NPB_statistics - Frederico

November 21, 2022

1 NPB Statistics

1.1 Utils

1.1.1 Imports

```
[ ]: import sys
     import argparse
     import math
     import numpy as np
     from scipy.stats import t
     import scipy.stats as stats
     import csv
     import matplotlib.pyplot as plt
     import matplotlib.ticker as ticker
```

```
[ ]: from google.colab import drive
     drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call
drive.mount("/content/drive", force_remount=True).
```

1.1.2 Global variables

```
[ ]: ##Global variables
     #VER_PYTHON_SERIAL="PYTHON-SERIAL"
     #VER_CPP_SERIAL="CPP-SERIAL"
     #VER_PYTHON_CUDA="PYTHON-CUDA"
     #VER_CUDA="CPP-CUDA"
     #VER_OPENACC="CPP-OPENACC"
     #VER_RTM_INTEL="RTM-INTEL"
     VER_RTM_INTEL_R1="RTM-INTEL-r1"
     VER_RTM_INTEL_R50="RTM-INTEL-r50"
     VER_RTM_INTEL_R500="RTM-INTEL-r500"
     VER_STM_TINY="STM-TINY"
     VER_STM_SWISS="STM-SWISS"
```

```
VER_SEQ="SEQ"

#VERSIONS_SERIAL = [VER_PYTHON_SERIAL, VER_CPP_SERIAL]
#VERSIONS_GPU = [VER_PYTHON_CUDA, VER_CUDA, VER_OPENACC]
#VERSIONS = [VER_HTM_INTEL, VER_STM_TINY]
#VERSIONS = [VER_RTM_INTEL, VER_SEQ]
VERSIONS = []
#fullVerList = [VER_RTM_INTEL, VER_STM_TINY, VER_STM_SWISS, VER_SEQ]
fullVerList = [VER_RTM_INTEL_R1, VER_RTM_INTEL_R50, VER_RTM_INTEL_R500,␣
 ↪VER_STM_TINY, VER_STM_SWISS, VER_SEQ]

#----Talvez trocar os nomes pra só "Lo" e "Hi" pra parar de ficar torto as␣
 ↪tabelas----
##CLASSES = ["B", "C"]
#CLASSES = ["LoContention", "HiContention"]
CLASSES = []
#fullClssList = ["LoContention", "HiContention"]
fullClssList = ["Low", "High"]

##BENCHS = ["BT", "CG", "EP", "FT", "IS", "LU", "MG", "SP"]
#BENCHS = ["bayes", "genome", "intruder", "kmeans", "labyrinth", "ssca2",␣
 ↪"vacation", "yada"]
#BENCHS = ["bayes", "genome", "kmeans", "labyrinth", "intruder", "yada"]
BENCHS = []
fullBnchList = ["bayes", "genome", "intruder", "kmeans", "labyrinth", "ssca2",␣
 ↪"vacation", "yada"]

#Para facilmente poder remover algum, listar os que devem ser ignorados da␣
 ↪lista criada com base no arquivo
#ignoreVer = [VER_RTM_INTEL, VER_STM_TINY]
#ignoreClss = ["LoContention"]
#ignoreBnch = ["bayes", "genome", "kmeans", "labyrinth", "ssca2", "vacation"]

ignoreVer = ["SEQ"]
ignoreClss = []
ignoreBnch = []

fileName = "/content/drive/MyDrive/Colab Notebooks/Arquivos/tratado"
with open(fileName) as f:
  file = f.read()
  if(("RTM-INTEL-r1" in file) and not("RTM-INTEL-r1" in ignoreVer)):
    VERSIONS.append(VER_RTM_INTEL_R1)
  if(("RTM-INTEL-r50" in file) and not("RTM-INTEL-r50" in ignoreVer)):
    VERSIONS.append(VER_RTM_INTEL_R50)
  if(("RTM-INTEL-r500" in file) and not("RTM-INTEL-r500" in ignoreVer)):
    VERSIONS.append(VER_RTM_INTEL_R500)
  if(("STM-TINY" in file) and not("STM-TINY" in ignoreVer)):
    VERSIONS.append(VER_STM_TINY)
  if(("STM-SWISS" in file) and not("STM-SWISS" in ignoreVer)):
    VERSIONS.append(VER_STM_SWISS)
  if(("SEQ" in file) and not("SEQ" in ignoreVer)):
    VERSIONS.append(VER_SEQ)

  #for clss in fullClssList:
  #  if((clss in file) and not(clss in ignoreClss)):
  #    CLASSES.append(clss)
  for clss in fullClssList:
    if((clss in file) and not(clss in ignoreClss)):
      CLASSES.append(clss)

  for Bnch in fullBnchList:
    if((Bnch in file) and not(Bnch in ignoreBnch)):
      BENCHS.append(Bnch)

dic_dados = {}
dic_dados_bench = {}
g_bench = ""
```

1.1.3 Statistical methods

```
[ ]: # CSV
def le_csv_desempenho(arquivos, prefixo, array_dados):
        if len(arquivos) < 1:
                return
        for a in arquivos:
                with open(a) as f:
                        reader = csv.reader(f, delimiter=';', quoting=csv.
 ↪QUOTE_NONE)
                        filtro = list(filter(lambda x: len(x) > 0 and x[0] ==␣
 ↪prefixo, reader))

                        for linha in filtro:
                                array_dados.append(linha[1:])
#END

def split(dado):
        aux = dado.split("=")
        if len(aux) == 2:
                return aux[1]
        return dado
#END

# DICTIONARY
```

```
def name_versao(versao):
        if "RTM" in versao:
                if "INTEL" in versao:
                        if "r500" in versao:
                                return "RTM-500"
                        if "r50" in versao:
                                return "RTM-50"
                        if "r1" in versao:
                                return "RTM-1"
                elif "IBM" in versao:
                        return "IBM"
        elif "STM" in versao:
                if "TINY" in versao:
                        return "TinySTM"
                elif "SWISS" in versao:
                        return "SwissTM"
        elif "SEQ" in versao:
                return "Sequential"

        #if "PYTHON" in versao:
        #        if "SERIAL" in versao:
        #                return "Python"
        #        elif "CUDA" in versao:
        #                return "Numba"
        #elif "OPENACC" in versao:
        #        return "OpenACC"
        #elif "CPP" in versao:
        #        if "SERIAL" in versao:
        #                return "C++"
        #        elif "CUDA" in versao:
        #                return "Cuda"

        return ""
 #END

def idx_dicionario(versao, classe):
        return versao + "_$$_" + classe

##Classe, size e gpus acho que não é necessário
def add_dicionario(dic, idx, desc, classe, size, iteraction, cpus, gpus, times):
        dic[idx] = {}
        dic[idx]["desc"] = desc
        dic[idx]["class"] = classe
        dic[idx]["size"] = size
        dic[idx]["iteraction"] = iteraction
        dic[idx]["cpus"] = cpus
        dic[idx]["gpus"] = gpus
        dic[idx]["times"] = times
#END

#Statiscs
def calc_stats(amostra):
        # confidence interval of 95%
        tdist = t.ppf(0.95, len(amostra)-1)
        mean = np.mean(amostra)
        std = np.std(amostra)
        error = tdist*(std/math.sqrt(len(amostra)))
        return mean, std, error

def report_df(data):
        mean, std, error = calc_stats(data)
        data_sort = sorted(data)
        sz = len(data)

        ks_stat, ks_p, ks_p_ok = ks_gaussian_test(data)
        sw_stat, sw_p, sw_p_ok = shapiro_wilk_gaussian_test(data)

        print("%12s %15.8f" %("count", sz))
        print("%12s %15.8f" %("mean", mean))
        print("%12s %15.8f" %("std", std))
        print("%12s %15.8f" %("error (95%)", error))
        print("%12s %15.8f" %("min", min(data)))
        print("%12s %15.8f" %("25%", max(data_sort[: (int(sz*0.25) if int(sz*0.
↪25) > 1 else 1)]) ) )
        print("%12s %15.8f" %("50%", max(data_sort[:int(sz*0.50)]) ) )
        print("%12s %15.8f" %("75%", max(data_sort[:int(sz*0.75)]) ) )
        print("%12s %15.8f" %("max", max(data)))
        print("%12s %15.8f" %("KS stat", ks_stat))
        print("%12s %15.8f" %("KS p", ks_p))
        print("%12s %15s" %( ("KS p>0.05", "Sample OK" if ks_p_ok else "Sample␣
↪Bad") ))
        print("%12s %15.8f" %("SW stat", sw_stat))
        print("%12s %15.8f" %("SW p", sw_p))
        print("%12s %15s" %( ("SW p>0.05", "Sample OK" if sw_p_ok else "Sample␣
↪Bad") ))
#END

def report_df_all(dic):
        column_0 = ["count", "mean", "std", "error (95%)", "min", "25%", "50%",␣
↪"75%", "max",
                                "KS stat", "KS p", "KS p>0.05", "SW stat", "SW␣
↪p", "SW p>0.05"]

        rows = []
        rows.append([])
        i = 0
        for c in column_0:
                rows[i].append("%12s" % (c))
                rows.append([])
                i += 1

        header = []
        header.append("%12s" % (""))
        for idx, dados in dic.items():
                header.append("%15s" % (dados["desc"] + " - " + dados["class"]))

                data = dados["times"]
                mean, std, error = calc_stats(data)
                data_sort = sorted(data)
                sz = len(data)

                ks_stat, ks_p, ks_p_ok = ks_gaussian_test(data)
                sw_stat, sw_p, sw_p_ok = shapiro_wilk_gaussian_test(data)

                rows[0].append("%15.8f" %(sz))
                rows[1].append("%15.8f" %(mean))
                rows[2].append("%15.8f" %(std))
                rows[3].append("%15.8f" %(error))
                rows[4].append("%15.8f" %(min(data)))
                rows[5].append("%15.8f" %(max(data_sort[: (int(sz*0.25) if␣
↪int(sz*0.25) > 1 else 1)])))
                rows[6].append("%15.8f" %(max(data_sort[:int(sz*0.50)])))
                rows[7].append("%15.8f" %(max(data_sort[:int(sz*0.75)])))
                rows[8].append("%15.8f" %(max(data)))
                rows[9].append("%15.8f" %(ks_stat))
                rows[10].append("%15.8f" %(ks_p))
                rows[11].append("%15s" %( ("Sample OK" if ks_p_ok else "Sample␣
↪Bad") ))
                rows[12].append("%15.8f" %(sw_stat))
                rows[13].append("%15.8f" %(sw_p))
                rows[14].append("%15s" %( ("Sample OK" if sw_p_ok else "Sample␣
↪Bad") ))

        for i in range(len(column_0)):
                if i == 0:
                        print(header[0], end="")
                        j = 1
                        for idx in dic.items():
                                print(header[j], end="")
                                j += 1
                        print()
                j = 0
                for idx, dados in dic.items():
                        if j == 0:
                                print(rows[i][j], end="")
                                j += 1

                        print(rows[i][j], end="")
                        j += 1
                print()
#END


def ks_gaussian_test(data):
        loc, scale = stats.norm.fit(data)
        n = stats.norm(loc=loc, scale=scale)

        stat, p = stats.kstest(data, n.cdf)

        alpha = 0.05
        return stat, p, (p > alpha)
#END

def ks_gaussian_teste_chart(data):
        loc, scale = stats.norm.fit(data)
        n = stats.norm(loc=loc, scale=scale)

        plt.hist(data, rwidth=0.5)
        #x = numpy.arange(min(data), max(data) + 0.2, 0.02)
        #plt.plot(x, data.mean()*n.pdf(x))
        plt.title('Comparação Entre Histograma e Projeção da Distribuição␣
 ↪Normal')
        plt.title('Histograma da Distribuição')
        plt.xlabel('Tempo de Execução')
        plt.ylabel('Número de Ocorrências')

        plt.show()

        stat, p = stats.kstest(data, n.cdf)
        print('Statistics=%.5f, p=%.5f' % (stat, p))

        alpha = 0.05
        if p > alpha:
                print('Sample looks Gaussian (fail to reject H0)')
        else:
                print('Sample does not look Gaussian (reject H0)')
#END
```

```
def shapiro_wilk_gaussian_test(data):
        stat, p = stats.shapiro(data)

        alpha = 0.05
        return stat, p, (p > alpha)
#END

# generate boxplot containing all columns from two dataframes (side by side␣
 ↪comparison)
def boxplot_chart(data, version):
        data_set = [data]
        fig, ax = plt.subplots()

        #Plot boxplot
        bp = ax.boxplot(data_set, widths=0.25, patch_artist = True)

        # changing color and linewidth of whiskers
        for whisker in bp['whiskers']:
                whisker.set(color ='#8B008B', linewidth = 1.5, linestyle =":")

        # changing color and linewidth of caps
        for cap in bp['caps']:
                cap.set(color ='#8B008B', linewidth = 2)

        # changing color and linewidth of medians
        for median in bp['medians']:
                median.set(color ='red', linewidth = 3)

        # changing style of fliers
        for flier in bp['fliers']:
                flier.set(marker ='D', color ='#e7298a', alpha = 0.5)

        # changing color
        colors = ['#0000FF', '#00FF00', '#FFFF00', '#FF00FF'] #Support for 4␣
 ↪series
        for patch, color in zip(bp['boxes'], colors):
                patch.set_facecolor(color)

        plt.xticks([1], [version])
        plt.ylabel('Execution time (s)')

        fig.tight_layout()
        plt.show()
#END
```

```
# apply student t test comparing two statistics
# Null Hypothesis (H0): μa = μb (the means of both populations are equal)
# Alternate Hypothesis (Ha): μa   μb (the means of both populations are not␣
↪equal)
def student_t_test(pop_a, pop_b):
        t_stat, p_value = stats.ttest_ind(pop_a, pop_b, equal_var=False)
        return t_stat, p_value, (p_value <= 0.05)
#END

def student_t_test_report(pop_a, pop_b):
        t_stat, p_value, p_value_ok = student_t_test(pop_a, pop_b)

        print("P-Value={0} T-Statistic={1}".format(p_value, t_stat))

        #if p_value <= 0.05:
        if p_value_ok:
                print('The mean of the samples is different (reject H0)')
        else:
                print('The mean of the samples is equal (fail to reject H0)')
#END

def mann_whitney_u_test(pop_a, pop_b):
        t_stat, p_value = stats.mannwhitneyu(pop_a, pop_b,␣
↪use_continuity=False, alternative='two-sided')
        return t_stat, p_value, (p_value <= 0.05)
#END

def mann_whitney_u_test_report(pop_a, pop_b):
        t_stat, p_value, p_value_ok = mann_whitney_u_test(pop_a, pop_b)

        print("P-Value={0} T-Statistic={1}".format(p_value,t_stat))

        #if p_value <= 0.05:
        if p_value_ok:
                print('The mean of the samples is different (reject H0)')
        else:
                print('The mean of the samples is equal (fail to reject H0)')
#END

def t_u_tests_report_all(dic, versions): #Versions is a matrix [[v1, v2], [v2,␣
↪v3]...]
        column_0 = ["KS OK?", "T-Test p", "T-Test stat", "T-Test p<=0.05",
                                                "U-Test p", "U-Test stat",␣
↪"U-Test p<=0.05"]

        rows = []
        rows.append([])
        i = 0
        for c in column_0:
                rows[i].append("%15s" % (c))
                rows.append([])
                i += 1

        header = []
        header.append("%15s" % (""))
        for v in versions:
                dic_a = dic[v[0]]
                pop_a = dic_a["times"]

                dic_b = dic[v[1]]
                pop_b = dic_b["times"]

                head = "(" + dic_a["desc"] + "[" + dic_a["class"] + "]) x (" +␣
↪dic_b["desc"] + "[" + dic_b["class"] + "])"
                header.append("%27s" % (head))


                a_ks_stat, a_ks_p, a_ks_p_ok = ks_gaussian_test(pop_a)
                b_ks_stat, b_ks_p, b_ks_p_ok = ks_gaussian_test(pop_b)
                ks_ok = (a_ks_p_ok and b_ks_p_ok)

                t_stat, t_p_value, t_p_value_ok = student_t_test(pop_a, pop_b)

                u_stat, u_p_value, u_p_value_ok = mann_whitney_u_test(pop_a,␣
↪pop_b)

                rows[0].append("%27s" % ( ("Yes" if ks_ok else "No") ))
                rows[1].append("%27.12e" % (t_p_value))
                rows[2].append("%27.8f" % (t_stat))
                t_test_app = ("T-Test OK" if t_p_value_ok else "T-Test Failed")␣
↪if ks_ok else "Not normally distrib."
                rows[3].append("%27s" % ( t_test_app ))
                rows[4].append("%27.12e" % (u_p_value))
                rows[5].append("%27.8f" % (u_stat))
                rows[6].append("%27s" % ( ("U-Test OK" if u_p_value_ok else␣
↪"U-Test Failed") ))

        for i in range(len(column_0)):
                if i == 0:
                        print(header[0], end="")
                        for j in range(1, len(versions)+1):
                                print(header[j], end="")
                        print()
                for j in range(0, len(versions)+1):
                        print(rows[i][j], end="")

                print()
#END
```

