17:17.379169
RELEASED 0 2023-07-17 17:17:17.384049
GRANTED 1 2023-07-17 17:17:17.384593
REQUEST 0 2023-07-17 17:17:17.384593
RELEASED 1 2023-07-17 17:17:17.400618
GRANTED 0 2023-07-17 17:17:17.401122
REQUEST 1 2023-07-17 17:17:17.401122
RELEASED 0 2023-07-17 17:17:17.411352
GRANTED 1 2023-07-17 17:17:17.411352
REQUEST 0 2023-07-17 17:17:17.411857
RELEASED 1 2023-07-17 17:17:17.423045
GRANTED 0 2023-07-17 17:17:17.424118
REQUEST 1 2023-07-17 17:17:17.424736
RELEASED 0 2023-07-17 17:17:17.442032
GRANTED 1 2023-07-17 17:17:17.443345
REQUEST 0 2023-07-17 17:17:17.444219
RELEASED 1 2023-07-17 17:17:17.455092
GRANTED 0 2023-07-17 17:17:17.456716
REQUEST 1 2023-07-17 17:17:17.458077
RELEASED 0 2023-07-17 17:17:17.459997
GRANTED 1 2023-07-17 17:17:17.461307
REQUEST 0 2023-07-17 17:17:17.462440
RELEASED 1 2023-07-17 17:17:17.478406
GRANTED 0 2023-07-17 17:17:17.479740
REQUEST 1 2023-07-17 17:17:17.480930
RELEASED 0 2023-07-17 17:17:17.491039
GRANTED 1 2023-07-17 17:17:17.492747
REQUEST 0 2023-07-17 17:17:17.494162
RELEASED 1 2023-07-17 17:17:17.503007
GRANTED 0 2023-07-17 17:17:17.503941
REQUEST 1 2023-07-17 17:17:17.505163
RELEASED 0 2023-07-17 17:17:17.519088
GRANTED 1 2023-07-17 17:17:17.520108
REQUEST 0 2023-07-17 17:17:17.520653
RELEASED 1 2023-07-17 17:17:17.532110
GRANTED 0 2023-07-17 17:17:17.534430
REQUEST 1 2023-07-17 17:17:17.535738
RELEASED 0 2023-07-17 17:17:17.544858
GRANTED 1 2023-07-17 17:17:17.545845
RELEASED 1 2023-07-17 17:17:17.557780
```

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▼ n = 4, r = 10, e k = 2 - 78,687 segundos

▼ results.txt (40 linhas 4x10)

```
Process Id: 0 - 2023-07-17 17:19:42.426839
Process Id: 2 - 2023-07-17 17:19:44.432405
Process Id: 1 - 2023-07-17 17:19:46.452579
Process Id: 3 - 2023-07-17 17:19:48.470325
Process Id: 0 - 2023-07-17 17:19:50.487298
Process Id: 2 - 2023-07-17 17:19:52.509304
Process Id: 1 - 2023-07-17 17:19:54.532697
Process Id: 3 - 2023-07-17 17:19:56.549142
Process Id: 0 - 2023-07-17 17:19:58.558853
Process Id: 2 - 2023-07-17 17:20:00.571264
Process Id: 1 - 2023-07-17 17:20:02.580204
Process Id: 3 - 2023-07-17 17:20:04.595085
Process Id: 0 - 2023-07-17 17:20:06.613292
Process Id: 2 - 2023-07-17 17:20:08.636104
Process Id: 1 - 2023-07-17 17:20:10.647731
Process Id: 3 - 2023-07-17 17:20:12.660433
Process Id: 0 - 2023-07-17 17:20:14.673557
Process Id: 2 - 2023-07-17 17:20:16.695859
Process Id: 1 - 2023-07-17 17:20:18.712242
Process Id: 3 - 2023-07-17 17:20:20.730280
Process Id: 0 - 2023-07-17 17:20:22.750273
Process Id: 2 - 2023-07-17 17:20:24.759113
Process Id: 1 - 2023-07-17 17:20:26.783128
Process Id: 3 - 2023-07-17 17:20:28.806881
Process Id: 0 - 2023-07-17 17:20:30.818644
Process Id: 2 - 2023-07-17 17:20:32.839548
Process Id: 1 - 2023-07-17 17:20:34.868760
Process Id: 3 - 2023-07-17 17:20:36.882065
Process Id: 0 - 2023-07-17 17:20:38.894821
Process Id: 2 - 2023-07-17 17:20:40.906720
Process Id: 1 - 2023-07-17 17:20:42.920795
Process Id: 3 - 2023-07-17 17:20:44.938612
Process Id: 0 - 2023-07-17 17:20:46.959691
Process Id: 2 - 2023-07-17 17:20:48.984828
Process Id: 1 - 2023-07-17 17:20:51.011068
Process Id: 3 - 2023-07-17 17:20:53.031755
Process Id: 0 - 2023-07-17 17:20:55.046324
Process Id: 2 - 2023-07-17 17:20:57.060135
Process Id: 1 - 2023-07-17 17:20:59.087298
Process Id: 3 - 2023-07-17 17:21:01.113508
```

```
Message Process ID Time
REQUEST 0 2023-07-17 17:19:19.424878
GRANTED 0 2023-07-17 17:19:19.425784
```

```
REQUEST 2 2023-07-17 17:19:19.451473
REQUEST 1 2023-07-17 17:19:19.466950
REQUEST 3 2023-07-17 17:19:19.482884
RELEASED 0 2023-07-17 17:19:19.430821
GRANTED 2 2023-07-17 17:19:19.431371
REQUEST 0 2023-07-17 17:19:19.431878
RELEASED 2 2023-07-17 17:19:19.449577
GRANTED 1 2023-07-17 17:19:19.450578
REQUEST 2 2023-07-17 17:19:19.451578
RELEASED 1 2023-07-17 17:19:19.468644
GRANTED 3 2023-07-17 17:19:19.469765
REQUEST 1 2023-07-17 17:19:19.469820
RELEASED 3 2023-07-17 17:19:19.481167
GRANTED 0 2023-07-17 17:19:19.482989
REQUEST 3 2023-07-17 17:19:19.484330
RELEASED 0 2023-07-17 17:19:19.506218
GRANTED 2 2023-07-17 17:19:19.507553
REQUEST 0 2023-07-17 17:19:19.508618
RELEASED 2 2023-07-17 17:19:19.530915
GRANTED 1 2023-07-17 17:19:19.531471
REQUEST 2 2023-07-17 17:19:19.532069
RELEASED 1 2023-07-17 17:19:19.544841
GRANTED 3 2023-07-17 17:19:19.546938
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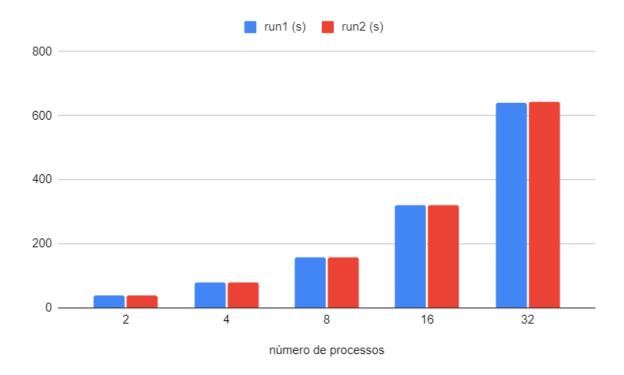
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▼ Test 2 de escalabilidade do sistema.

