

```
// ////////////////////////////////////////  
//  
//         FEDERAL UNIVERSITY OF RIO GRANDE DO NORTE - UFRN  
//             DIGITAL METROPOLIS INSTITUTE - IMD  
//           BACHELOR OF INFORMATION TECHNOLOGY - BTI  
//    SPECIAL TOPICS ON INTERNET OF THINGS "B" - IMD0291  
//  
// ////////////////////////////////////////  
//  
// Names: integral.h  
//          report.h  
//          report.pdf  
//          integral-by-trapezoid-rule-serial.cpp  
//          integral-by-trapezoid-rule-parallel.cpp  
//          calculates-serie-parallel-analysis.cpp  
//          shellscript_start.sh  
//          README.txt  
// Date: 14/10/2020  
// Version: 1.0  
//  
// Author: P.R.O.Lima  
//  
// Repository: https://github.com/r4m0nllm4/integral-by-trapezoid-rule  
//  
// Software: GNU Compiler Collection (gcc) 9.3.0  
//  
// ////////////////////////////////////////  
//  
// Description: Approximating the definite integral by trapezoid rule by  
// serial and parallel computing.  
//  
// ////////////////////////////////////////  
//  
// To execute:  
// ~$ bash shellscript_start.sh  
//  
// ////////////////////////////////////////
```

```
/*  
 * CPU Report  
 */
```

```
model name      : Intel(R) Core(TM) i7-4770K CPU @ 3.50GHz  
vendor_id       : GenuineIntel  
cpu cores       : 4  
siblings        : 8  
cache size      : 8192 KB
```

```
/*
 * Serie Runtime Report In Seconds
 */

2 100000      :4.31e-04:1.49e-03:1.58e-03:1.18e-03:6.57e-04
2 200000      :1.28e-03:2.01e-03:2.02e-03:1.51e-03:2.32e-03
4 100000      :1.21e-03:7.17e-04:8.76e-04:8.29e-04:1.25e-03
4 200000      :1.05e-03:1.97e-03:1.85e-03:9.85e-04:1.76e-03
6 100000      :9.62e-04:7.17e-04:1.13e-03:1.07e-03:7.17e-04
6 200000      :1.67e-03:2.59e-03:1.77e-03:1.47e-03:1.37e-03
8 100000      :9.40e-04:7.76e-04:8.52e-04:9.25e-04:1.06e-03
8 200000      :1.96e-03:1.58e-03:1.50e-03:3.47e-03:1.50e-03
```

```
/*
 * Parallel Runtime Report In Seconds
 */

2 100000      :3.94e-04:3.99e-04:3.46e-04:2.73e-04:2.43e-04
2 200000      :8.12e-04:6.08e-04:6.91e-04:6.67e-04:6.04e-04
4 100000      :2.57e-04:4.72e-04:2.39e-04:1.57e-04:2.97e-04
4 200000      :4.53e-04:4.38e-04:5.46e-04:5.25e-04:2.43e-04
6 100000      :1.52e-04:2.52e-03:1.08e-04:2.48e-04:1.74e-04
6 200000      :3.34e-04:2.52e-04:2.83e-04:2.27e-04:3.67e-04
8 100000      :1.24e-04:1.04e-04:2.04e-04:2.94e-04:1.50e-04
8 200000      :4.03e-04:2.54e-04:2.52e-04:2.04e-04:1.93e-04
```

```
/*
 * Speedup Report In %
 */

2 100000      :1.09e+02:3.73e+02:4.57e+02:4.32e+02:2.70e+02
2 200000      :1.58e+02:3.31e+02:2.92e+02:2.26e+02:3.84e+02
4 100000      :4.71e+02:1.52e+02:3.67e+02:5.28e+02:4.21e+02
4 200000      :2.32e+02:4.50e+02:3.39e+02:1.88e+02:7.24e+02
6 100000      :6.33e+02:2.85e+01:1.05e+03:4.31e+02:4.12e+02
6 200000      :5.00e+02:1.03e+03:6.25e+02:6.48e+02:3.73e+02
8 100000      :7.58e+02:7.46e+02:4.18e+02:3.15e+02:7.07e+02
8 200000      :4.86e+02:6.22e+02:5.95e+02:1.70e+03:7.77e+02
```

```
/*
 * Parallel Calculation Report
 */

2 Cores CPU - Size Problem 100000
```