1.1.4 Load dictionary

```
[ ]: def load_data_dictionary(bench):
         global g_bench
         g_bench = bench

         # Load dictionary
         dados = [] # array das linhas

         #le_csv_desempenho(["sample_data/exec_20220224_BT.txt", "sample_data/
      ↪exec_20210924_EP.txt",
         #                    "sample_data/exec_20210929_CG.txt", "sample_data/
      ↪exec_20210930_FT.txt",
         #                    "sample_data/exec_20211001_MG.txt", "sample_data/
      ↪exec_20220227_LU.txt",
         #                    "sample_data/exec_20211001_IS.txt", "sample_data/
      ↪exec_20220226_SP.txt"], "BENCH=" + bench, dados)
         #le_csv_desempenho(["/content/sample_data/exec_20210924_EP.txt"], "BENCH="␣
      ↪+ bench, dados)
         #le_csv_desempenho(["/content/sample_data/tratado"], "BENCH=" + bench,␣
      ↪dados)

         le_csv_desempenho(["/content/drive/MyDrive/Colab Notebooks/Arquivos/
      ↪tratado"], "BENCH=" + bench, dados)

         bench_process_data(dados, bench)
```

1.1.5 Benchmark Methods

```
[ ]: def bench_time_chart():
             times = []
             class_ids = range(1, len(CLASSES)+2, 2)

             max_time = 0
             #for v in VERSIONS_GPU:
             for v in VERSIONS:
                     #if g_bench == "IS" and "OPENACC" in v:
                     #        continue
```

```
                v_time = []

                #time, a, b = calc_stats(dic_dados[idx_dicionario(v,␣
↪"LoContention")]["times"])
                time, a, b = calc_stats(dic_dados[idx_dicionario(v,␣
↪"Low")]["times"])
                v_time.append(time)
                max_time = max(time, max_time)

                #if "HiContention" in CLASSES:
                if "High" in CLASSES:
                        #time, a, b = calc_stats(dic_dados[idx_dicionario(v,␣
↪"HiContention")]["times"])
                        time, a, b = calc_stats(dic_dados[idx_dicionario(v,␣
↪"High")]["times"])
                        v_time.append(time)
                        max_time = max(time, max_time)

                times.append(v_time)

        #Chart
        #desenha as barras no gráfico
        fig, ax = plt.subplots()

        bars = []
        #idx = -0.3
        idx = (1.5/len(times))
        value = idx * -(math.floor(len(times)/2))
        for t in times:
                bar = ax.bar(np.array(class_ids)+value, np.array(t), width=0.25)
                bars.append(bar)
                value += idx

        ax.set_xlabel('Classes')
        ax.set_ylabel('Execution time (s)')
        ax.set_xlim(0, 4)
        ax.set_ylim(0, math.ceil(max_time))

        #ax.title('Execution time')
        ax.legend(tuple(map(name_versao, VERSIONS)))

        ax.set_xticks(class_ids)
        ax.set_xticklabels(CLASSES)

        #for b in bars:
        #        ax.bar_label(b, padding=3, fmt='%5.3f')
        fig.tight_layout()

        plt.show() #mostra o gráfico
#END

def bench_speedup_chart(version_serial, versions_gpu):
        speedups = []
        class_ids = range(1, len(CLASSES)+2, 2)
        #class_ids = range((4/len(CLASSES)),(4/len(CLASSES))*2)

        #time_serial_B, a, b =␣
 ↪calc_stats(dic_dados[idx_dicionario(version_serial, "B")]["times"])
        #time_serial_C, a, b =␣
 ↪calc_stats(dic_dados[idx_dicionario(version_serial, "C")]["times"])
        #if "LoContention" in CLASSES:
        #         time_serial_Lo, a, b =␣
 ↪calc_stats(dic_dados[idx_dicionario(version_serial,␣
 ↪"LoContention")]["times"])
        #if "HiContention" in CLASSES:
        #         time_serial_Hi, a, b =␣
 ↪calc_stats(dic_dados[idx_dicionario(version_serial,␣
 ↪"HiContention")]["times"])
        if "Low" in CLASSES:
                time_serial_Lo, a, b =␣
 ↪calc_stats(dic_dados[idx_dicionario(version_serial, "Low")]["times"])
        if "High" in CLASSES:
                time_serial_Hi, a, b =␣
 ↪calc_stats(dic_dados[idx_dicionario(version_serial, "High")]["times"])

        max_speedup = 0
        for v in versions_gpu:
                v_speedup = []

                #if "LoContention" in CLASSES:
                #         time, a, b = calc_stats(dic_dados[idx_dicionario(v,␣
 ↪"LoContention")]["times"])
                if "Low" in CLASSES:
                        time, a, b = calc_stats(dic_dados[idx_dicionario(v,␣
 ↪"Low")]["times"])
                        speedup = time_serial_Lo/time
                        v_speedup.append(speedup)
                        max_speedup = max(speedup, max_speedup)

                #if "HiContention" in CLASSES:
```

```
                #       time, a, b = calc_stats(dic_dados[idx_dicionario(v,␣
↪"HiContention")]["times"])
                if "High" in CLASSES:
                        time, a, b = calc_stats(dic_dados[idx_dicionario(v,␣
↪"High")]["times"])
                        speedup = time_serial_Hi/time
                        v_speedup.append(speedup)
                        max_speedup = max(speedup, max_speedup)

                speedups.append(v_speedup)

        #Chart
        #desenha as barras no gráfico
        fig, ax = plt.subplots()

        bars = []
        #idx = 0.30 if len(speedups) > 1 else 0.0
        idx = 1.5/len(speedups) if len(speedups) > 1 else 0.0
        value = idx * -(math.floor(len(speedups)/2))
        for s in speedups:
                bar = ax.bar(np.array(class_ids)+value, np.array(s), width=0.25)
                bars.append(bar)
                value += idx

        ax.set_xlabel('Classes')
        ax.set_ylabel('Speedup')
        ax.set_xlim(0, 4)
        ax.set_ylim(0, math.ceil(max_speedup*1.1))

        #ax.title('Speedup')
        ax.legend(tuple(map(name_versao, versions_gpu)))

        ax.set_xticks(class_ids)
        ax.set_xticklabels(CLASSES)

        #for b in bars:
        #        ax.bar_label(b, padding=3)

        fig.tight_layout()

        plt.show() #mostra o gráfico
#END

def bench_report_t_u_tests(classe):
        versoes_comp = []
        #versoes_comp.append([idx_dicionario(VER_PYTHON_SERIAL, classe),␣
↪idx_dicionario(VER_PYTHON_CUDA, classe)])
        #versoes_comp.append([idx_dicionario(VER_RTM_INTEL, classe),␣
↪idx_dicionario(VER_SEQ, classe)])

        #versoes_comp.append([idx_dicionario(VER_RTM_INTEL, classe),␣
↪idx_dicionario(VER_STM_TINY, classe)])
        #versoes_comp.append([idx_dicionario(VERSIONS[0], classe),␣
↪idx_dicionario(VERSIONS[1], classe)])
        #versoes_comp.append(idx_dicionario(v, classe))
        for v in range(0,len(VERSIONS)-1):
                versoes_comp.append([idx_dicionario(VERSIONS[v], classe),␣
↪idx_dicionario(VERSIONS[v+1], classe)])
                t_u_tests_report_all(dic_dados, versoes_comp)
                versoes_comp = []

        #versoes_comp.append([idx_dicionario(VER_CPP_SERIAL, classe),␣
↪idx_dicionario(VER_CUDA, classe)])
        #if g_bench != "IS":
        #        versoes_comp.append([idx_dicionario(VER_CPP_SERIAL, classe),␣
↪idx_dicionario(VER_OPENACC, classe)])
        #        versoes_comp.append([idx_dicionario(VER_CUDA, classe),␣
↪idx_dicionario(VER_OPENACC, classe)])
        #versoes_comp.append([idx_dicionario(VER_PYTHON_CUDA, classe),␣
↪idx_dicionario(VER_CUDA, classe)])
        #if g_bench != "IS":
        #        versoes_comp.append([idx_dicionario(VER_PYTHON_CUDA, classe),␣
↪idx_dicionario(VER_OPENACC, classe)])

        #print(versoes_comp)
        #print(dic_dados)
        #t_u_tests_report_all(dic_dados, versoes_comp)
#END

def bench_calc_stats(dados, versao, classe, threads=0, gpus=0):
        global dic_dados

        idx_versao = 0
        idx_classe = 1
        idx_size = 2
        idx_iter = 3
        idx_threads = 4
        idx_gpus = 5
        idx_time = 6
        linhas = list(filter(lambda x: versao in split(x[idx_versao]) and␣
↪classe in split(x[idx_classe]), dados))
```

```
        if len(linhas) > 0:
                times = [float(split(l[idx_time])) for l in linhas]
                add_dicionario(dic_dados, idx_dicionario(versao, classe),␣
 ↪name_versao(versao), classe,
#                               split(linhas[0][idx_size]),␣
 ↪split(linhas[0][idx_iter]), threads, gpus, times)
                               split(linhas[0][idx_size]),␣
 ↪split(linhas[0][idx_iter]), split(linhas[0][idx_threads]), gpus, times)
#END

def bench_process_data(dados, bench):
        print("Gerando", bench, "...")

        for c in CLASSES:
                for v in VERSIONS:
                        bench_calc_stats(dados, v, c, 1, 0)

                #for v in VERSIONS_GPU:
                #        if bench == "IS" and "OPENACC" in v:
                #                continue
                #        bench_calc_stats(dados, v, c, 0, 1)

        print(bench, "OK")
#END

def bench_apply_ks_tests(classe):
        for idx, value in dic_dados.items():
                if value["class"] == classe:
                        print('----------', value["desc"], "-", value["class"],␣
 ↪'----------')
                        ks_gaussian_teste_chart(value["times"])
                        print()
#END

def bench_apply_boxplots(classe):
        for idx, value in dic_dados.items():
                if value["class"] == classe:
                        print('----------', value["desc"], "-", value["class"],␣
 ↪'----------')
                        boxplot_chart(value["times"], value["desc"] + " - " +␣
 ↪value["class"])
                        print()
#END
```

