Performance Evaluation and Applications

2022-2023

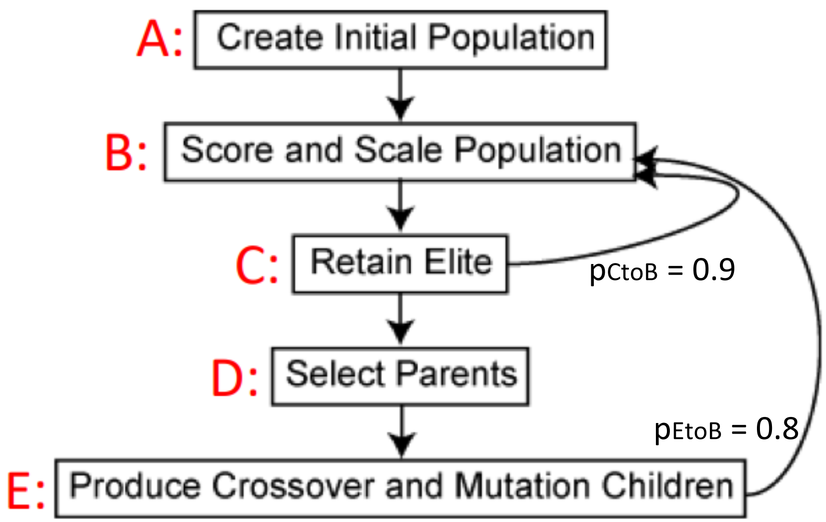
Professor Marco Gribaudo

PROJECT TYPE A

Elisa Servidio

10544789

The problem:
Performance of a Genetic Algorithm



Runtime of execution of the stages:

TraceA-A	TraceA-B	TraceA-C	TraceA-D	TraceA-E
0.71087795	0.11064513	0.04675949	0.25993050	0.21122156
0.13224217	9.73066332	0.27461941	0.19036620	1.38127096
0.23755462	17.59158162	0.03235590	0.22025383	0.43908806
0.30897996	5.72131182	0.03841262	0.01742415	0.25656726
0.57796399	1.30353606	0.06856267	0.09234362	0.02876801
0.32314768	7.02870473	0.06892380	0.41048447	0.06188163
0.18991331	12.62322785	0.50940406	0.08319836	0.73593947
1.70765743	3.31312406	0.13868625	0.07541423	0.17154645
0.00150048	1.75164841	0.13747957	0.23707276	0.94890661
0.17232313	14.78476658	0.04880492	0.05553179	0.07704857
0.20178501	5.72940229	0.29947072	0.08170527	0.26884314
0.65458747	9.41396964	0.00754012	0.26257350	0.31984218
0.64865542	9.89084876	0.01091985	0.06112535	0.09634073
0.83854821	7.78355214	0.00213362	0.12316024	0.73047864

- **multi-core machine**
- stages B and E can be **fully parallelized**

The problem:
Performance of a Genetic Algorithm

*What is the **minimum number of cores** required to provide an average of more than 30 solutions per second?*

*Which would be the **average utilization** of the CPU in this case?*

The solution:
PHASE 1 – Data preparation

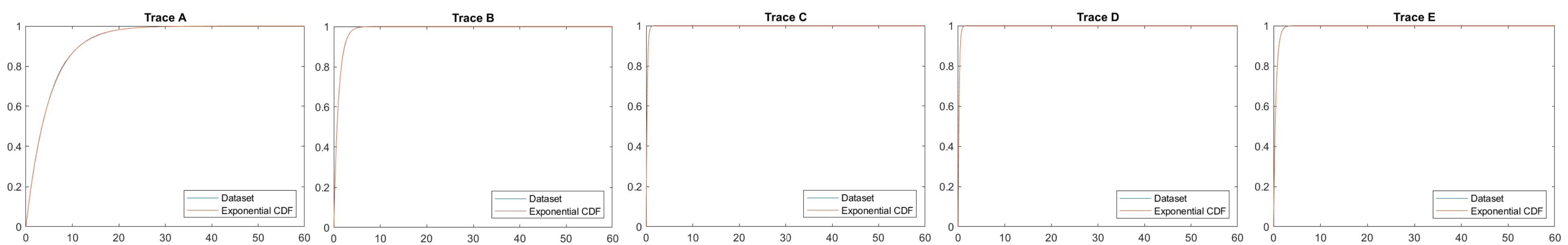
Data fitting

- Analysis of coefficient of variation *cv*

```
Check if cv almost equal to 1:
    1.0007    1.0004    1.0056    1.0019    1.0016
```