Try 1

Runtime 3.94e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	2	50000	100000	1.458333	1.458333
1	2	50000	100000	1.208333	2.666667

---

Try 2

Runtime 3.99e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	2	50000	100000	1.458333	1.458333
1	2	50000	100000	1.208333	2.666667

---

Try 3

Runtime 3.46e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	2	50000	100000	1.458333	1.458333
1	2	50000	100000	1.208333	2.666667

---

Try 4

Runtime 2.73e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	2	50000	100000	1.458333	1.458333
1	2	50000	100000	1.208333	2.666667

---

Try 5

Runtime 2.43e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	2	50000	100000	1.458333	1.458333
1	2	50000	100000	1.208333	2.666667

---

2 Cores CPU - Size Problem 200000

Try 1

Runtime 8.12e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	2	100000	200000	1.458333	1.458333
1	2	100000	200000	1.208333	2.666667

---

Try 2

Runtime 6.08e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	2	100000	200000	1.458333	1.458333
1	2	100000	200000	1.208333	2.666667

---

Try 3

Runtime 6.91e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	2	100000	200000	1.458333	1.458333
1	2	100000	200000	1.208333	2.666667

---

 Try 4

Runtime 6.67e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	2	100000	200000	1.458333	1.458333
1	2	100000	200000	1.208333	2.666667

---

Try 5

Runtime 6.04e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	2	100000	200000	1.458333	1.458333
1	2	100000	200000	1.208333	2.666667

---

4 Cores CPU - Size Problem 100000

Try 1

Runtime 2.57e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	4	25000	100000	0.744792	0.744792
1	4	25000	100000	0.713542	1.458333
2	4	25000	100000	0.651042	2.109375
3	4	25000	100000	0.557292	2.666667

---

Try 2

Runtime 4.72e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	4	25000	100000	0.744792	0.744792
1	4	25000	100000	0.713542	1.458333
2	4	25000	100000	0.651042	2.109375
3	4	25000	100000	0.557292	2.666667

---

Try 3

Runtime 2.39e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	4	25000	100000	0.744792	0.744792
1	4	25000	100000	0.713542	1.458333
2	4	25000	100000	0.651042	2.109375
3	4	25000	100000	0.557292	2.666667

---

Try 4

Runtime 1.57e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	4	25000	100000	0.744792	0.744792
1	4	25000	100000	0.713542	1.458333
2	4	25000	100000	0.651042	2.109375
3	4	25000	100000	0.557292	2.666667

---

Try 5

Runtime 2.97e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	4	25000	100000	0.744792	0.744792
1	4	25000	100000	0.713542	1.458333
2	4	25000	100000	0.651042	2.109375
3	4	25000	100000	0.557292	2.666667

---

4 Cores CPU - Size Problem 200000

Try 1

Runtime 4.53e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	4	50000	200000	0.744792	0.744792
1	4	50000	200000	0.713542	1.458333
2	4	50000	200000	0.651042	2.109375
3	4	50000	200000	0.557292	2.666667

Try 2

Runtime 4.38e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	4	50000	200000	0.744792	0.744792
1	4	50000	200000	0.713542	1.458333
2	4	50000	200000	0.651042	2.109375
3	4	50000	200000	0.557292	2.666667

Try 3

Runtime 5.46e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	4	50000	200000	0.744792	0.744792
1	4	50000	200000	0.713542	1.458333
2	4	50000	200000	0.651042	2.109375
3	4	50000	200000	0.557292	2.666667

Try 4

Runtime 5.25e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	4	50000	200000	0.744792	0.744792
1	4	50000	200000	0.713542	1.458333
2	4	50000	200000	0.651042	2.109375
3	4	50000	200000	0.557292	2.666667

Try 5

Runtime 2.43e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	4	50000	200000	0.744792	0.744792
1	4	50000	200000	0.713542	1.458333
2	4	50000	200000	0.651042	2.109375
3	4	50000	200000	0.557292	2.666667