1.2 Main Benchmark

```
[ ]: ##Parameter: BT | CG | EP | FT | IS | LU | MG | SP
     ##load_data_dictionary("EP")

     for b in BENCHS:
       load_data_dictionary(b)
```

```
Gerando bayes …
bayes OK
Gerando genome …
genome OK
Gerando intruder …
intruder OK
Gerando kmeans …
kmeans OK
Gerando labyrinth …
labyrinth OK
Gerando ssca2 …
ssca2 OK
Gerando vacation …
vacation OK
Gerando yada …
yada OK
```

1.2.1 Report DF

```
[ ]: report_df_all(dic_dados)
```

```
                RTM-1 - Low   RTM-50 - Low  RTM-500 - Low  TinySTM - Low
SwissTM - Low   RTM-1 - High  RTM-50 - High RTM-500 - High TinySTM - High
SwissTM - High
       count    30.00000000    37.00000000     7.00000000    30.00000000
30.00000000    30.00000000    37.00000000     7.00000000    30.00000000
30.00000000
        mean     0.15813333     0.71324324     2.23342857     0.09640000
0.10370000     8.06883460    50.74735327   166.43853400    17.55868447
17.34454050
         std     0.00084591     0.73444623     0.00955969     0.00055377
0.00069041     0.07509578    56.02583192     9.10472888     0.12975196
0.15426650
 error (95%)     0.00026241     0.20384881     0.00702115     0.00017179
0.00021418     0.02329597    15.55021806     6.68699645     0.04025123
0.04785605
         min     0.15700000     0.35300000     2.22200000     0.09600000
0.10300000     7.97327700    23.36720200   162.08470700    17.38628100
17.14186900
```

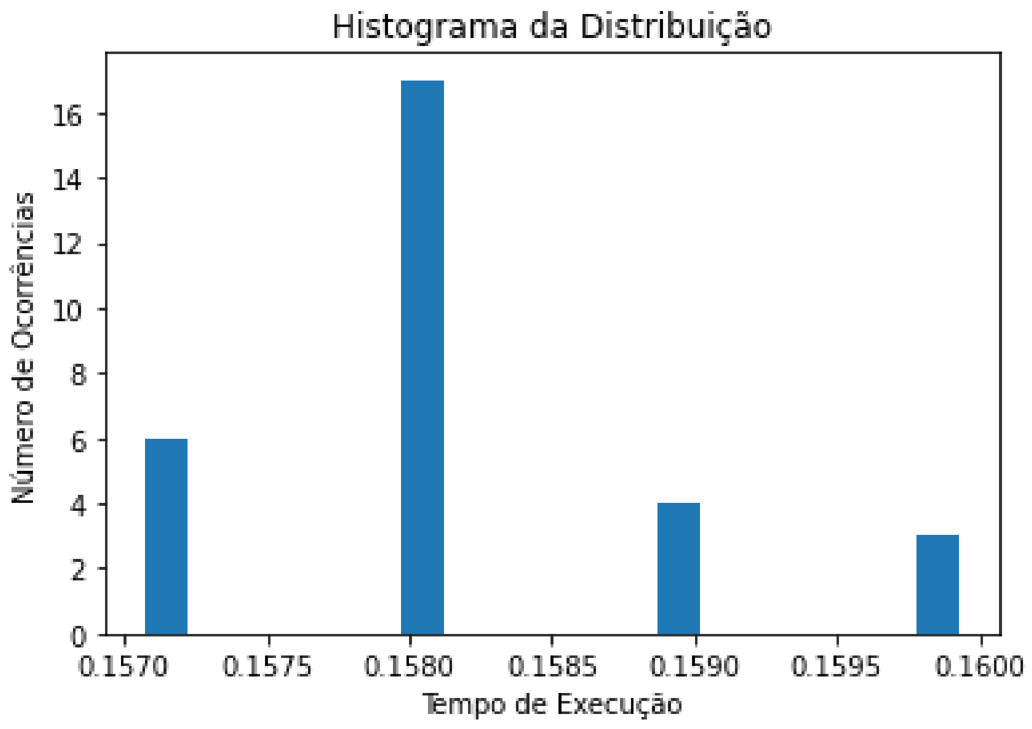
```
         25%     0.15800000     0.35500000     2.22200000     0.09600000
0.10300000     8.01037900    23.54291700   162.08470700    17.44124400
17.21117700
         50%     0.15800000     0.35700000     2.22800000     0.09600000
0.10400000     8.02558100    23.64089700   162.52476300    17.52216600
17.32612800
         75%     0.15800000     0.35700000     2.23400000     0.09700000
0.10400000     8.10682000    24.27746600   163.16261100    17.60505800
17.38662600
         max     0.16000000     2.25300000     2.25300000     0.09800000
0.10500000     8.21485600   188.70525100   188.70525100    17.82436600
17.81947600
     KS stat     0.32928937     0.46948033     0.21149960     0.39828295
0.27801561     0.21768535     0.48627767     0.47456225     0.19473709
0.14981348
        KS p     0.00212453     0.00000005     0.85448764     0.00008335
0.01528637     0.09966094     0.00000001     0.05733030     0.17978156
0.46643610
   KS p>0.05     Sample Bad     Sample Bad      Sample OK     Sample Bad
Sample Bad      Sample OK     Sample Bad      Sample OK      Sample OK
Sample OK
     SW stat     0.81561947     0.48656350     0.90809351     0.66927099
0.78072971     0.85799658     0.49827093     0.50430793     0.89850789
0.91609687
        SW p     0.00012799     0.00000000     0.38283044     0.00000057
0.00002978     0.00091592     0.00000000     0.00001871     0.00772318
0.02126906
   SW p>0.05     Sample Bad     Sample Bad      Sample OK     Sample Bad
Sample Bad     Sample Bad     Sample Bad     Sample Bad     Sample Bad
Sample Bad
```

1.2.2 KS Test

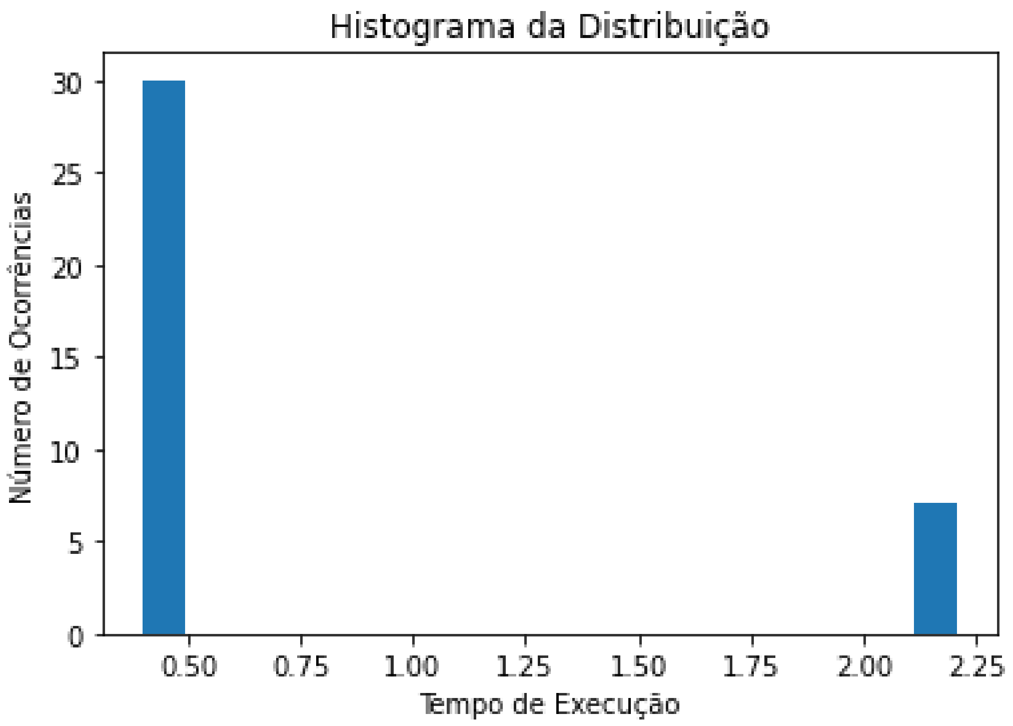
Low Contention

```
[ ]: #bench_apply_ks_tests("B")
     #bench_apply_ks_tests("LoContention")
     bench_apply_ks_tests("Low")
```

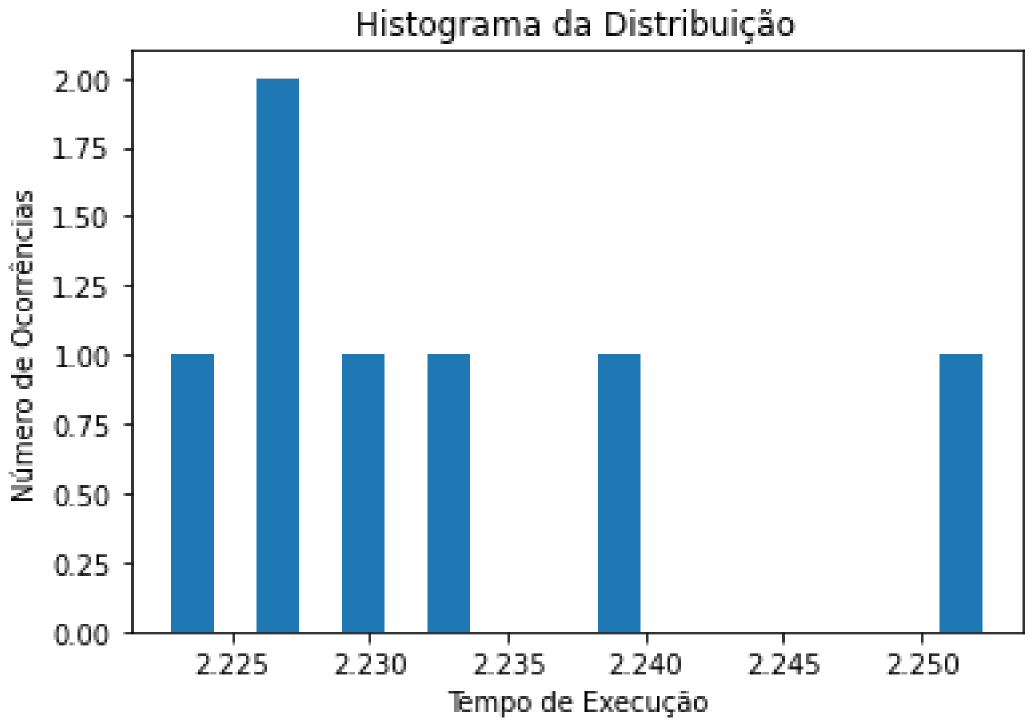
```
---------- RTM-1 - Low ----------
```