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Message Process ID Time
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GRANTED 0 2023-07-17 18:37:37.357777
REQUEST 1 2023-07-17 18:37:37.372886
RELEASED 0 2023-07-17 18:37:37.368761
GRANTED 1 2023-07-17 18:37:37.370835
```

```
REQUEST 0 2023-07-17 18:37:37.372082
RELEASED 1 2023-07-17 18:37:37.379042
GRANTED 0 2023-07-17 18:37:37.379465
REQUEST 1 2023-07-17 18:37:37.379969
RELEASED 0 2023-07-17 18:37:37.394309
GRANTED 1 2023-07-17 18:37:37.394309
REQUEST 0 2023-07-17 18:37:37.395416
RELEASED 1 2023-07-17 18:37:37.405828
GRANTED 0 2023-07-17 18:37:37.406322
REQUEST 1 2023-07-17 18:37:37.406934
RELEASED 0 2023-07-17 18:37:37.417320
GRANTED 1 2023-07-17 18:37:37.420923
REQUEST 0 2023-07-17 18:37:37.421431
RELEASED 1 2023-07-17 18:37:37.429738
GRANTED 0 2023-07-17 18:37:37.429738
REQUEST 1 2023-07-17 18:37:37.430305
RELEASED 0 2023-07-17 18:37:37.440270
GRANTED 1 2023-07-17 18:37:37.440630
REQUEST 0 2023-07-17 18:37:37.441150
RELEASED 1 2023-07-17 18:37:37.449263
GRANTED 0 2023-07-17 18:37:37.451485
REQUEST 1 2023-07-17 18:37:37.452094
RELEASED 0 2023-07-17 18:37:37.465009
GRANTED 1 2023-07-17 18:37:37.466134
RELEASED 1 2023-07-17 18:37:37.488129
```

▼ n = 4, r = 5, e k = 1 - 19,296 segundos

▼ results.txt (20 linhas 4x5)

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Process Id: 0 - 2023-07-17 18:37:52.056271
Process Id: 1 - 2023-07-17 18:37:53.071924
Process Id: 2 - 2023-07-17 18:37:54.086812
Process Id: 3 - 2023-07-17 18:37:55.099980
Process Id: 0 - 2023-07-17 18:37:56.123367
Process Id: 1 - 2023-07-17 18:37:57.137289
Process Id: 2 - 2023-07-17 18:37:58.147653
Process Id: 3 - 2023-07-17 18:37:59.167682
Process Id: 0 - 2023-07-17 18:38:00.193694
Process Id: 1 - 2023-07-17 18:38:01.217484
Process Id: 2 - 2023-07-17 18:38:02.232130
Process Id: 3 - 2023-07-17 18:38:03.247082
Process Id: 0 - 2023-07-17 18:38:04.259228
Process Id: 1 - 2023-07-17 18:38:05.276428
Process Id: 2 - 2023-07-17 18:38:06.285366
Process Id: 3 - 2023-07-17 18:38:07.295615
Process Id: 0 - 2023-07-17 18:38:08.307521
Process Id: 1 - 2023-07-17 18:38:09.323413
Process Id: 2 - 2023-07-17 18:38:10.337610
Process Id: 3 - 2023-07-17 18:38:11.351990
```

```
Message Process ID Time
REQUEST 0 2023-07-17 18:37:37.054174
GRANTED 0 2023-07-17 18:37:37.055223
REQUEST 1 2023-07-17 18:37:37.070186
REQUEST 2 2023-07-17 18:37:37.100375
REQUEST 3 2023-07-17 18:37:37.114815
RELEASED 0 2023-07-17 18:37:37.070899
GRANTED 1 2023-07-17 18:37:37.070899
REQUEST 0 2023-07-17 18:37:37.071403
RELEASED 1 2023-07-17 18:37:37.084736
GRANTED 2 2023-07-17 18:37:37.085742
REQUEST 1 2023-07-17 18:37:37.086270
RELEASED 2 2023-07-17 18:37:37.095164
GRANTED 3 2023-07-17 18:37:37.096463
REQUEST 2 2023-07-17 18:37:37.097530
RELEASED 3 2023-07-17 18:37:37.122337
GRANTED 0 2023-07-17 18:37:37.122337
REQUEST 3 2023-07-17 18:37:37.122842
RELEASED 0 2023-07-17 18:37:37.136253
GRANTED 1 2023-07-17 18:37:37.136253
REQUEST 0 2023-07-17 18:37:37.136758
RELEASED 1 2023-07-17 18:37:37.146095
GRANTED 2 2023-07-17 18:37:37.146622
REQUEST 1 2023-07-17 18:37:37.147127
RELEASED 2 2023-07-17 18:37:37.160139
GRANTED 3 2023-07-17 18:37:37.162725
REQUEST 2 2023-07-17 18:37:37.164784
RELEASED 3 2023-07-17 18:38:38.188370
GRANTED 0 2023-07-17 18:38:38.191119
REQUEST 3 2023-07-17 18:38:38.192815
RELEASED 0 2023-07-17 18:38:38.216400
GRANTED 1 2023-07-17 18:38:38.216924
REQUEST 0 2023-07-17 18:38:38.216979
RELEASED 1 2023-07-17 18:38:38.230128
GRANTED 2 2023-07-17 18:38:38.230706
REQUEST 1 2023-07-17 18:38:38.231621
RELEASED 2 2023-07-17 18:38:38.244944
GRANTED 3 2023-07-17 18:38:38.245459
REQUEST 2 2023-07-17 18:38:38.246535
RELEASED 3 2023-07-17 18:38:38.258669
GRANTED 0 2023-07-17 18:38:38.258669
REQUEST 3 2023-07-17 18:38:38.259228
RELEASED 0 2023-07-17 18:38:38.274230
GRANTED 1 2023-07-17 18:38:38.274812
REQUEST 0 2023-07-17 18:38:38.275921
RELEASED 1 2023-07-17 18:38:38.284531
GRANTED 2 2023-07-17 18:38:38.284859
REQUEST 1 2023-07-17 18:38:38.285366
RELEASED 2 2023-07-17 18:38:38.294069
GRANTED 3 2023-07-17 18:38:38.294576
REQUEST 2 2023-07-17 18:38:38.295615
```

```
RELEASED 3 2023-07-17 18:38:38.306023
GRANTED 0 2023-07-17 18:38:38.306917
REQUEST 3 2023-07-17 18:38:38.306917
RELEASED 0 2023-07-17 18:38:38.321878
GRANTED 1 2023-07-17 18:38:38.322385
RELEASED 1 2023-07-17 18:38:38.336361
GRANTED 2 2023-07-17 18:38:38.336361
RELEASED 2 2023-07-17 18:38:38.347167
GRANTED 3 2023-07-17 18:38:38.348879
RELEASED 3 2023-07-17 18:38:38.369307
```

▼ n = 8, r = 5, e k = 1 - 39,556 segundos

▼ results.txt (40 linhas 8x5)