6 Cores CPU - Size Problem 100000

Try 1

Runtime 1.52e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	6	16666	100000	0.498437	0.498437
1	6	16666	100000	0.489179	0.987616
2	6	16666	100000	0.470663	1.458278
3	6	16666	100000	0.442888	1.901166
4	6	16666	100000	0.405855	2.307022
5	6	16666	100000	0.359565	2.666587

Try 2

Runtime 2.52e-03 [s]

Process	Total	problemSize	Total	Local	Total
0	6	16666	100000	0.498437	0.498437
1	6	16666	100000	0.489179	0.987616
2	6	16666	100000	0.470663	1.458278



3	6	16666	100000	0.442888	1.901166
4	6	16666	100000	0.405855	2.307022
5	6	16666	100000	0.359565	2.666587

-----  
Try 3

Runtime 1.08e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	6	16666	100000	0.498437	0.498437
1	6	16666	100000	0.489179	0.987616
2	6	16666	100000	0.470663	1.458278
3	6	16666	100000	0.442888	1.901166
4	6	16666	100000	0.405855	2.307022
5	6	16666	100000	0.359565	2.666587

-----  
Try 4

Runtime 2.48e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	6	16666	100000	0.498437	0.498437
1	6	16666	100000	0.489179	0.987616
2	6	16666	100000	0.470663	1.458278
3	6	16666	100000	0.442888	1.901166
4	6	16666	100000	0.405855	2.307022
5	6	16666	100000	0.359565	2.666587

-----  
Try 5

Runtime 1.74e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	6	16666	100000	0.498437	0.498437
1	6	16666	100000	0.489179	0.987616
2	6	16666	100000	0.470663	1.458278
3	6	16666	100000	0.442888	1.901166
4	6	16666	100000	0.405855	2.307022
5	6	16666	100000	0.359565	2.666587

-----  
6 Cores CPU - Size Problem 200000

Try 1

Runtime 3.34e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	6	33333	200000	0.498452	0.498452
1	6	33333	200000	0.489193	0.987645
2	6	33333	200000	0.470675	1.458320
3	6	33333	200000	0.442898	1.901218
4	6	33333	200000	0.405862	2.307080
5	6	33333	200000	0.359567	2.666647

-----  
Try 2

Runtime 2.52e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	6	33333	200000	0.498452	0.498452
1	6	33333	200000	0.489193	0.987645
2	6	33333	200000	0.470675	1.458320
3	6	33333	200000	0.442898	1.901218
4	6	33333	200000	0.405862	2.307080
5	6	33333	200000	0.359567	2.666647

-----  
Try 3

Runtime 2.83e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	6	33333	200000	0.498452	0.498452

1	6	33333	200000	0.489193	0.987645
2	6	33333	200000	0.470675	1.458320
3	6	33333	200000	0.442898	1.901218
4	6	33333	200000	0.405862	2.307080
5	6	33333	200000	0.359567	2.666647

---

Try 4

Runtime 2.27e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	6	33333	200000	0.498452	0.498452
1	6	33333	200000	0.489193	0.987645
2	6	33333	200000	0.470675	1.458320
3	6	33333	200000	0.442898	1.901218
4	6	33333	200000	0.405862	2.307080
5	6	33333	200000	0.359567	2.666647

---

Try 5

Runtime 3.67e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	6	33333	200000	0.498452	0.498452
1	6	33333	200000	0.489193	0.987645
2	6	33333	200000	0.470675	1.458320
3	6	33333	200000	0.442898	1.901218
4	6	33333	200000	0.405862	2.307080
5	6	33333	200000	0.359567	2.666647

---

8 Cores CPU - Size Problem 100000

Try 1

Runtime 1.24e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	8	12500	100000	0.374349	0.374349
1	8	12500	100000	0.370443	0.744792
2	8	12500	100000	0.362630	1.107422
3	8	12500	100000	0.350911	1.458333
4	8	12500	100000	0.335286	1.793620
5	8	12500	100000	0.315755	2.109375
6	8	12500	100000	0.292318	2.401693
7	8	12500	100000	0.264974	2.666667