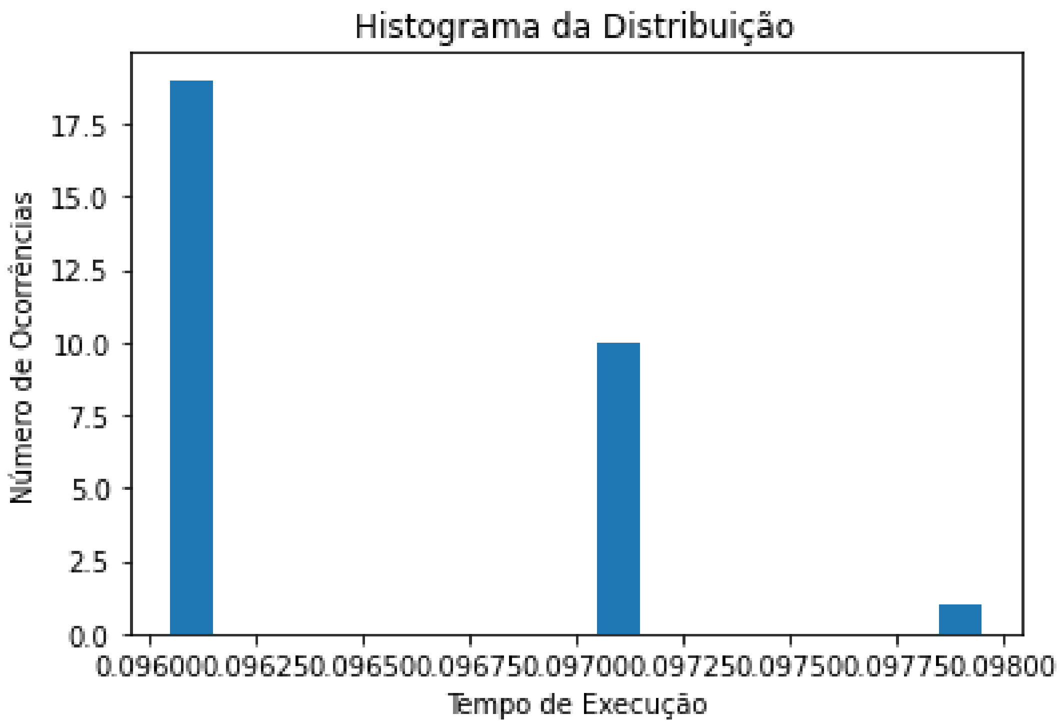
```
Statistics=0.32929, p=0.00212
Sample does not look Gaussian (reject H0)

---------- RTM-50 - Low ----------
```



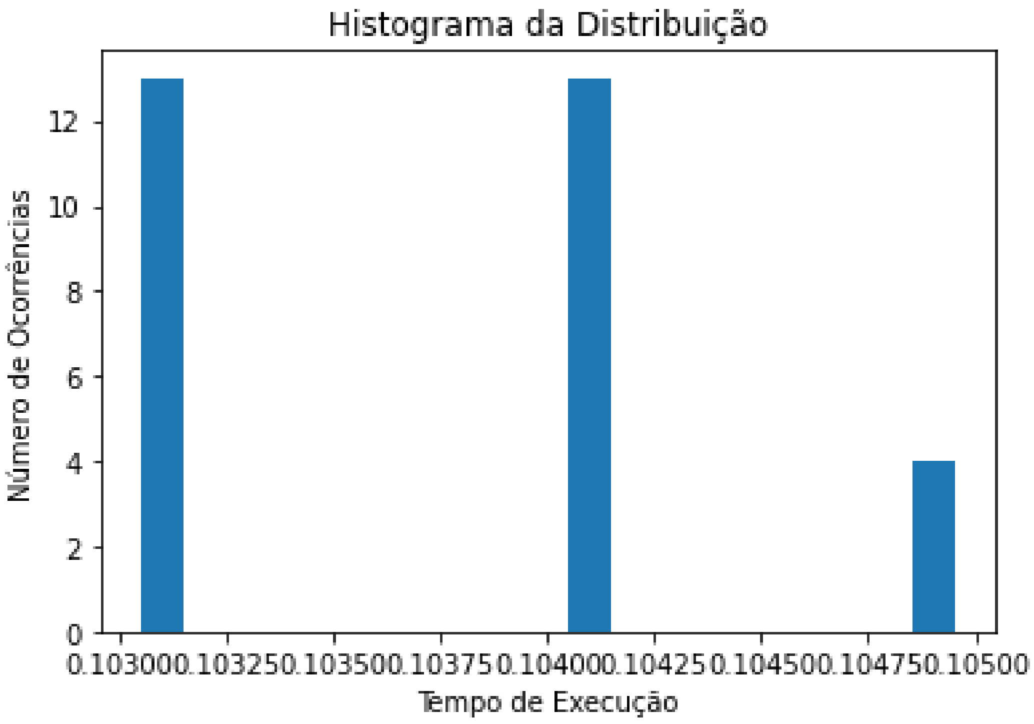
```
Statistics=0.46948, p=0.00000
Sample does not look Gaussian (reject H0)

---------- RTM-500 - Low ----------
```



```
Statistics=0.21150, p=0.85449
Sample looks Gaussian (fail to reject H0)

---------- TinySTM - Low ----------
```



```
Statistics=0.39828, p=0.00008
Sample does not look Gaussian (reject H0)

---------- SwissTM - Low ----------
```

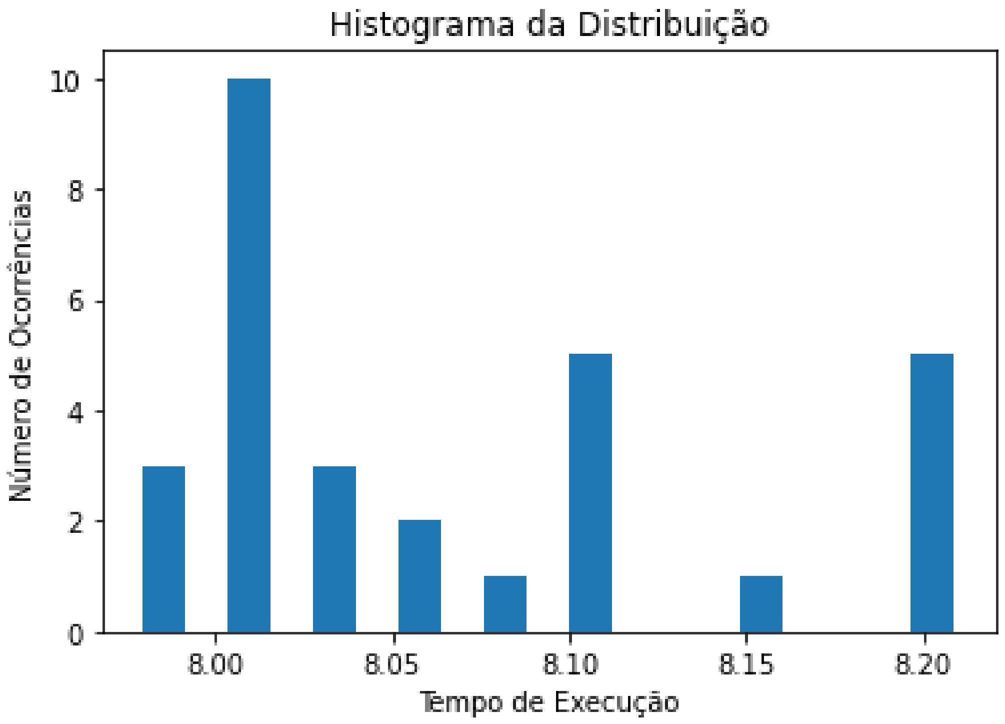


```
Statistics=0.27802, p=0.01529
Sample does not look Gaussian (reject H0)
```

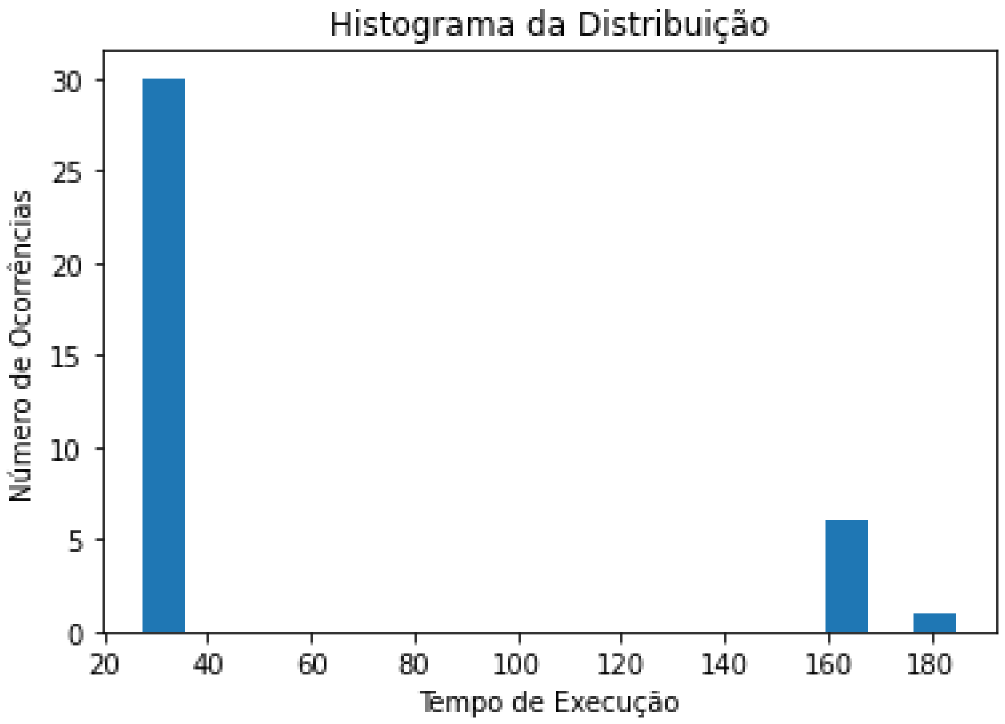
High Contention

```
[ ]: ##bench_apply_ks_tests("C")
     #bench_apply_ks_tests("HiContention")
     bench_apply_ks_tests("High")
```

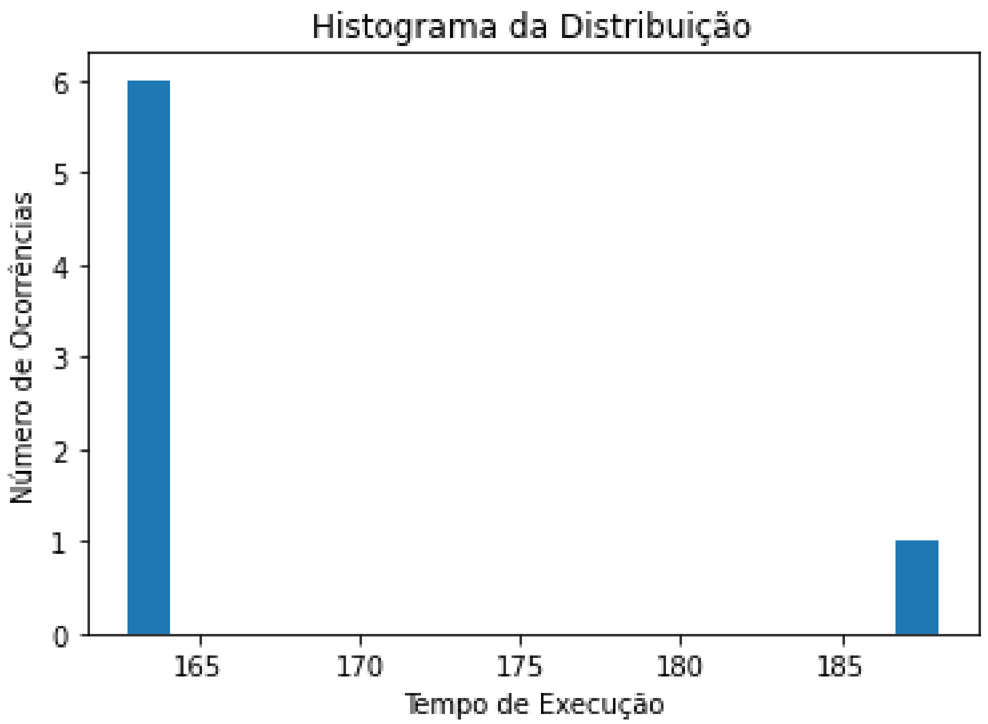
```
---------- RTM-1 - High ----------
```



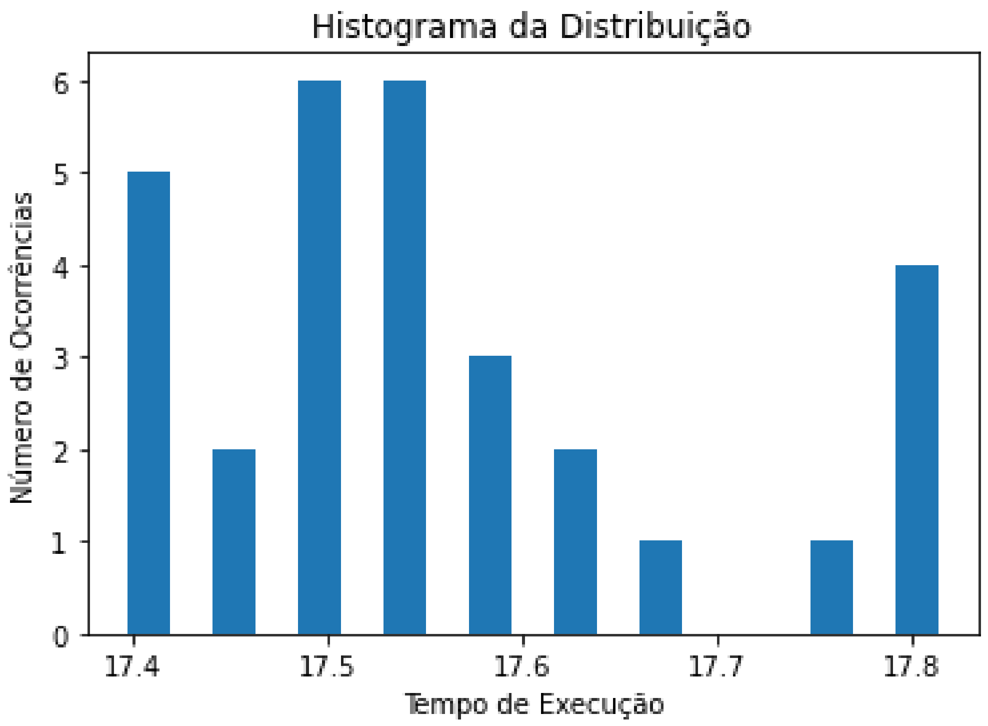
```
Statistics=0.21769, p=0.09966
Sample looks Gaussian (fail to reject H0)

---------- RTM-50 - High ----------
```