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Process Id: 0 - 2023-07-17 18:38:42.490084
Process Id: 1 - 2023-07-17 18:38:43.502062
Process Id: 2 - 2023-07-17 18:38:44.512622
Process Id: 3 - 2023-07-17 18:38:45.533106
Process Id: 4 - 2023-07-17 18:38:46.553839
Process Id: 5 - 2023-07-17 18:38:47.565941
Process Id: 6 - 2023-07-17 18:38:48.573751
Process Id: 7 - 2023-07-17 18:38:49.589964
Process Id: 0 - 2023-07-17 18:38:50.600442
Process Id: 1 - 2023-07-17 18:38:51.616319
Process Id: 2 - 2023-07-17 18:38:52.656682
Process Id: 3 - 2023-07-17 18:38:53.673667
Process Id: 4 - 2023-07-17 18:38:54.687588
Process Id: 5 - 2023-07-17 18:38:55.703056
Process Id: 6 - 2023-07-17 18:38:56.722417
Process Id: 7 - 2023-07-17 18:38:57.731698
Process Id: 0 - 2023-07-17 18:38:58.741850
Process Id: 1 - 2023-07-17 18:38:59.753361
Process Id: 2 - 2023-07-17 18:39:00.765351
Process Id: 3 - 2023-07-17 18:39:01.779106
Process Id: 4 - 2023-07-17 18:39:02.789982
Process Id: 5 - 2023-07-17 18:39:03.797712
Process Id: 6 - 2023-07-17 18:39:04.810773
Process Id: 7 - 2023-07-17 18:39:05.827010
Process Id: 0 - 2023-07-17 18:39:06.839176
Process Id: 1 - 2023-07-17 18:39:07.850665
Process Id: 2 - 2023-07-17 18:39:08.868133
Process Id: 3 - 2023-07-17 18:39:09.875192
Process Id: 4 - 2023-07-17 18:39:10.888225
Process Id: 5 - 2023-07-17 18:39:11.897813
Process Id: 6 - 2023-07-17 18:39:12.905348
Process Id: 7 - 2023-07-17 18:39:13.920667
Process Id: 0 - 2023-07-17 18:39:14.928090
Process Id: 1 - 2023-07-17 18:39:15.947514
Process Id: 2 - 2023-07-17 18:39:16.972256
Process Id: 3 - 2023-07-17 18:39:17.984078
Process Id: 4 - 2023-07-17 18:39:18.994217
```

```
Process Id: 5 - 2023-07-17 18:39:20.012899

Process Id: 6 - 2023-07-17 18:39:21.023695

Process Id: 7 - 2023-07-17 18:39:22.048631
```

```
Message Process ID Time
REQUEST 0 2023-07-17 18:38:38.487280
GRANTED 0 2023-07-17 18:38:38.488909
REQUEST 1 2023-07-17 18:38:38.517971
REQUEST 2 2023-07-17 18:38:38.548687
REQUEST 3 2023-07-17 18:38:38.548687
REQUEST 4 2023-07-17 18:38:38.579665
REQUEST 5 2023-07-17 18:38:38.609395
REQUEST 6 2023-07-17 18:38:38.640817
REQUEST 7 2023-07-17 18:38:38.686923
RELEASED 0 2023-07-17 18:38:38.500501
GRANTED 1 2023-07-17 18:38:38.501033
REQUEST 0 2023-07-17 18:38:38.501538
RELEASED 1 2023-07-17 18:38:38.511047
GRANTED 2 2023-07-17 18:38:38.511583
REQUEST 1 2023-07-17 18:38:38.512092
RELEASED 2 2023-07-17 18:38:38.526545
GRANTED 3 2023-07-17 18:38:38.531346
REQUEST 2 2023-07-17 18:38:38.532383
RELEASED 3 2023-07-17 18:38:38.552808
GRANTED 4 2023-07-17 18:38:38.552808
REQUEST 3 2023-07-17 18:38:38.553314
RELEASED 4 2023-07-17 18:38:38.563619
GRANTED 5 2023-07-17 18:38:38.564920
REQUEST 4 2023-07-17 18:38:38.565427
RELEASED 5 2023-07-17 18:38:38.572521
GRANTED 6 2023-07-17 18:38:38.572521
REQUEST 5 2023-07-17 18:38:38.573189
RELEASED 6 2023-07-17 18:38:38.587110
GRANTED 7 2023-07-17 18:38:38.588386
REQUEST 6 2023-07-17 18:38:38.589502
RELEASED 7 2023-07-17 18:38:38.597901
GRANTED 0 2023-07-17 18:38:38.599331
REQUEST 7 2023-07-17 18:38:38.599936
RELEASED 0 2023-07-17 18:38:38.611842
GRANTED 1 2023-07-17 18:38:38.613349
REQUEST 0 2023-07-17 18:38:38.615076
RELEASED 1 2023-07-17 18:38:38.651742
GRANTED 2 2023-07-17 18:38:38.653986
REQUEST 1 2023-07-17 18:38:38.655089
RELEASED 2 2023-07-17 18:38:38.672638
GRANTED 3 2023-07-17 18:38:38.672638
REQUEST 2 2023-07-17 18:38:38.673143
RELEASED 3 2023-07-17 18:38:38.684883
GRANTED 4 2023-07-17 18:38:38.684883
REQUEST 3 2023-07-17 18:38:38.686958
```

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RELEASED 4 2023-07-17 18:38:38.702012
GRANTED 5 2023-07-17 18:38:38.702012
REQUEST 4 2023-07-17 18:38:38.702517
RELEASED 5 2023-07-17 18:38:38.720909
GRANTED 6 2023-07-17 18:38:38.721383
REQUEST 5 2023-07-17 18:38:38.721889
RELEASED 6 2023-07-17 18:38:38.729496
GRANTED 7 2023-07-17 18:38:38.730582
REQUEST 6 2023-07-17 18:38:38.731615
RELEASED 7 2023-07-17 18:38:38.740784
GRANTED 0 2023-07-17 18:38:38.741295
REQUEST 7 2023-07-17 18:38:38.741850
RELEASED 0 2023-07-17 18:38:38.752292
GRANTED 1 2023-07-17 18:38:38.752796
REQUEST 0 2023-07-17 18:38:38.752854
RELEASED 1 2023-07-17 18:39:39.764318
GRANTED 2 2023-07-17 18:39:39.764318
REQUEST 1 2023-07-17 18:39:39.764825
RELEASED 2 2023-07-17 18:39:39.778070
GRANTED 3 2023-07-17 18:39:39.778070
REQUEST 2 2023-07-17 18:39:39.778574
RELEASED 3 2023-07-17 18:39:39.788916
GRANTED 4 2023-07-17 18:39:39.788916
REQUEST 3 2023-07-17 18:39:39.789473
RELEASED 4 2023-07-17 18:39:39.796152
GRANTED 5 2023-07-17 18:39:39.796661
REQUEST 4 2023-07-17 18:39:39.797347
RELEASED 5 2023-07-17 18:39:39.809772
GRANTED 6 2023-07-17 18:39:39.810268
REQUEST 5 2023-07-17 18:39:39.810773
RELEASED 6 2023-07-17 18:39:39.824197
GRANTED 7 2023-07-17 18:39:39.825300
REQUEST 6 2023-07-17 18:39:39.826447
RELEASED 7 2023-07-17 18:39:39.838147
GRANTED 0 2023-07-17 18:39:39.838147
REQUEST 7 2023-07-17 18:39:39.838653
RELEASED 0 2023-07-17 18:39:39.849087
GRANTED 1 2023-07-17 18:39:39.849592
REQUEST 0 2023-07-17 18:39:39.850128
RELEASED 1 2023-07-17 18:39:39.864850
GRANTED 2 2023-07-17 18:39:39.865359
REQUEST 1 2023-07-17 18:39:39.866284
RELEASED 2 2023-07-17 18:39:39.873653
GRANTED 3 2023-07-17 18:39:39.874159
REQUEST 2 2023-07-17 18:39:39.874668
RELEASED 3 2023-07-17 18:39:39.887137
GRANTED 4 2023-07-17 18:39:39.887137
REQUEST 3 2023-07-17 18:39:39.887720
RELEASED 4 2023-07-17 18:39:39.896122
GRANTED 5 2023-07-17 18:39:39.896631
REQUEST 4 2023-07-17 18:39:39.897732
RELEASED 5 2023-07-17 18:39:39.904290
GRANTED 6 2023-07-17 18:39:39.904290
REQUEST 5 2023-07-17 18:39:39.904795
RELEASED 6 2023-07-17 18:39:39.920160
```

```
GRANTED 7 2023-07-17 18:39:39.920160
REQUEST 6 2023-07-17 18:39:39.920667
RELEASED 7 2023-07-17 18:39:39.927043
GRANTED 0 2023-07-17 18:39:39.927043
REQUEST 7 2023-07-17 18:39:39.927548
RELEASED 0 2023-07-17 18:39:39.944510
GRANTED 1 2023-07-17 18:39:39.945925
RELEASED 1 2023-07-17 18:39:39.971173
GRANTED 2 2023-07-17 18:39:39.971173
RELEASED 2 2023-07-17 18:39:39.981735
GRANTED 3 2023-07-17 18:39:39.982243
RELEASED 3 2023-07-17 18:39:39.992818
GRANTED 4 2023-07-17 18:39:39.993186
RELEASED 4 2023-07-17 18:39:39.011432
GRANTED 5 2023-07-17 18:39:39.012395
RELEASED 5 2023-07-17 18:39:39.020895
GRANTED 6 2023-07-17 18:39:39.021402
RELEASED 6 2023-07-17 18:39:39.046404
GRANTED 7 2023-07-17 18:39:39.046917
RELEASED 7 2023-07-17 18:39:39.063224
```