---

Try 2

Runtime 1.04e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	8	12500	100000	0.374349	0.374349
1	8	12500	100000	0.370443	0.744792
2	8	12500	100000	0.362630	1.107422
3	8	12500	100000	0.350911	1.458333
4	8	12500	100000	0.335286	1.793620
5	8	12500	100000	0.315755	2.109375
6	8	12500	100000	0.292318	2.401693
7	8	12500	100000	0.264974	2.666667

---

Try 3

Runtime 2.04e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	8	12500	100000	0.374349	0.374349
1	8	12500	100000	0.370443	0.744792
2	8	12500	100000	0.362630	1.107422
3	8	12500	100000	0.350911	1.458333
4	8	12500	100000	0.335286	1.793620
5	8	12500	100000	0.315755	2.109375
6	8	12500	100000	0.292318	2.401693

7	8	12500	100000	0.264974	2.666667
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Try 4

Runtime 2.94e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	8	12500	100000	0.374349	0.374349
1	8	12500	100000	0.370443	0.744792
2	8	12500	100000	0.362630	1.107422
3	8	12500	100000	0.350911	1.458333
4	8	12500	100000	0.335286	1.793620
5	8	12500	100000	0.315755	2.109375
6	8	12500	100000	0.292318	2.401693
7	8	12500	100000	0.264974	2.666667

---

Try 5

Runtime 1.50e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	8	12500	100000	0.374349	0.374349
1	8	12500	100000	0.370443	0.744792
2	8	12500	100000	0.362630	1.107422
3	8	12500	100000	0.350911	1.458333
4	8	12500	100000	0.335286	1.793620
5	8	12500	100000	0.315755	2.109375
6	8	12500	100000	0.292318	2.401693
7	8	12500	100000	0.264974	2.666667

---

8 Cores CPU - Size Problem 200000

Try 1

Runtime 4.03e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	8	25000	200000	0.374349	0.374349
1	8	25000	200000	0.370443	0.744792
2	8	25000	200000	0.362630	1.107422
3	8	25000	200000	0.350911	1.458333
4	8	25000	200000	0.335286	1.793620
5	8	25000	200000	0.315755	2.109375
6	8	25000	200000	0.292318	2.401693
7	8	25000	200000	0.264974	2.666667

---

Try 2

Runtime 2.54e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	8	25000	200000	0.374349	0.374349
1	8	25000	200000	0.370443	0.744792
2	8	25000	200000	0.362630	1.107422
3	8	25000	200000	0.350911	1.458333
4	8	25000	200000	0.335286	1.793620
5	8	25000	200000	0.315755	2.109375
6	8	25000	200000	0.292318	2.401693
7	8	25000	200000	0.264974	2.666667

---

Try 3

Runtime 2.52e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	8	25000	200000	0.374349	0.374349
1	8	25000	200000	0.370443	0.744792
2	8	25000	200000	0.362630	1.107422
3	8	25000	200000	0.350911	1.458333
4	8	25000	200000	0.335286	1.793620
5	8	25000	200000	0.315755	2.109375
6	8	25000	200000	0.292318	2.401693

7	8	25000	200000	0.264974	2.666667
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Try 4

Runtime 2.04e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	8	25000	200000	0.374349	0.374349
1	8	25000	200000	0.370443	0.744792
2	8	25000	200000	0.362630	1.107422
3	8	25000	200000	0.350911	1.458333
4	8	25000	200000	0.335286	1.793620
5	8	25000	200000	0.315755	2.109375
6	8	25000	200000	0.292318	2.401693
7	8	25000	200000	0.264974	2.666667

---

Try 5

Runtime 1.93e-04 [s]

Process	Total	problemSize	Total	Local	Total
0	8	25000	200000	0.374349	0.374349
1	8	25000	200000	0.370443	0.744792
2	8	25000	200000	0.362630	1.107422
3	8	25000	200000	0.350911	1.458333
4	8	25000	200000	0.335286	1.793620
5	8	25000	200000	0.315755	2.109375
6	8	25000	200000	0.292318	2.401693
7	8	25000	200000	0.264974	2.666667

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