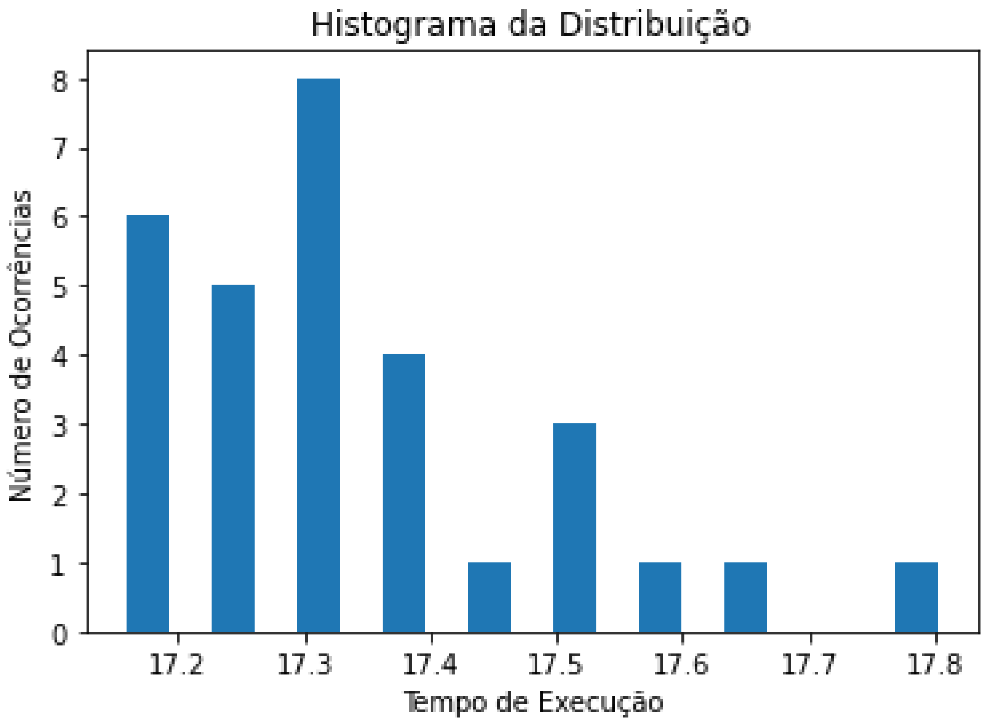
```
Statistics=0.48628, p=0.00000
Sample does not look Gaussian (reject H0)

---------- RTM-500 - High ----------
```



```
Statistics=0.47456, p=0.05733
Sample looks Gaussian (fail to reject H0)

---------- TinySTM - High ----------
```



```
Statistics=0.19474, p=0.17978
Sample looks Gaussian (fail to reject H0)

---------- SwissTM - High ----------
```



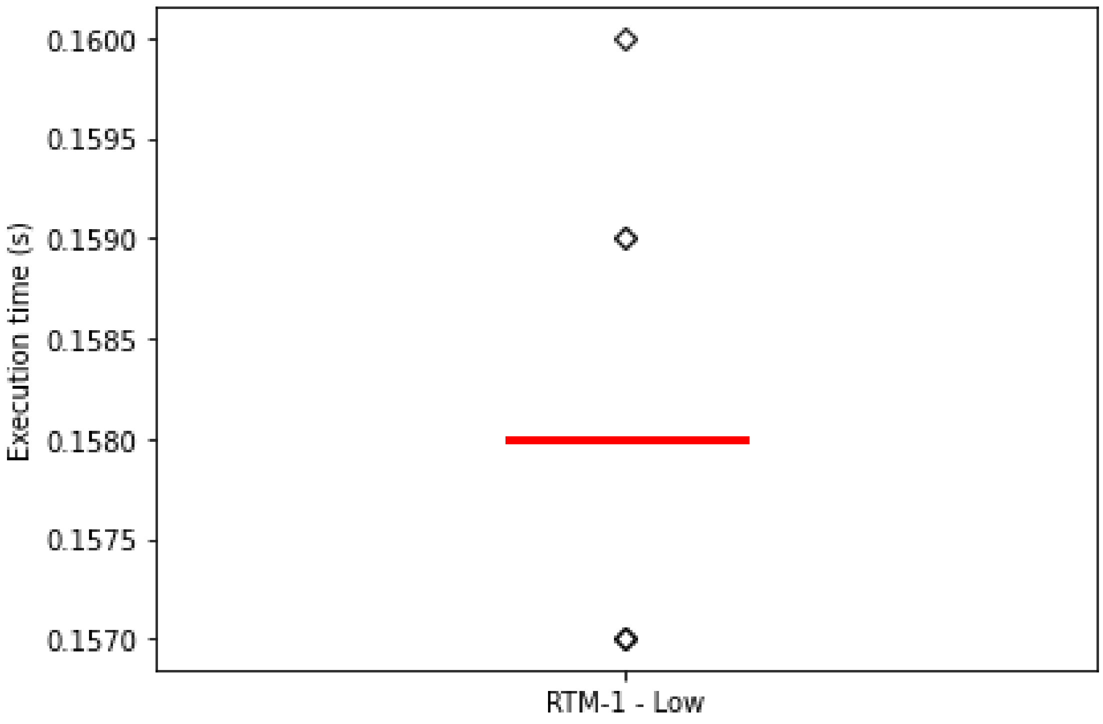
```
Statistics=0.14981, p=0.46644
Sample looks Gaussian (fail to reject H0)
```

1.2.3 Boxplots

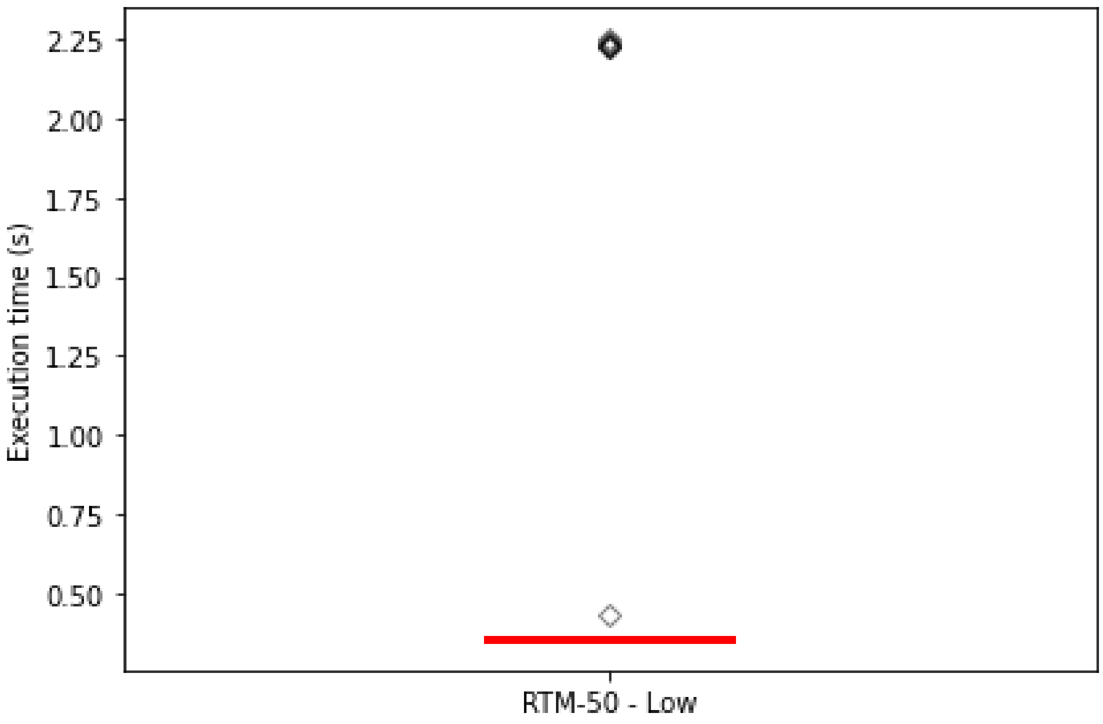
Low Contention

```
[ ]: #bench_apply_boxplots("B")
     #bench_apply_boxplots("LoContention")
     bench_apply_boxplots("Low")
```

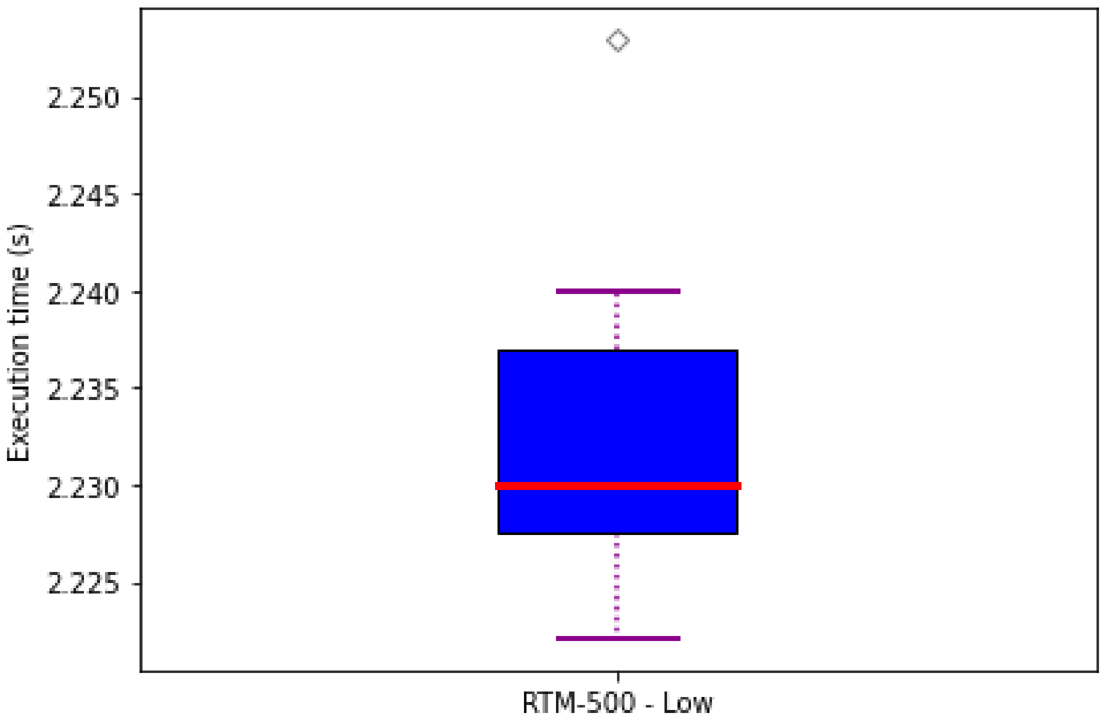
```
---------- RTM-1 - Low ----------
```