▼ n = 16, r = 5, e k = 1 - 80,085 segundos

▼ results.txt (80 linhas 16x5)

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Process Id: 0 - 2023-07-17 18:42:48.744008
Process Id: 1 - 2023-07-17 18:42:49.752802
Process Id: 2 - 2023-07-17 18:42:50.770926
Process Id: 3 - 2023-07-17 18:42:51.779279
Process Id: 4 - 2023-07-17 18:42:52.784989
Process Id: 5 - 2023-07-17 18:42:53.798220
Process Id: 6 - 2023-07-17 18:42:54.812032
Process Id: 7 - 2023-07-17 18:42:55.820102
Process Id: 8 - 2023-07-17 18:42:56.832118
Process Id: 9 - 2023-07-17 18:42:57.852712
Process Id: 10 - 2023-07-17 18:42:58.862294
Process Id: 11 - 2023-07-17 18:42:59.871174
Process Id: 12 - 2023-07-17 18:43:00.888574
Process Id: 13 - 2023-07-17 18:43:01.900817
Process Id: 14 - 2023-07-17 18:43:02.914289
Process Id: 15 - 2023-07-17 18:43:03.926501
Process Id: 0 - 2023-07-17 18:43:04.941966
Process Id: 1 - 2023-07-17 18:43:05.948657
Process Id: 2 - 2023-07-17 18:43:06.971088
Process Id: 3 - 2023-07-17 18:43:07.992399
Process Id: 4 - 2023-07-17 18:43:09.004262
Process Id: 5 - 2023-07-17 18:43:10.019157
Process Id: 6 - 2023-07-17 18:43:11.024531
Process Id: 7 - 2023-07-17 18:43:12.038839
Process Id: 8 - 2023-07-17 18:43:13.046472
Process Id: 9 - 2023-07-17 18:43:14.059431
Process Id: 10 - 2023-07-17 18:43:15.070978
```

```
Process Id: 11 - 2023-07-17 18:43:16.083074
Process Id: 12 - 2023-07-17 18:43:17.096709
Process Id: 13 - 2023-07-17 18:43:18.121695
Process Id: 14 - 2023-07-17 18:43:19.142720
Process Id: 15 - 2023-07-17 18:43:20.158493
Process Id: 0 - 2023-07-17 18:43:21.173284
Process Id: 1 - 2023-07-17 18:43:22.183727
Process Id: 2 - 2023-07-17 18:43:23.195234
Process Id: 3 - 2023-07-17 18:43:24.208217
Process Id: 4 - 2023-07-17 18:43:25.230484
Process Id: 5 - 2023-07-17 18:43:26.251669
Process Id: 6 - 2023-07-17 18:43:27.265522
Process Id: 7 - 2023-07-17 18:43:28.280239
Process Id: 8 - 2023-07-17 18:43:29.289404
Process Id: 9 - 2023-07-17 18:43:30.309653
Process Id: 10 - 2023-07-17 18:43:31.322636
Process Id: 11 - 2023-07-17 18:43:32.339357
Process Id: 12 - 2023-07-17 18:43:33.350861
Process Id: 13 - 2023-07-17 18:43:34.373534
Process Id: 14 - 2023-07-17 18:43:35.382225
Process Id: 15 - 2023-07-17 18:43:36.393565
Process Id: 0 - 2023-07-17 18:43:37.412231
Process Id: 1 - 2023-07-17 18:43:38.421758
Process Id: 2 - 2023-07-17 18:43:39.433172
Process Id: 3 - 2023-07-17 18:43:40.457133
Process Id: 4 - 2023-07-17 18:43:41.468776
Process Id: 5 - 2023-07-17 18:43:42.478310
Process Id: 6 - 2023-07-17 18:43:43.485907
Process Id: 7 - 2023-07-17 18:43:44.497309
Process Id: 8 - 2023-07-17 18:43:45.514655
Process Id: 9 - 2023-07-17 18:43:46.524807
Process Id: 10 - 2023-07-17 18:43:47.546953
Process Id: 11 - 2023-07-17 18:43:48.555355
Process Id: 12 - 2023-07-17 18:43:49.563655
Process Id: 13 - 2023-07-17 18:43:50.585928
Process Id: 14 - 2023-07-17 18:43:51.598568
Process Id: 15 - 2023-07-17 18:43:52.621427
Process Id: 0 - 2023-07-17 18:43:53.631093
Process Id: 1 - 2023-07-17 18:43:54.642606
Process Id: 2 - 2023-07-17 18:43:55.656385
Process Id: 3 - 2023-07-17 18:43:56.669175
Process Id: 4 - 2023-07-17 18:43:57.683062
Process Id: 5 - 2023-07-17 18:43:58.704171
Process Id: 6 - 2023-07-17 18:43:59.718421
Process Id: 7 - 2023-07-17 18:44:00.733149
Process Id: 8 - 2023-07-17 18:44:01.745237
Process Id: 9 - 2023-07-17 18:44:02.757768
Process Id: 10 - 2023-07-17 18:44:03.771548
Process Id: 11 - 2023-07-17 18:44:04.783201
Process Id: 12 - 2023-07-17 18:44:05.798783
Process Id: 13 - 2023-07-17 18:44:06.806474
Process Id: 14 - 2023-07-17 18:44:07.820202
Process Id: 15 - 2023-07-17 18:44:08.829472
```