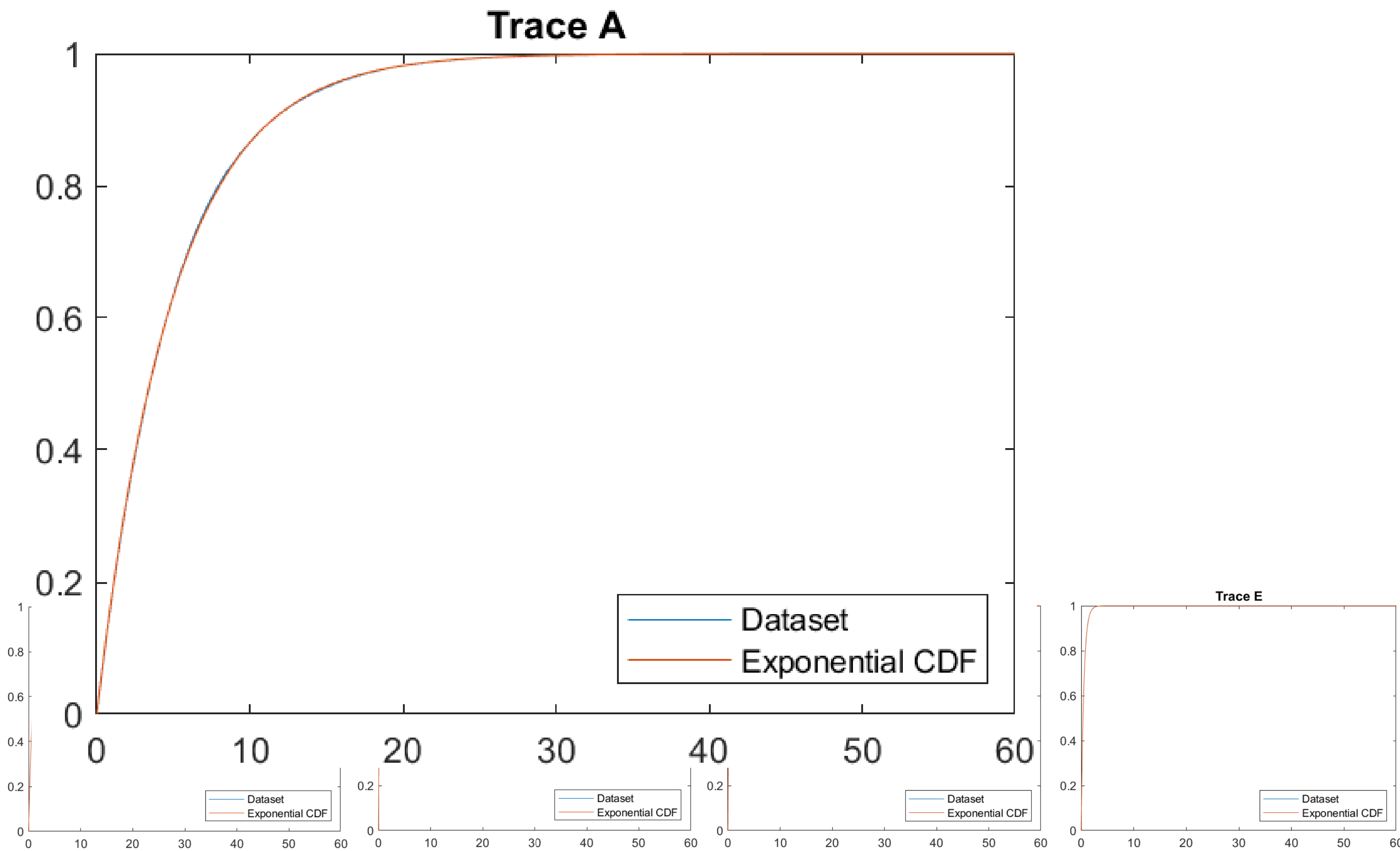
EXPONENTIAL DISTRIBUTION

- Computation of *lambda* parameters
- Generation of exponential distribution fitting the data