0.1600
0.1595
0.1590
0.1585
0.1580
0.1575
0.1570
Execution time (s)
RTM-1 - Low

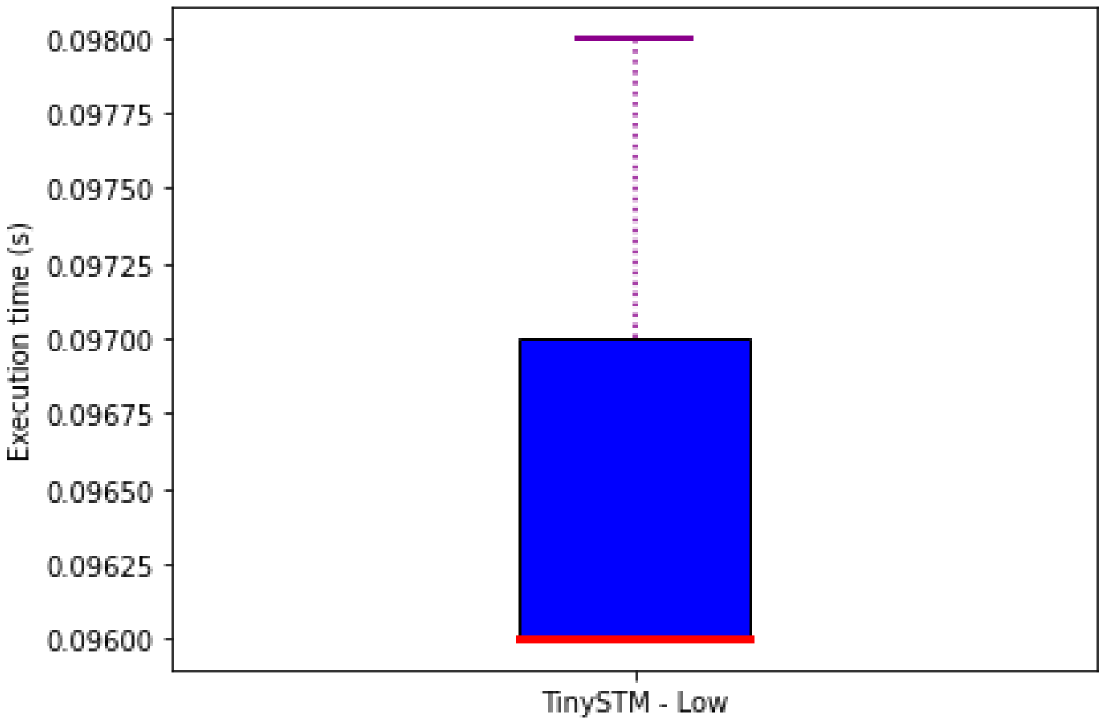
```
---------- RTM-50 - Low ----------
```


2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
Execution time (s)
RTM-50 - Low

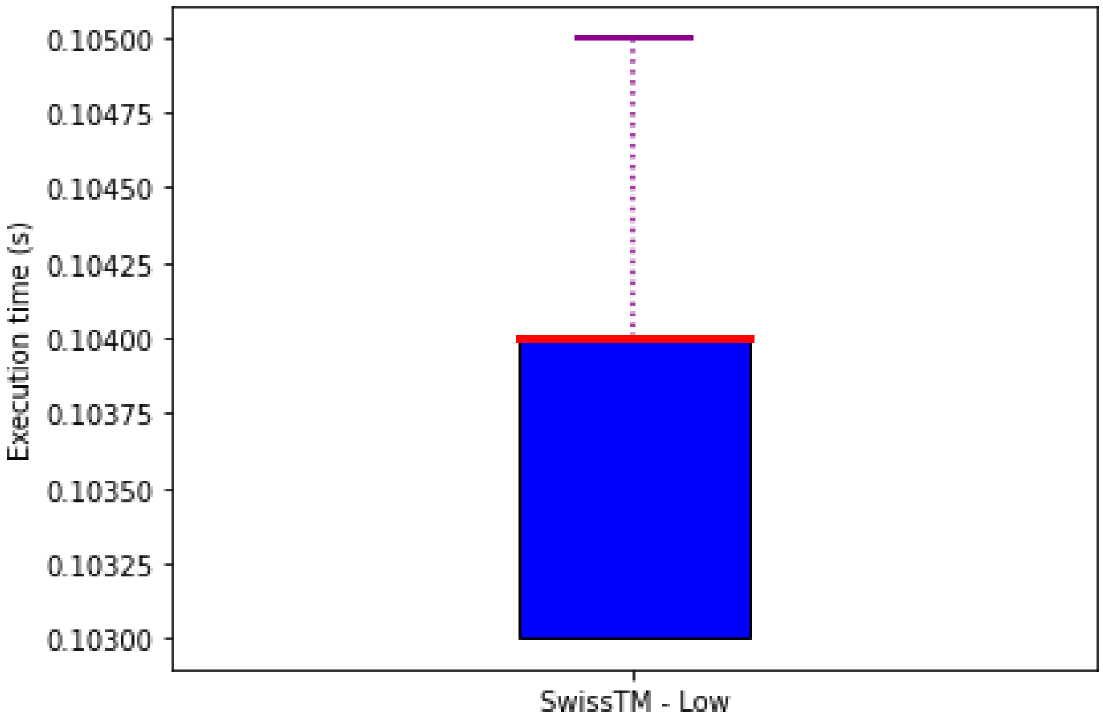
```
---------- RTM-500 - Low ----------
```



```
---------- TinySTM - Low ----------
```


0.09800
0.09775
0.09750
0.09725
0.09700
0.09675
0.09650
0.09625
0.09600
Execution time (s)
TinySTM - Low

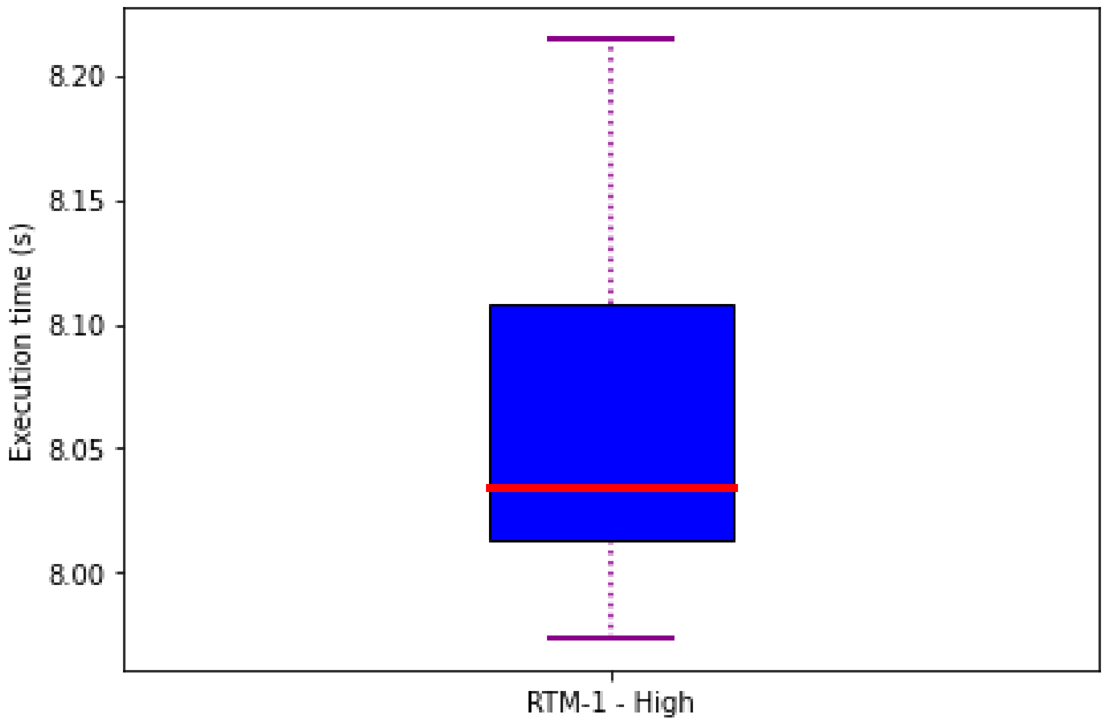
```
---------- SwissTM - Low ----------
```


0.10500
0.10475
0.10450
0.10425
0.10400
0.10375
0.10350
0.10325
0.10300
Execution time (s)
SwissTM - Low

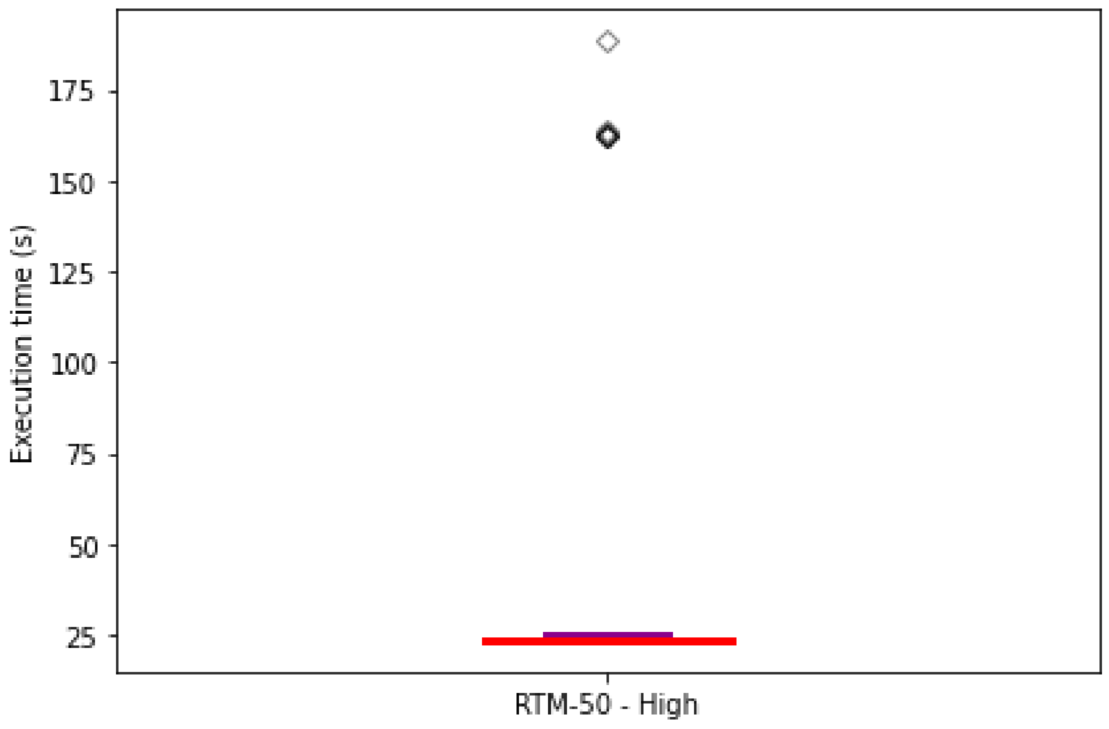
High Contention

```
[ ]: ##bench_apply_boxplots("C")
     #bench_apply_boxplots("HiContention")
     bench_apply_boxplots("High")
```

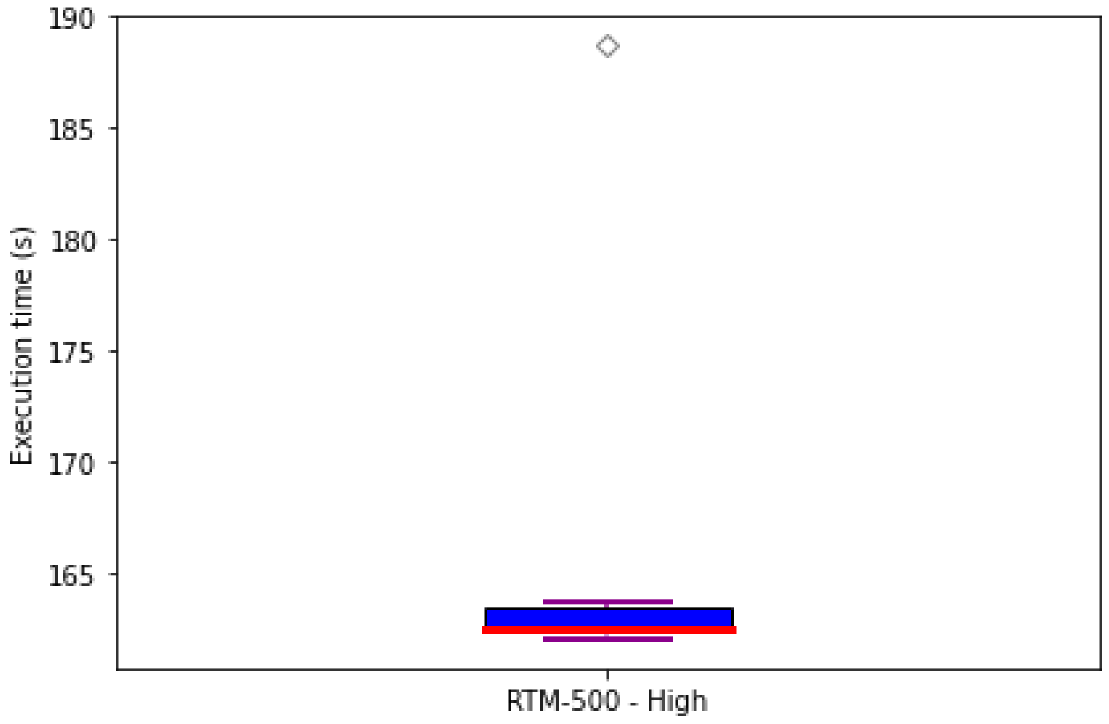
```
---------- RTM-1 - High ----------
```