```
Message Process ID Time
REQUEST 0 2023-07-17 18:42:42.742468
GRANTED 0 2023-07-17 18:42:42.743490
REQUEST 1 2023-07-17 18:42:42.773992
REQUEST 2 2023-07-17 18:42:42.803767
REQUEST 3 2023-07-17 18:42:42.820139
REQUEST 4 2023-07-17 18:42:42.835348
REQUEST 5 2023-07-17 18:42:42.881928
REQUEST 6 2023-07-17 18:42:42.975630
REQUEST 7 2023-07-17 18:42:42.006052
REQUEST 8 2023-07-17 18:42:42.130723
REQUEST 9 2023-07-17 18:42:42.194584
REQUEST 10 2023-07-17 18:42:42.209169
REQUEST 11 2023-07-17 18:42:42.255511
REQUEST 12 2023-07-17 18:42:42.287141
REQUEST 13 2023-07-17 18:42:42.302206
REQUEST 14 2023-07-17 18:42:42.348281
REQUEST 15 2023-07-17 18:42:42.379376
RELEASED 0 2023-07-17 18:42:42.749844
GRANTED 1 2023-07-17 18:42:42.751005
REQUEST 0 2023-07-17 18:42:42.751653
RELEASED 1 2023-07-17 18:42:42.769898
GRANTED 2 2023-07-17 18:42:42.769898
REQUEST 1 2023-07-17 18:42:42.770404
RELEASED 2 2023-07-17 18:42:42.778250
GRANTED 3 2023-07-17 18:42:42.778250
REOUEST 2 2023-07-17 18:42:42.778756
RELEASED 3 2023-07-17 18:42:42.783858
GRANTED 4 2023-07-17 18:42:42.784364
REQUEST 3 2023-07-17 18:42:42.784364
RELEASED 4 2023-07-17 18:42:42.796621
GRANTED 5 2023-07-17 18:42:42.797131
REQUEST 4 2023-07-17 18:42:42.797661
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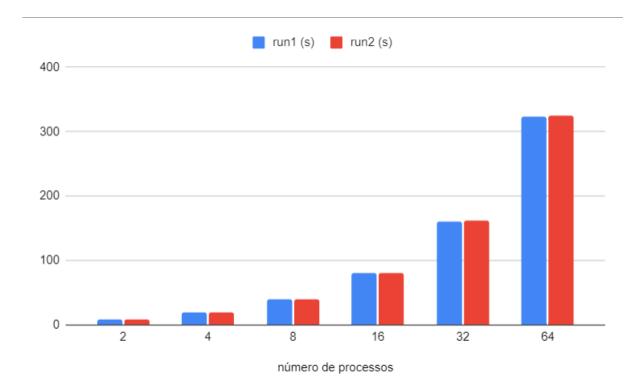
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GRANTED 62 2023-07-17 18:54:54.477912
RELEASED 63 2023-07-17 18:54:54.488109
GRANTED 63 2023-07-17 18:54:54.488613
RELEASED 63 2023-07-17 18:54:54.54.502517



▼ Test 3 de escalabilidade do sistema.

▼ n = 2, r = 3, e k = 0 - 0,035 segundo

▼ results.txt (6 linhas 2x3)

```
Process Id: 0 - 2023-07-17 18:59:44.013432

Process Id: 0 - 2023-07-17 18:59:44.016245

Process Id: 0 - 2023-07-17 18:59:44.022492

Process Id: 1 - 2023-07-17 18:59:44.029043
```

```
Process Id: 1 - 2023-07-17 18:59:44.036521
Process Id: 1 - 2023-07-17 18:59:44.047951
```

▼ serverlog.txt

```
Message Process ID Time
REQUEST 0 2023-07-17 18:59:59.011667
GRANTED 0 2023-07-17 18:59:59.012177
RELEASED 0 2023-07-17 18:59:59.014655
REQUEST 0 2023-07-17 18:59:59.015162
GRANTED 0 2023-07-17 18:59:59.015741
RELEASED 0 2023-07-17 18:59:59.020917
REQUEST 0 2023-07-17 18:59:59.021433
GRANTED 0 2023-07-17 18:59:59.021955
REQUEST 1 2023-07-17 18:59:59.026409
RELEASED 0 2023-07-17 18:59:59.028011
GRANTED 1 2023-07-17 18:59:59.028011
RELEASED 1 2023-07-17 18:59:59.034440
REQUEST 1 2023-07-17 18:59:59.035473
GRANTED 1 2023-07-17 18:59:59.035473
RELEASED 1 2023-07-17 18:59:59.041527
REQUEST 1 2023-07-17 18:59:59.043034
GRANTED 1 2023-07-17 18:59:59.046881
RELEASED 1 2023-07-17 18:59:59.052848
```

▼ n = 4, r = 3, e k = 0 - 0,083 segundos

▼ results.txt (12 linhas 4x3)

```
Process Id: 0 - 2023-07-17 19:00:30.078617

Process Id: 0 - 2023-07-17 19:00:30.081265

Process Id: 0 - 2023-07-17 19:00:30.089574

Process Id: 1 - 2023-07-17 19:00:30.096996

Process Id: 1 - 2023-07-17 19:00:30.104460

Process Id: 2 - 2023-07-17 19:00:30.114859

Process Id: 1 - 2023-07-17 19:00:30.121958

Process Id: 2 - 2023-07-17 19:00:30.127984

Process Id: 3 - 2023-07-17 19:00:30.135602

Process Id: 3 - 2023-07-17 19:00:30.143774

Process Id: 3 - 2023-07-17 19:00:30.152624

Process Id: 3 - 2023-07-17 19:00:30.161434
```

▼ serverlog.txt

```
Message Process ID Time
REQUEST 0 2023-07-17 19:00:00.076561
```

```
GRANTED 0 2023-07-17 19:00:00.077582
RELEASED 0 2023-07-17 19:00:00.079471
REQUEST 0 2023-07-17 19:00:00.080236
GRANTED 0 2023-07-17 19:00:00.080236
RELEASED 0 2023-07-17 19:00:00.088151
REQUEST 0 2023-07-17 19:00:00.088657
GRANTED 0 2023-07-17 19:00:00.089016
REQUEST 1 2023-07-17 19:00:00.093391
RELEASED 0 2023-07-17 19:00:00.095850
GRANTED 1 2023-07-17 19:00:00.095850
RELEASED 1 2023-07-17 19:00:00.102341
REQUEST 1 2023-07-17 19:00:00.103429
GRANTED 1 2023-07-17 19:00:00.103429
REQUEST 2 2023-07-17 19:00:00.108802
RELEASED 1 2023-07-17 19:00:00.110361
GRANTED 2 2023-07-17 19:00:00.114225
REQUEST 1 2023-07-17 19:00:00.114859
RELEASED 2 2023-07-17 19:00:00.120371
GRANTED 1 2023-07-17 19:00:00.120935
REQUEST 2 2023-07-17 19:00:00.121440
REQUEST 3 2023-07-17 19:00:00.123936
RELEASED 1 2023-07-17 19:00:00.127045
GRANTED 2 2023-07-17 19:00:00.127465
RELEASED 2 2023-07-17 19:00:00.134040
GRANTED 3 2023-07-17 19:00:00.134974
REQUEST 2 2023-07-17 19:00:00.135094
RELEASED 3 2023-07-17 19:00:00.142137
GRANTED 2 2023-07-17 19:00:00.142642
REQUEST 3 2023-07-17 19:00:00.143267
RELEASED 2 2023-07-17 19:00:00.150511
GRANTED 3 2023-07-17 19:00:00.152078
RELEASED 3 2023-07-17 19:00:00.159172
REQUEST 3 2023-07-17 19:00:00.160083
GRANTED 3 2023-07-17 19:00:00.160394
RELEASED 3 2023-07-17 19:00:00.168955
```