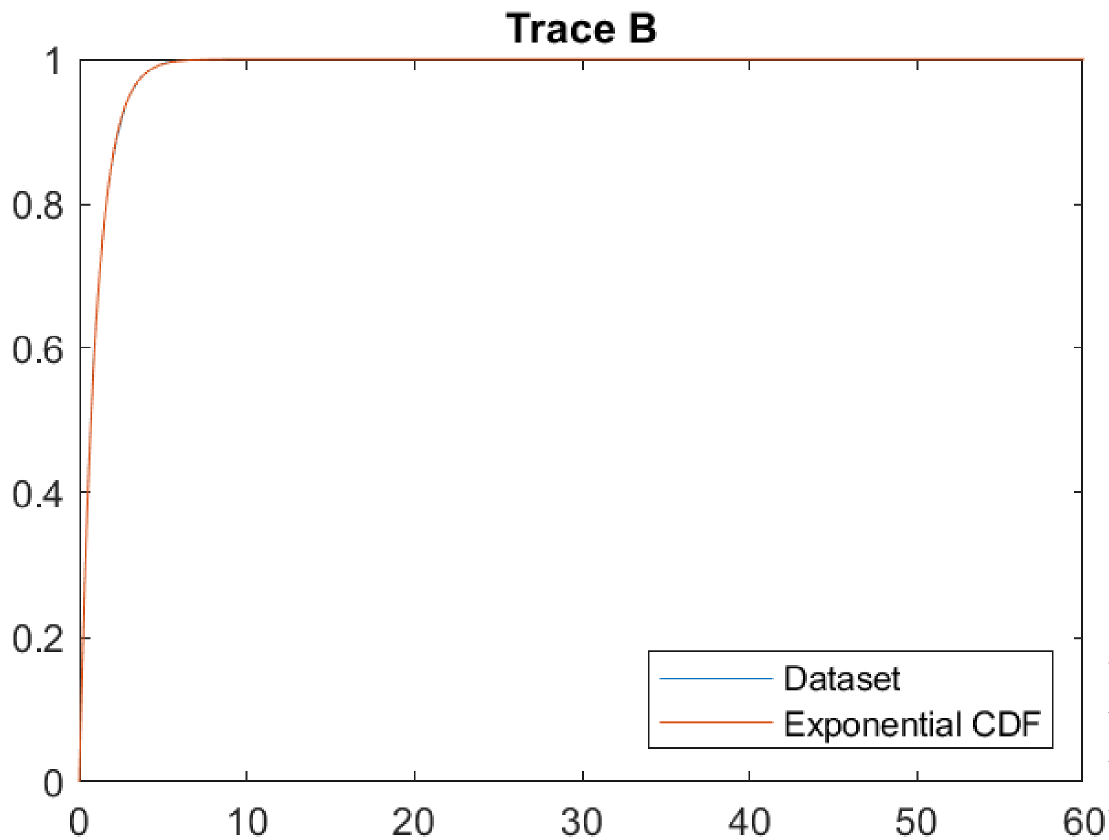


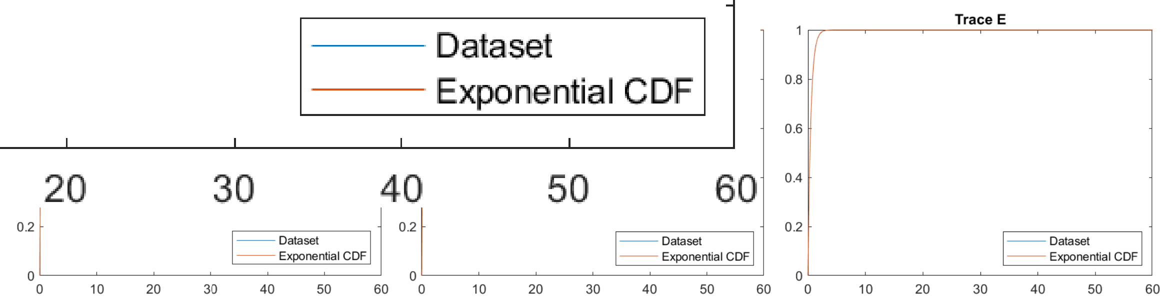
The solution:

PHASE 1 – Data preparation

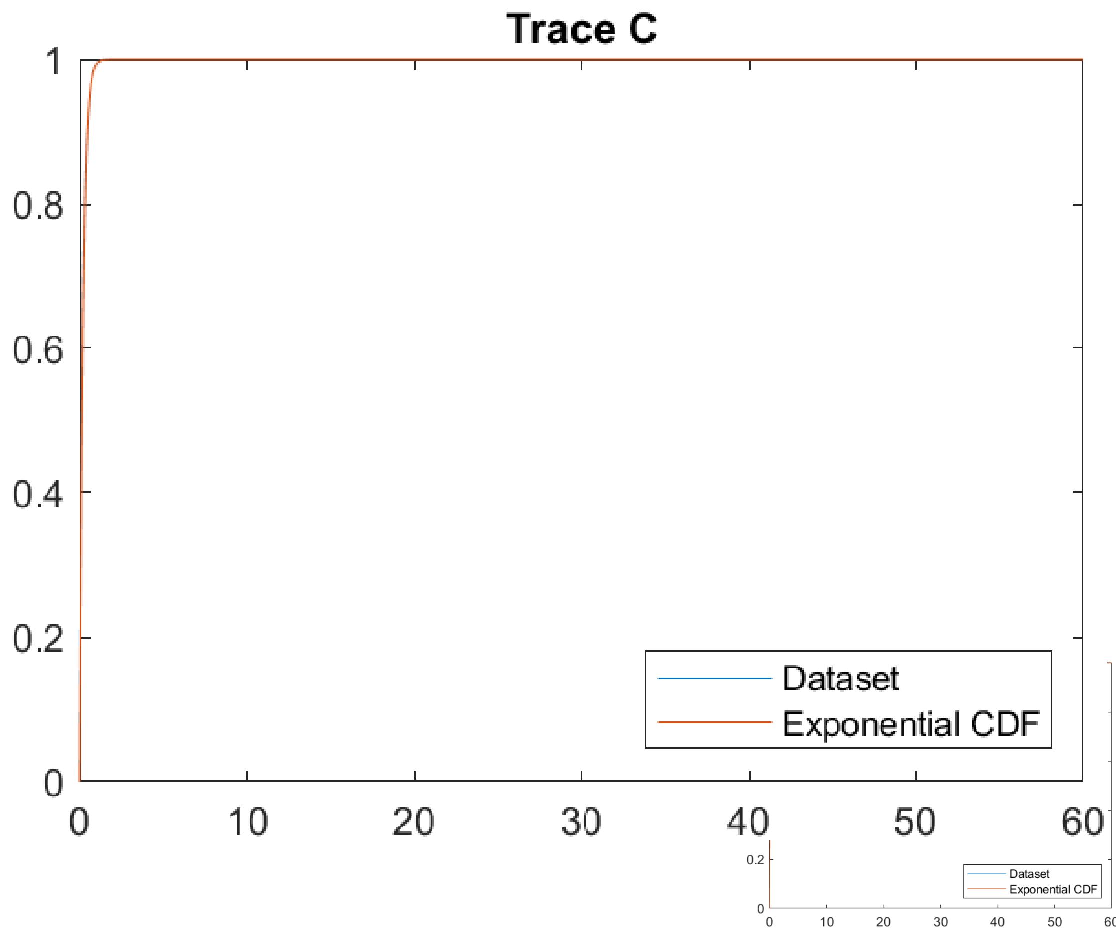


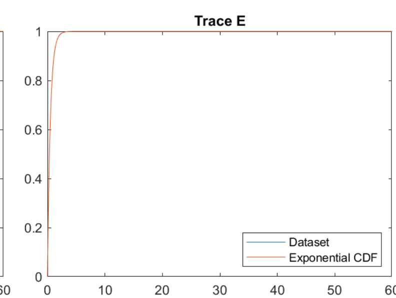
The solution:
PHASE 1 – Data preparation