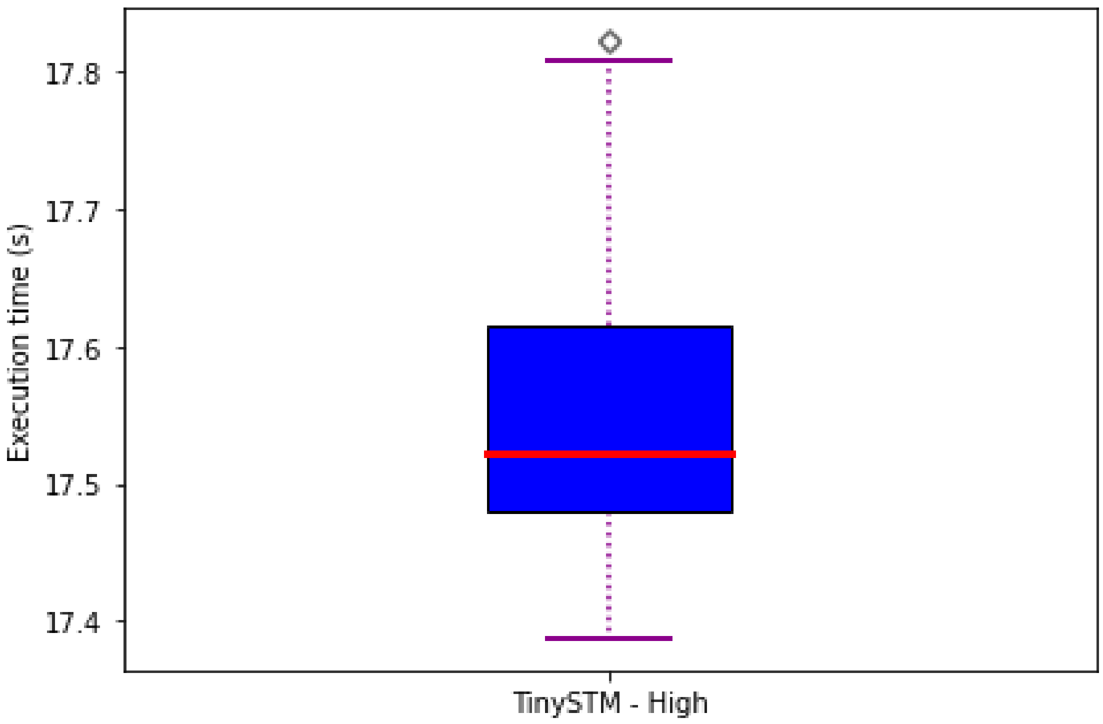
```
---------- RTM-50 - High ----------
```


175
150
125
100
75
50
25
Execution time (s)
RTM-50 - High

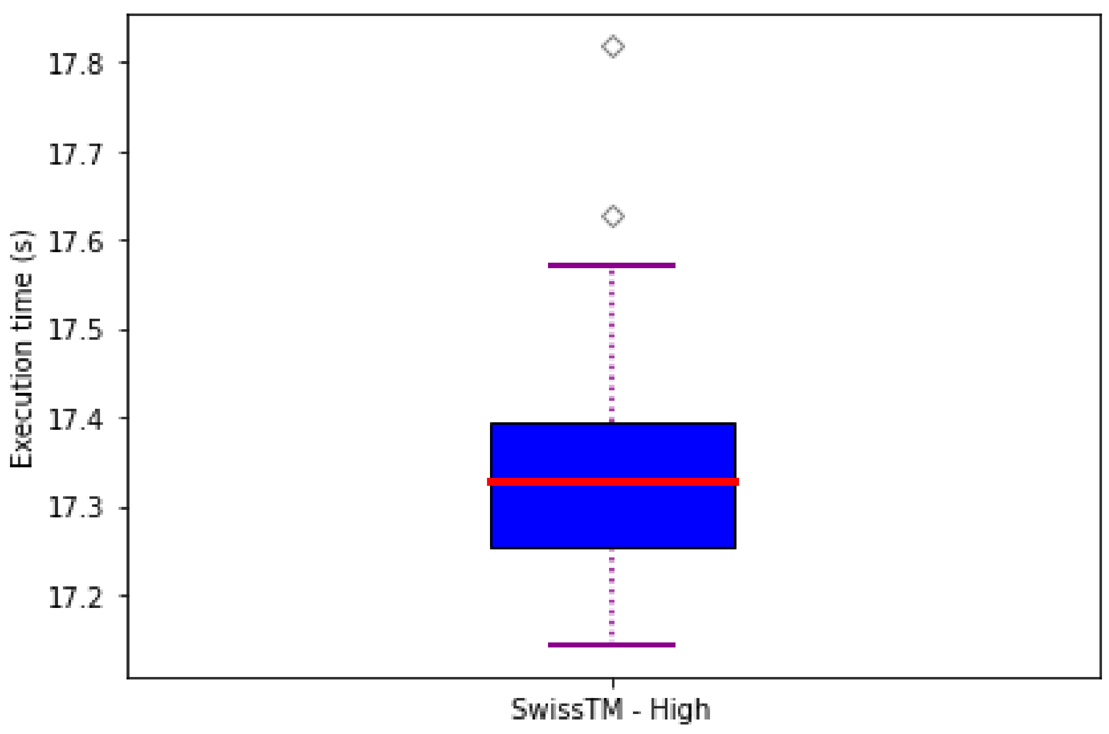
```
---------- RTM-500 - High ----------
```


190
185
180
175
170
165
Execution time (s)
RTM-500 - High

```
---------- TinySTM - High ----------
```



```
---------- SwissTM - High ----------
```



1.2.4 T-Test and U-Test

Low Contention

```
[ ]: #bench_report_t_u_tests("B")
     #if("LoContention" in CLASSES):
     #  bench_report_t_u_tests("LoContention")
     if("Low" in CLASSES):
       bench_report_t_u_tests("Low")
```

```
               (RTM-1[Low]) x (RTM-50[Low])
        KS OK?                           No
      T-Test p           6.163134747051e-05
   T-Test stat                  -4.53492248
T-Test p<=0.05         Not normally distrib.
      U-Test p           1.479276809093e-12
   U-Test stat                   0.00000000
U-Test p<=0.05                    U-Test OK
```

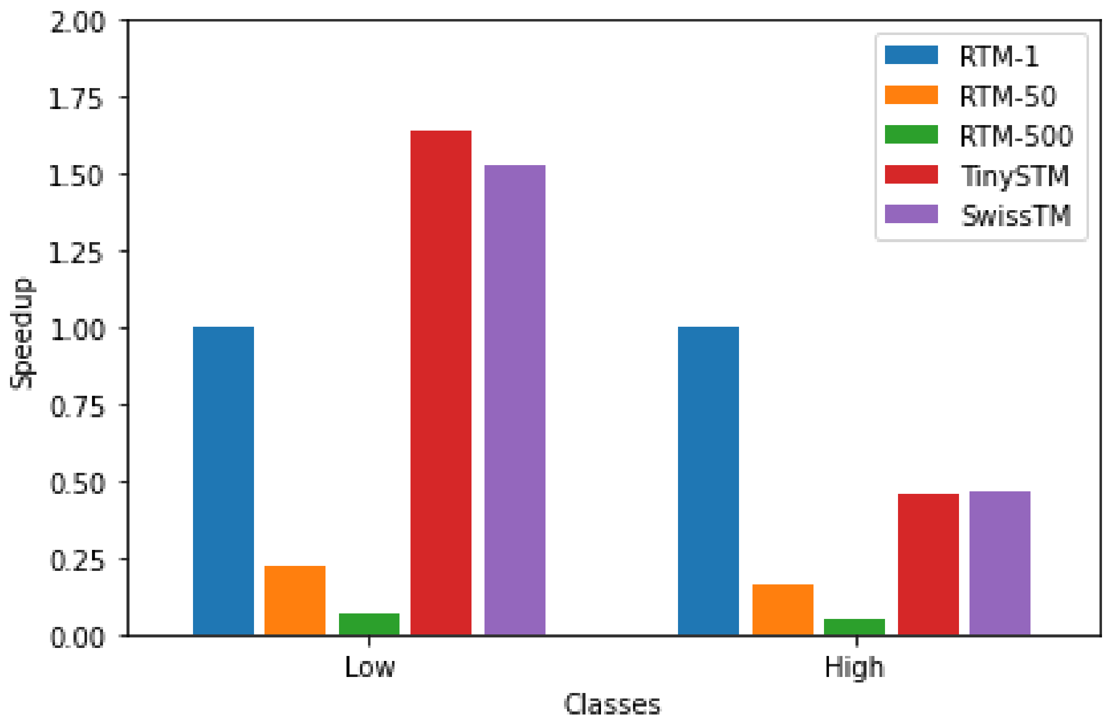
High Contention

```
[ ]: ##bench_report_t_u_tests("C")
     #if "HiContention" in CLASSES:
     #  bench_report_t_u_tests("HiContention")
     if "High" in CLASSES:
       bench_report_t_u_tests("High")
```

```
                 (RTM-1[High]) x (RTM-50[High])
         KS OK?                              No
       T-Test p          5.535443884005e-05
    T-Test stat                 -4.57058499
 T-Test p<=0.05      Not normally distrib.
       U-Test p          2.598295687016e-12
    U-Test stat                  0.00000000
 U-Test p<=0.05                   U-Test OK
```

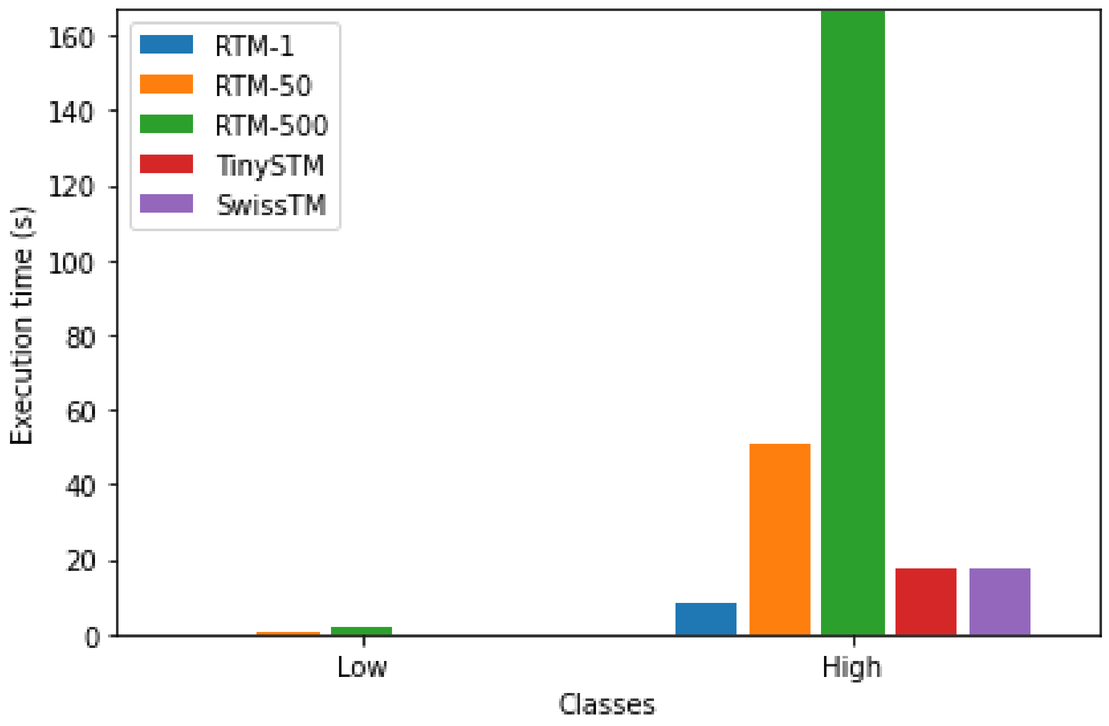
1.2.5 Speedup charts

```
[ ]: #O speedup to comparando uma execução com ela mesma, isso preciso mudar

     ##Aqui provavelmente tenha que mudar
     ##Aqui usa as questões de versão e classe que não sei se traduzi corretamente␣
      ↪pro meu caso
     #print('----------', "Python", '----------')
     #versions_gpu = [VER_PYTHON_CUDA]
     #versions = [VER_RTM_INTEL_R1]
     #versions2 = ["VER_RTM_INTEL_R1", "VER_STM_TINY", "VER_STM_SWISS"]

     #bench_speedup_chart(VER_PYTHON_SERIAL, versions_gpu)
     #bench_speedup_chart(VER_RTM_INTEL, versions)
     #bench_speedup_chart(VER_RTM_INTEL_R1, versions)
     #for v in VERSIONS:
     v = VERSIONS[0]
     bench_speedup_chart(v, VERSIONS)


     #print("\n\n", '----------', "C++", '----------')
     #if g_bench == "IS":
     #    versions_gpu = [VER_CUDA]
     #else:
     #    versions_gpu = [VER_CUDA, VER_OPENACC]
     #versions = [VER_SEQ]
     #versions = [VER_STM_TINY]

     #bench_speedup_chart(VER_CPP_SERIAL, versions_gpu)
     #bench_speedup_chart(VER_SEQ, versions)
     #bench_speedup_chart(VER_STM_TINY, versions)
```