▼ n = 8, r = 3, e k = 0 - 0,210 segundos

▼ results.txt (24 linhas 8x3)

```
Process Id: 0 - 2023-07-17 19:01:03.917713

Process Id: 1 - 2023-07-17 19:01:03.919607

Process Id: 0 - 2023-07-17 19:01:03.925551

Process Id: 1 - 2023-07-17 19:01:03.930986

Process Id: 0 - 2023-07-17 19:01:03.937202

Process Id: 1 - 2023-07-17 19:01:03.943384

Process Id: 2 - 2023-07-17 19:01:03.951473

Process Id: 2 - 2023-07-17 19:01:03.959070

Process Id: 2 - 2023-07-17 19:01:03.968929

Process Id: 3 - 2023-07-17 19:01:03.995596

Process Id: 3 - 2023-07-17 19:01:04.004494

Process Id: 3 - 2023-07-17 19:01:04.004494
```

```
Process Id: 4 - 2023-07-17 19:01:04.042446

Process Id: 5 - 2023-07-17 19:01:04.049738

Process Id: 4 - 2023-07-17 19:01:04.057700

Process Id: 6 - 2023-07-17 19:01:04.064523

Process Id: 5 - 2023-07-17 19:01:04.072428

Process Id: 4 - 2023-07-17 19:01:04.080273

Process Id: 7 - 2023-07-17 19:01:04.088642

Process Id: 6 - 2023-07-17 19:01:04.095732

Process Id: 5 - 2023-07-17 19:01:04.104447

Process Id: 7 - 2023-07-17 19:01:04.111371

Process Id: 6 - 2023-07-17 19:01:04.120752

Process Id: 7 - 2023-07-17 19:01:04.127589
```

```
Message Process ID Time
REQUEST 0 2023-07-17 19:01:01.916074
GRANTED 0 2023-07-17 19:01:01.916661
REQUEST 1 2023-07-17 19:01:01.917185
RELEASED 0 2023-07-17 19:01:01.917713
GRANTED 1 2023-07-17 19:01:01.918571
REQUEST 0 2023-07-17 19:01:01.919077
RELEASED 1 2023-07-17 19:01:01.923667
GRANTED 0 2023-07-17 19:01:01.924495
REQUEST 1 2023-07-17 19:01:01.925001
RELEASED 0 2023-07-17 19:01:01.929853
GRANTED 1 2023-07-17 19:01:01.929853
REQUEST 0 2023-07-17 19:01:01.930359
RELEASED 1 2023-07-17 19:01:01.936695
GRANTED 0 2023-07-17 19:01:01.936695
REQUEST 1 2023-07-17 19:01:01.937202
RELEASED 0 2023-07-17 19:01:01.940767
GRANTED 1 2023-07-17 19:01:01.942276
REQUEST 2 2023-07-17 19:01:01.947480
RELEASED 1 2023-07-17 19:01:01.949580
GRANTED 2 2023-07-17 19:01:01.950225
RELEASED 2 2023-07-17 19:01:01.957190
REQUEST 2 2023-07-17 19:01:01.958013
GRANTED 2 2023-07-17 19:01:01.958013
RELEASED 2 2023-07-17 19:01:01.965661
REQUEST 2 2023-07-17 19:01:01.967419
GRANTED 2 2023-07-17 19:01:01.968343
RELEASED 2 2023-07-17 19:01:01.975527
REQUEST 3 2023-07-17 19:01:01.994303
GRANTED 3 2023-07-17 19:01:01.994303
RELEASED 3 2023-07-17 19:01:01.002110
REQUEST 3 2023-07-17 19:01:01.003385
GRANTED 3 2023-07-17 19:01:01.003385
RELEASED 3 2023-07-17 19:01:01.009502
REQUEST 3 2023-07-17 19:01:01.010250
GRANTED 3 2023-07-17 19:01:01.010564
RELEASED 3 2023-07-17 19:01:01.018108
```

```
REQUEST 4 2023-07-17 19:01:01.041094
GRANTED 4 2023-07-17 19:01:01.041094
REQUEST 5 2023-07-17 19:01:01.041931
RELEASED 4 2023-07-17 19:01:01.047983
GRANTED 5 2023-07-17 19:01:01.048874
REQUEST 4 2023-07-17 19:01:01.049738
REQUEST 6 2023-07-17 19:01:01.056058
RELEASED 5 2023-07-17 19:01:01.056596
GRANTED 4 2023-07-17 19:01:01.057190
REQUEST 5 2023-07-17 19:01:01.057190
RELEASED 4 2023-07-17 19:01:01.063206
GRANTED 6 2023-07-17 19:01:01.063712
REQUEST 4 2023-07-17 19:01:01.063892
RELEASED 6 2023-07-17 19:01:01.070818
GRANTED 5 2023-07-17 19:01:01.071334
REQUEST 7 2023-07-17 19:01:01.071919
REQUEST 6 2023-07-17 19:01:01.072428
RELEASED 5 2023-07-17 19:01:01.079143
GRANTED 4 2023-07-17 19:01:01.079143
REQUEST 5 2023-07-17 19:01:01.079652
RELEASED 4 2023-07-17 19:01:01.086809
GRANTED 7 2023-07-17 19:01:01.087222
RELEASED 7 2023-07-17 19:01:01.094667
GRANTED 6 2023-07-17 19:01:01.094667
REQUEST 7 2023-07-17 19:01:01.095226
RELEASED 6 2023-07-17 19:01:01.102869
GRANTED 5 2023-07-17 19:01:01.103380
REQUEST 6 2023-07-17 19:01:01.103905
RELEASED 5 2023-07-17 19:01:01.109977
GRANTED 7 2023-07-17 19:01:01.110308
RELEASED 7 2023-07-17 19:01:01.119659
GRANTED 6 2023-07-17 19:01:01.120164
REQUEST 7 2023-07-17 19:01:01.120164
RELEASED 6 2023-07-17 19:01:01.126551
GRANTED 7 2023-07-17 19:01:01.126551
RELEASED 7 2023-07-17 19:01:01.135652
```