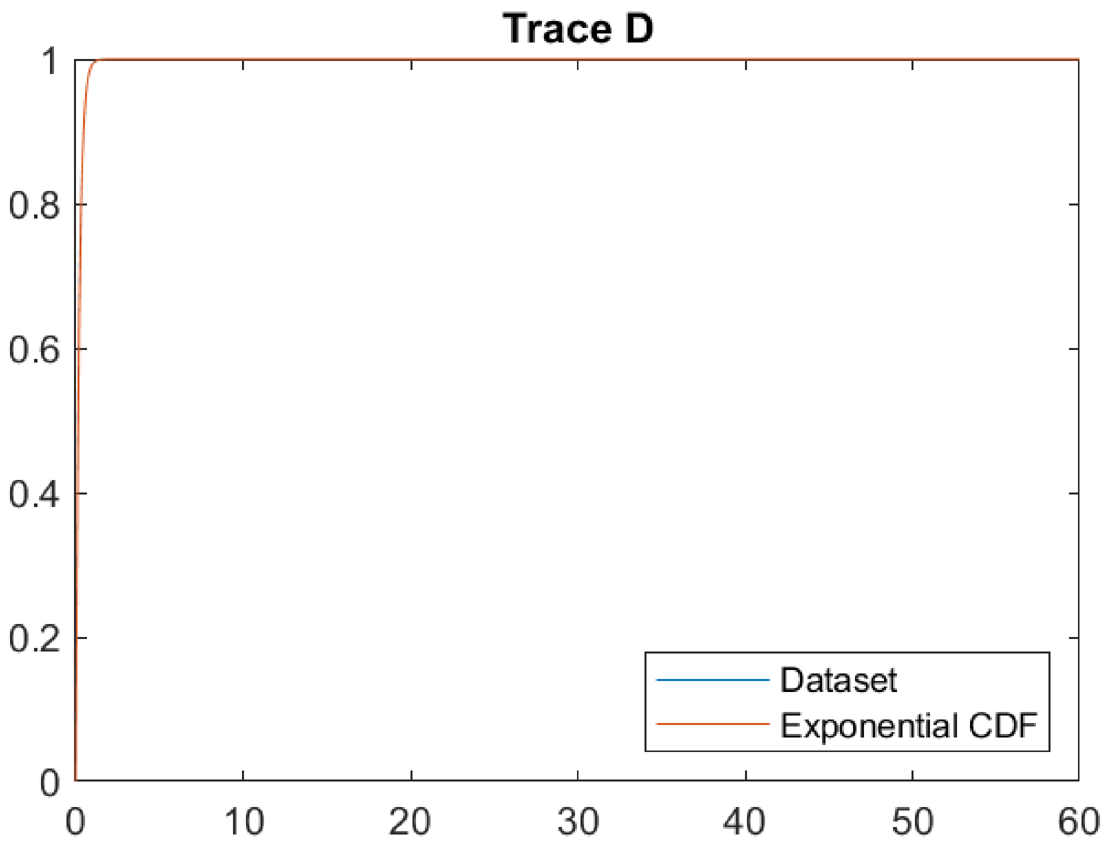


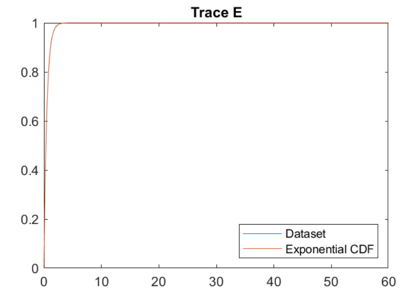
The solution:
PHASE 1 – Data preparation