▼ n = 16, r = 3, e k = 0 - 0,728 segundos

▼ results.txt (48 linhas 16x3)

```
Process Id: 0 - 2023-07-17 19:01:30.208954

Process Id: 0 - 2023-07-17 19:01:30.211787

Process Id: 0 - 2023-07-17 19:01:30.218920

Process Id: 1 - 2023-07-17 19:01:30.254829

Process Id: 1 - 2023-07-17 19:01:30.260902

Process Id: 1 - 2023-07-17 19:01:30.270870

Process Id: 2 - 2023-07-17 19:01:30.276833

Process Id: 2 - 2023-07-17 19:01:30.287499

Process Id: 3 - 2023-07-17 19:01:30.295120

Process Id: 3 - 2023-07-17 19:01:30.305883

Process Id: 3 - 2023-07-17 19:01:30.312515
```

```
Process Id: 3 - 2023-07-17 19:01:30.325391
Process Id: 4 - 2023-07-17 19:01:30.346440
Process Id: 4 - 2023-07-17 19:01:30.356438
Process Id: 5 - 2023-07-17 19:01:30.364233
Process Id: 4 - 2023-07-17 19:01:30.371970
Process Id: 5 - 2023-07-17 19:01:30.378936
Process Id: 5 - 2023-07-17 19:01:30.388649
Process Id: 6 - 2023-07-17 19:01:30.461110
Process Id: 7 - 2023-07-17 19:01:30.477721
Process Id: 6 - 2023-07-17 19:01:30.487435
Process Id: 7 - 2023-07-17 19:01:30.495412
Process Id: 6 - 2023-07-17 19:01:30.503180
Process Id: 7 - 2023-07-17 19:01:30.509442
Process Id: 8 - 2023-07-17 19:01:30.618212
Process Id: 8 - 2023-07-17 19:01:30.625564
Process Id: 8 - 2023-07-17 19:01:30.633492
Process Id: 9 - 2023-07-17 19:01:30.714039
Process Id: 9 - 2023-07-17 19:01:30.721144
Process Id: 9 - 2023-07-17 19:01:30.729024
Process Id: 11 - 2023-07-17 19:01:30.736537
Process Id: 11 - 2023-07-17 19:01:30.745439
Process Id: 10 - 2023-07-17 19:01:30.752479
Process Id: 11 - 2023-07-17 19:01:30.759709
Process Id: 10 - 2023-07-17 19:01:30.766659
Process Id: 10 - 2023-07-17 19:01:30.775749
Process Id: 12 - 2023-07-17 19:01:30.792582
Process Id: 12 - 2023-07-17 19:01:30.805633
Process Id: 12 - 2023-07-17 19:01:30.816626
Process Id: 13 - 2023-07-17 19:01:30.839346
Process Id: 13 - 2023-07-17 19:01:30.851165
Process Id: 13 - 2023-07-17 19:01:30.860875
Process Id: 14 - 2023-07-17 19:01:30.872107
Process Id: 14 - 2023-07-17 19:01:30.879879
Process Id: 14 - 2023-07-17 19:01:30.890926
Process Id: 15 - 2023-07-17 19:01:30.917692
Process Id: 15 - 2023-07-17 19:01:30.927391
Process Id: 15 - 2023-07-17 19:01:30.936923
```

```
Message Process ID Time
REQUEST 0 2023-07-17 19:01:01.206673
GRANTED 0 2023-07-17 19:01:01.207703
RELEASED 0 2023-07-17 19:01:01.210000
REQUEST 0 2023-07-17 19:01:01.210507
GRANTED 0 2023-07-17 19:01:01.210765
RELEASED 0 2023-07-17 19:01:01.217606
REQUEST 0 2023-07-17 19:01:01.218112
GRANTED 0 2023-07-17 19:01:01.218414
RELEASED 0 2023-07-17 19:01:01.224535
REQUEST 1 2023-07-17 19:01:01.253064
GRANTED 1 2023-07-17 19:01:01.253591
```

```
RELEASED 1 2023-07-17 19:01:01.259338
REQUEST 1 2023-07-17 19:01:01.259853
GRANTED 1 2023-07-17 19:01:01.260376
RELEASED 1 2023-07-17 19:01:01.265566
REQUEST 1 2023-07-17 19:01:01.266474
GRANTED 1 2023-07-17 19:01:01.270344
REQUEST 2 2023-07-17 19:01:01.270870
RELEASED 1 2023-07-17 19:01:01.275804
GRANTED 2 2023-07-17 19:01:01.275804
RELEASED 2 2023-07-17 19:01:01.282891
REQUEST 2 2023-07-17 19:01:01.285786
GRANTED 2 2023-07-17 19:01:01.286960
REQUEST 3 2023-07-17 19:01:01.286960
RELEASED 2 2023-07-17 19:01:01.293382
GRANTED 3 2023-07-17 19:01:01.293888
REQUEST 2 2023-07-17 19:01:01.294614
RELEASED 3 2023-07-17 19:01:01.303177
GRANTED 2 2023-07-17 19:01:01.304258
REQUEST 3 2023-07-17 19:01:01.304765
RELEASED 2 2023-07-17 19:01:01.310398
GRANTED 3 2023-07-17 19:01:01.310398
RELEASED 3 2023-07-17 19:01:01.320535
REQUEST 3 2023-07-17 19:01:01.322536
GRANTED 3 2023-07-17 19:01:01.323770
RELEASED 3 2023-07-17 19:01:01.330940
REQUEST 4 2023-07-17 19:01:01.345151
GRANTED 4 2023-07-17 19:01:01.345269
RELEASED 4 2023-07-17 19:01:01.353494
REQUEST 4 2023-07-17 19:01:01.355409
GRANTED 4 2023-07-17 19:01:01.355914
REQUEST 5 2023-07-17 19:01:01.360514
RELEASED 4 2023-07-17 19:01:01.362028
GRANTED 5 2023-07-17 19:01:01.363119
REQUEST 4 2023-07-17 19:01:01.363728
RELEASED 5 2023-07-17 19:01:01.370947
GRANTED 4 2023-07-17 19:01:01.370947
REQUEST 5 2023-07-17 19:01:01.371455
RELEASED 4 2023-07-17 19:01:01.377907
GRANTED 5 2023-07-17 19:01:01.377907
RELEASED 5 2023-07-17 19:01:01.386470
REQUEST 5 2023-07-17 19:01:01.387056
GRANTED 5 2023-07-17 19:01:01.387591
RELEASED 5 2023-07-17 19:01:01.395173
REQUEST 6 2023-07-17 19:01:01.458630
GRANTED 6 2023-07-17 19:01:01.459637
REQUEST 7 2023-07-17 19:01:01.469870
RELEASED 6 2023-07-17 19:01:01.475496
GRANTED 7 2023-07-17 19:01:01.476108
REQUEST 6 2023-07-17 19:01:01.476622
RELEASED 7 2023-07-17 19:01:01.486260
GRANTED 6 2023-07-17 19:01:01.486772
REQUEST 7 2023-07-17 19:01:01.486772
RELEASED 6 2023-07-17 19:01:01.493475
GRANTED 7 2023-07-17 19:01:01.494800
REQUEST 6 2023-07-17 19:01:01.494905
```

```
RELEASED 7 2023-07-17 19:01:01.501835
GRANTED 6 2023-07-17 19:01:01.502144
REQUEST 7 2023-07-17 19:01:01.502648
RELEASED 6 2023-07-17 19:01:01.508396
GRANTED 7 2023-07-17 19:01:01.508396
RELEASED 7 2023-07-17 19:01:01.516274
REQUEST 8 2023-07-17 19:01:01.604282
GRANTED 8 2023-07-17 19:01:01.617043
RELEASED 8 2023-07-17 19:01:01.623936
REQUEST 8 2023-07-17 19:01:01.624972
GRANTED 8 2023-07-17 19:01:01.624972
RELEASED 8 2023-07-17 19:01:01.631075
REQUEST 8 2023-07-17 19:01:01.631936
GRANTED 8 2023-07-17 19:01:01.632441
RELEASED 8 2023-07-17 19:01:01.639506
REQUEST 9 2023-07-17 19:01:01.712488
GRANTED 9 2023-07-17 19:01:01.712993
RELEASED 9 2023-07-17 19:01:01.719083
REQUEST 9 2023-07-17 19:01:01.720640
GRANTED 9 2023-07-17 19:01:01.720640
RELEASED 9 2023-07-17 19:01:01.726885
REQUEST 9 2023-07-17 19:01:01.727909
GRANTED 9 2023-07-17 19:01:01.728439
REQUEST 11 2023-07-17 19:01:01.729024
RELEASED 9 2023-07-17 19:01:01.735479
GRANTED 11 2023-07-17 19:01:01.735479
RELEASED 11 2023-07-17 19:01:01.742048
REQUEST 11 2023-07-17 19:01:01.743786
GRANTED 11 2023-07-17 19:01:01.744747
REQUEST 10 2023-07-17 19:01:01.744934
RELEASED 11 2023-07-17 19:01:01.750999
GRANTED 10 2023-07-17 19:01:01.751974
REQUEST 11 2023-07-17 19:01:01.751974
RELEASED 10 2023-07-17 19:01:01.758017
GRANTED 11 2023-07-17 19:01:01.758475
REQUEST 10 2023-07-17 19:01:01.759709
RELEASED 11 2023-07-17 19:01:01.765628
GRANTED 10 2023-07-17 19:01:01.765628
RELEASED 10 2023-07-17 19:01:01.772583
REQUEST 10 2023-07-17 19:01:01.773089
GRANTED 10 2023-07-17 19:01:01.774537
RELEASED 10 2023-07-17 19:01:01.782779
REQUEST 12 2023-07-17 19:01:01.791021
GRANTED 12 2023-07-17 19:01:01.791529
RELEASED 12 2023-07-17 19:01:01.800591
REQUEST 12 2023-07-17 19:01:01.803225
GRANTED 12 2023-07-17 19:01:01.803455
RELEASED 12 2023-07-17 19:01:01.812677
REQUEST 12 2023-07-17 19:01:01.813407
GRANTED 12 2023-07-17 19:01:01.814139
RELEASED 12 2023-07-17 19:01:01.825470
REQUEST 13 2023-07-17 19:01:01.837797
GRANTED 13 2023-07-17 19:01:01.838303
RELEASED 13 2023-07-17 19:01:01.845413
REQUEST 13 2023-07-17 19:01:01.847539
```

```
GRANTED 13 2023-07-17 19:01:01.849140
RELEASED 13 2023-07-17 19:01:01.859252
REQUEST 13 2023-07-17 19:01:01.859812
GRANTED 13 2023-07-17 19:01:01.860369
RELEASED 13 2023-07-17 19:01:01.868387
REQUEST 14 2023-07-17 19:01:01.870549
GRANTED 14 2023-07-17 19:01:01.871070
RELEASED 14 2023-07-17 19:01:01.878301
REQUEST 14 2023-07-17 19:01:01.878808
GRANTED 14 2023-07-17 19:01:01.879343
RELEASED 14 2023-07-17 19:01:01.889378
REQUEST 14 2023-07-17 19:01:01.889884
GRANTED 14 2023-07-17 19:01:01.890403
RELEASED 14 2023-07-17 19:01:01.897652
REQUEST 15 2023-07-17 19:01:01.916075
GRANTED 15 2023-07-17 19:01:01.916647
RELEASED 15 2023-07-17 19:01:01.925428
REQUEST 15 2023-07-17 19:01:01.926306
GRANTED 15 2023-07-17 19:01:01.926812
RELEASED 15 2023-07-17 19:01:01.934609
REQUEST 15 2023-07-17 19:01:01.935645
GRANTED 15 2023-07-17 19:01:01.935895
RELEASED 15 2023-07-17 19:01:01.942510
```