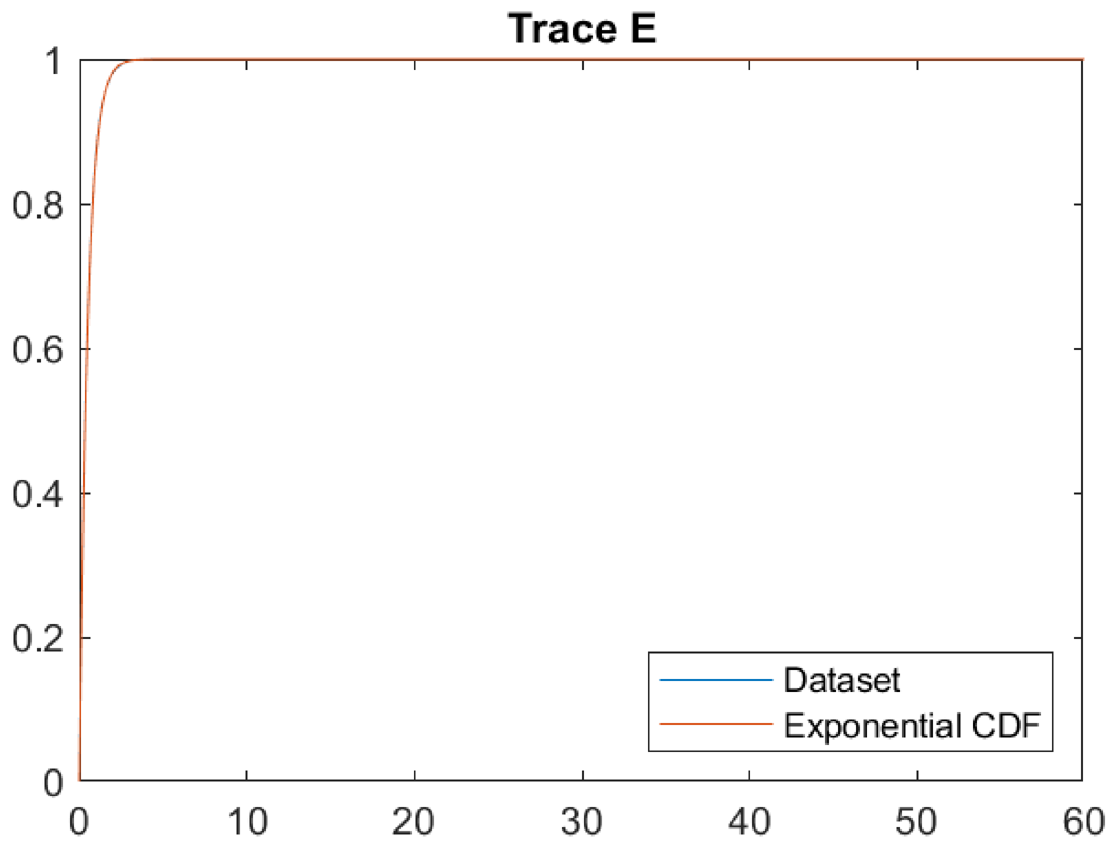


The solution:
PHASE 1 – Data preparation





The solution:
PHASE 1 – Data preparation



PHASE 2 – State Machine based model

Generation of high-level algorithm to produce a trace

- Creation of *State Machine based model* of the system
- Generation of the corresponding *trace*
- Computation of *throughput*
  - *Performance counters are updated in the code that handles each state*

The solution:
PHASE 2 – State Machine based model

Throughput computation

- Analysis of throughput with different number of cores while...

```
while solution <= 30          % compute until solution > 30
    s = 1;                    % reset initial state --> state A
    core = core + 1;          % at each iteration add core, at first set to 1
    t = 0;                    % reset time
    sol = 0;                  % solutions completed, at first set to 0
    singleCoreBusyTime = 0; % BusyTime of one core (for non parallelized stages A, C, D)
    multiCoreBusyTime = 0;  % BusyTime of all cores (for parallelized stages B, E)
    multiCoreTime = 0;        % sum of dt considering multiple cores
    while t <= Tmax ...
    solution = sol/(t/1000); %solutions per seconds (throughput) (t from ms to s)
end
```

- Completion variable *sol* is updated in the code that handles final state E

```
if s == 5   %state E: produce crossover and mutation children
    dt = (-log(rand())/lambda(1,5))/ core;
    multiCoreBusyTime = multiCoreBusyTime + dt*core;
    r = rand();
    if r <= 0.8
        ns = 2; %next state B
    else
        ns = 1; %next state A
        sol = sol + 1; %one solution completed
    end
end
```

run time perfectly divided by the number of cores

Results

```
Minimum number of cores required to provide an average of more than 30 solutions per second:
     4

Throughput with 4 core:
   34.1240
```

Representative result which may vary depending on random *dt* generation based on exponential distribution

```
dt = -log(rand())/lambda(1,1);
   dt = (-log(rand())/lambda(1,2))/ core;
      dt = -log(rand())/lambda(1,3);
         dt = -log(rand())/lambda(1,4);
            dt = (-log(rand())/lambda(1,5))/ core;
```

PHASE 3 – Average Utilization

Computation of the average utilization considering 4 cores

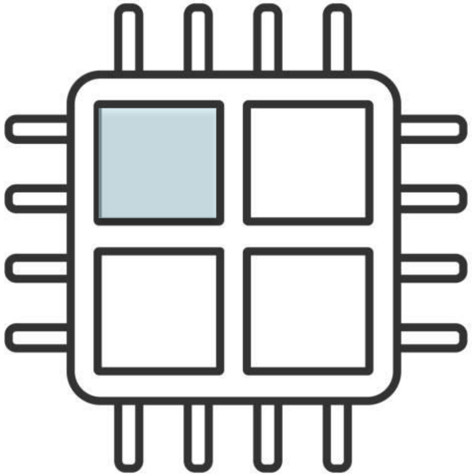
- $Utilization = \frac{Busy\ time}{time}$
- At each state, $Busy\ time$ and $time$ are computed
- Time is computed considering all cores

```
            end
            s = ns; %update current state
            t = t + dt;
            multiCoreTime = multiCoreTime + dt*core;
        end
        solution = sol/(t/1000); %solutions per seconds (throughput) (t from ms to s)
    end
```

The solution:
PHASE 3 – Average Utilization

- For non-parallelized stages A, C, D
    - *singleCoreBusyTime*: busy time of only one core

```
if s == 1   %state A: create initial population
    dt = -log(rand())/lambda(1,1);
    ns = 2; %next state B
    singleCoreBusyTime = singleCoreBusyTime + dt;
end
```

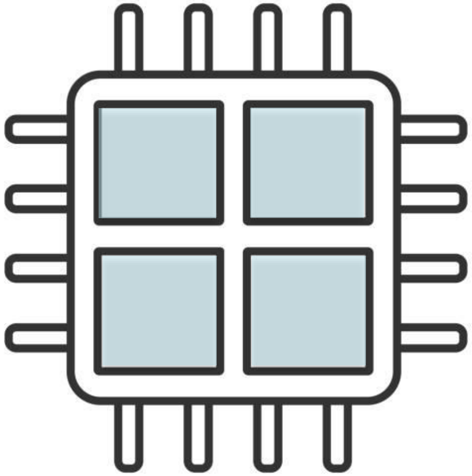


Only one core is busy *dt*

The solution:
PHASE 3 – Average Utilization

- For parallelized stages B,E
  - *multiCoreBusyTime*: busy time distributed among all cores

```
if s == 2   %state B: score and scale population
    dt = (-log(rand())/lambda(1,2))/ core;
    ns = 3; %next state C
    multiCoreBusyTime = multiCoreBusyTime + dt*core;
end
```



All cores are busy *dt*

The solution:
PHASE 3 – Average Utilization

- $Utilization = \frac{Busy\ time}{time}$

- Eventually, utilization can be computed

```
Utilization = (singleCoreBusyTime + multiCoreBusyTime)/multiCoreTime;
disp("Average utilization of the CPU:")
disp(Utilization)
```

The solution:
PHASE 3 – Average Utilization

Results

```
Average utilization of the CPU:
    0.5886
```

POLITECNICO
MILANO 1863