▼ n = 32, r = 3, e k = 0 - 2,019 segundos

▼ results.txt (96 linhas 32x3)

```
Process Id: 1 - 2023-07-17 19:02:00.420772
Process Id: 1 - 2023-07-17 19:02:00.424581
Process Id: 0 - 2023-07-17 19:02:00.432183
Process Id: 1 - 2023-07-17 19:02:00.440489
Process Id: 0 - 2023-07-17 19:02:00.447499
Process Id: 0 - 2023-07-17 19:02:00.457320
Process Id: 2 - 2023-07-17 19:02:00.470939
Process Id: 2 - 2023-07-17 19:02:00.483209
Process Id: 2 - 2023-07-17 19:02:00.492943
Process Id: 3 - 2023-07-17 19:02:00.504154
Process Id: 3 - 2023-07-17 19:02:00.521879
Process Id: 4 - 2023-07-17 19:02:00.537663
Process Id: 3 - 2023-07-17 19:02:00.611975
Process Id: 4 - 2023-07-17 19:02:00.621721
Process Id: 4 - 2023-07-17 19:02:00.634245
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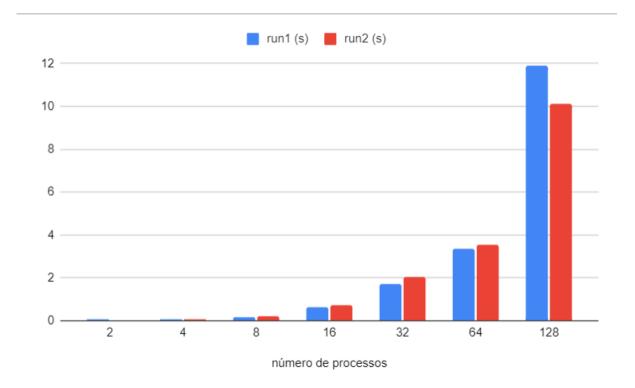
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Conclusões

Dado o fato de que o servidor precisa organizar o acesso exclusivo à zona crítica, e ordenar os pedidos que chegam nele de maneira sequencial, o tempo de conclusão acaba sendo muito correlacionado (quase linearmente) à quantidade de acessos à zona crítica necessária (n * r).

Especialmente no teste de escalabilidade 1 e 2, onde o tempo de espera entre pedidos é mais significativo, dobrar a quantidade de processos resulta no dobro do tempo necessário para gerar o arquivo; Faz sentido, já que a maior parte do tempo percorrido vem do tempo de espera entre requisições, quando o processo pede o REQUEST, recebe seu GRANT rapidamente, o tempo total é majoritariamente determinado por (n * r * k) segundos.

Já no teste de escalabilidade 3, com k = 0, caminhamos pra uma situação menos previsível onde todos os processos constantemente pedem acesso à região crítica, mas o servidor ainda consegue ordenar e excluir mutuamente o acesso. O resultado é que saímos um pouco do regime linear, de maneira que duplicar a quantidade de processos (e requisições/acessos à ZC necessários) mais que duplica o tempo necessários, especialmente no caso de 128 processos.

Isso se dá, provavelmente, ao fato da limitação do servidor à ter 100 sockets conectados ao mesmo tempo, nos testes de escalabilidade 1 e 2, dado que o tempo de sleep é o que mais demora, não temos todos os processos ao mesmo tempo tentando se comunicar com o servidor, o que é verdade no teste 3. Mesmo com essa superlinearidade, o tempo total necessário para resolver todos os pedidos é muito mais rápido ao deixar os pedidos pedirem sem tempo de espera, já que no nosso caso a ZC é O(1) e o os processos acabam esperando muito mais que efetivamente executando.