1.2.6 GPU comparison chart

[ ]:
```
bench_time_chart()
```



1.3 Main general view

1.3.1 Utils

[ ]:
```
def load_npb_data_dictinary():
    global dic_dados_bench
    global dic_dados
    for b in BENCHS:
        dic_dados = {}
        load_data_dictionary(b)
        dic_dados_bench[b] = dict(dic_dados)
#END
```

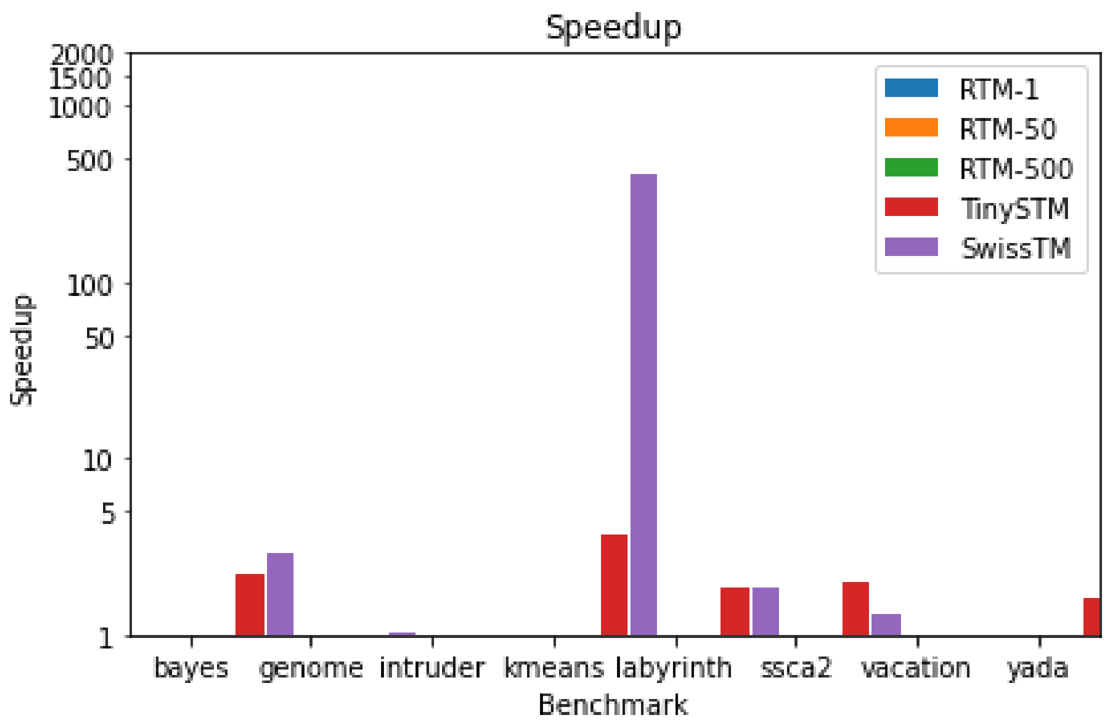
[ ]:
```
##Aqui também tive que mudar bastante coisa com classes e versões e não sei se␣
 ↪tá correto
def npb_time_chart(classe):
        times = []
        bench_ids = range(1, len(BENCHS)*2+1, 2)

        #for v in VERSIONS_GPU:
        for v in VERSIONS:
                v_time = []
                for bench in BENCHS:
                        dic_bench = dic_dados_bench[bench]
                        if idx_dicionario(v, classe) in dic_bench.keys():
                                time, a, b =␣
↪calc_stats(dic_bench[idx_dicionario(v, classe)]["times"])
                        else:
                                time = 0.0
                        v_time.append(time)

                times.append(v_time)

        #Chart
        #desenha as barras no gráfico
        fig, ax = plt.subplots()

        bars = []
        idx = -0.5
        for t in times:
                bar = ax.bar(np.array(bench_ids)+idx, np.array(t), width=0.45)
                bars.append(bar)
                idx += 0.5

        ax.set_xlabel('Benchmark')
        ax.set_ylabel('Execution time (s)')
        ax.set_xlim(0, 16)
        ax.set_ylim(0.01, 60)

        ax.set_title('Execution time')
        ax.legend(tuple(map(name_versao, VERSIONS)))

        ax.set_xticks(bench_ids)
        ax.set_xticklabels(BENCHS)

        #ax.set_yscale('log', base=2)
        ax.set_yscale('log')

        locs = [0.05, 0.1, 0.5, 1, 5, 10, 20, 40, 60]
        ax.yaxis.set_minor_locator(ticker.FixedLocator(locs))
        ax.yaxis.set_major_locator(ticker.NullLocator())

        ax.yaxis.set_minor_formatter(ticker.ScalarFormatter())

        #for b in bars:
        #         ax.bar_label(b, padding=3, fmt='%4.2f')

        fig.tight_layout()
        plt.show() #mostra o gráfico
#END

def npb_speedup_chart(classe):
        speedups = []
        bench_ids = range(1, len(BENCHS)*2+1, 2)

        #for v in VERSIONS_GPU:
        for v in VERSIONS:
                v_speedup = []

                for bench in BENCHS:
                        dic_bench = dic_dados_bench[bench]

                        if idx_dicionario(v, classe) in dic_bench.keys():
                                time_serial = 1.0
                                #if "PYTHON" in v:
                                #         time_serial, a, b =␣
 ↪calc_stats(dic_bench[idx_dicionario(VER_PYTHON_SERIAL, classe)]["times"])
                                #time_serial, a, b =␣
 ↪calc_stats(dic_bench[idx_dicionario(VER_RTM_INTEL, classe)]["times"])
                                time_serial, a, b =␣
 ↪calc_stats(dic_bench[idx_dicionario(VER_RTM_INTEL_R1, classe)]["times"])
                                #else:
                                #         time_serial, a, b =␣
 ↪calc_stats(dic_bench[idx_dicionario(VER_CPP_SERIAL, classe)]["times"])
                                #
                                #if idx_dicionario(v, classe) in dic_bench.
 ↪keys():
                                time, a, b =␣
 ↪calc_stats(dic_bench[idx_dicionario(v, classe)]["times"])
                                v_speedup.append(time_serial/time)
                        else:
                                v_speedup.append(-100.0)

                speedups.append(v_speedup)

        #Chart
        #desenha as barras no gráfico
        fig, ax = plt.subplots()

        bars = []
        idx = -0.5
        for s in speedups:
                bar = ax.bar(np.array(bench_ids)+idx, np.array(s), width=0.45)
                bars.append(bar)
                idx += 0.5

        ax.set_xlabel('Benchmark')
        ax.set_ylabel('Speedup')
        ax.set_xlim(0, 16)
        ax.set_ylim(1, 2000)

        ax.set_title('Speedup')
        ax.legend(tuple(map(name_versao, VERSIONS)))

        ax.set_xticks(bench_ids)
        ax.set_xticklabels(BENCHS)

        ax.set_yscale('log')

        locs = [1, 5, 10, 50, 100, 500, 1000, 1500, 2000]
        ax.yaxis.set_minor_locator(ticker.FixedLocator(locs))
        ax.yaxis.set_major_locator(ticker.NullLocator())

        ax.yaxis.set_minor_formatter(ticker.ScalarFormatter())

        #for b in bars:
        #         ax.bar_label(b, padding=3, fmt='%4.1f')

        fig.tight_layout()

        plt.show() #mostra o gráfico
#END
```

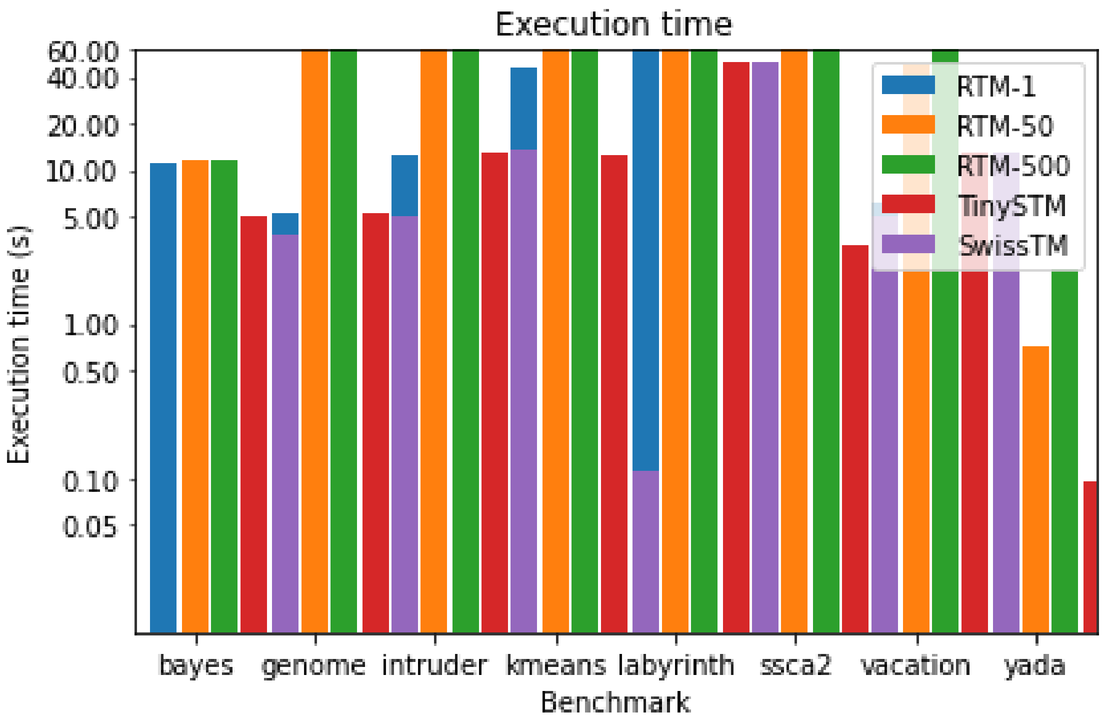
1.3.2 Charts

```
[ ]: load_npb_data_dictinary()

     #print('\n', '----------', "Class B", '----------')
     #npb_speedup_chart("B")
     #npb_speedup_chart("LoContention")
     npb_speedup_chart("Low")

     #npb_time_chart("B")
     #npb_time_chart("LoContention")
     npb_time_chart("Low")
```

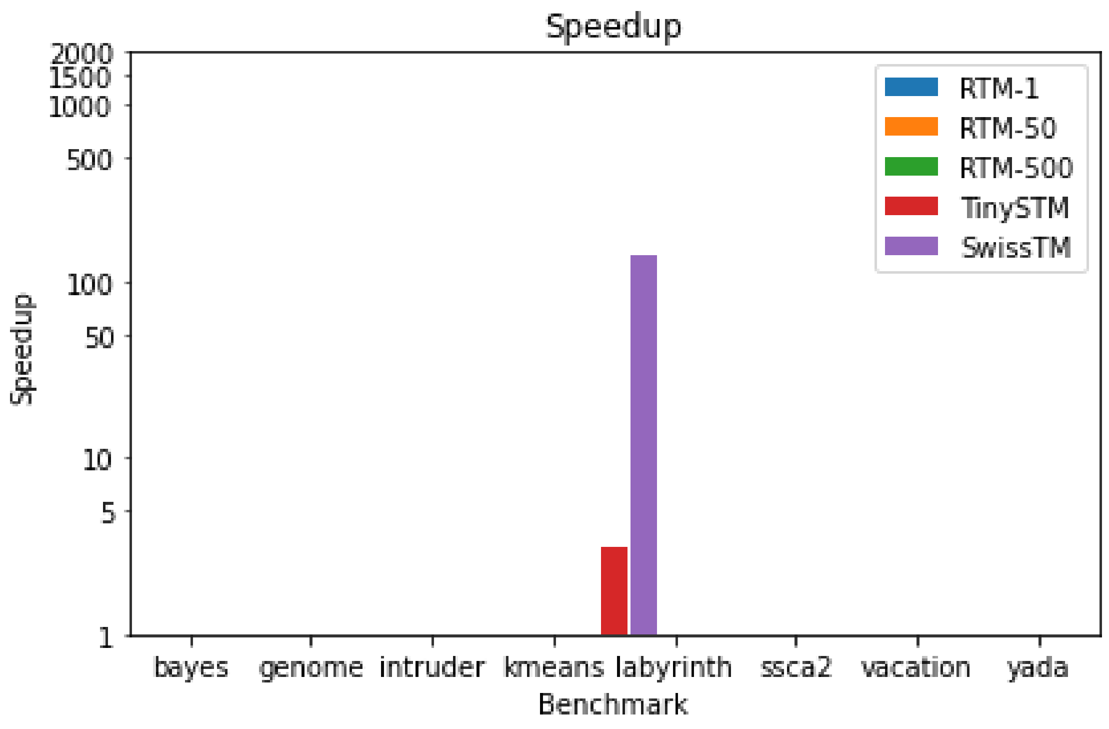
```
Gerando bayes …
bayes OK
Gerando genome …
```

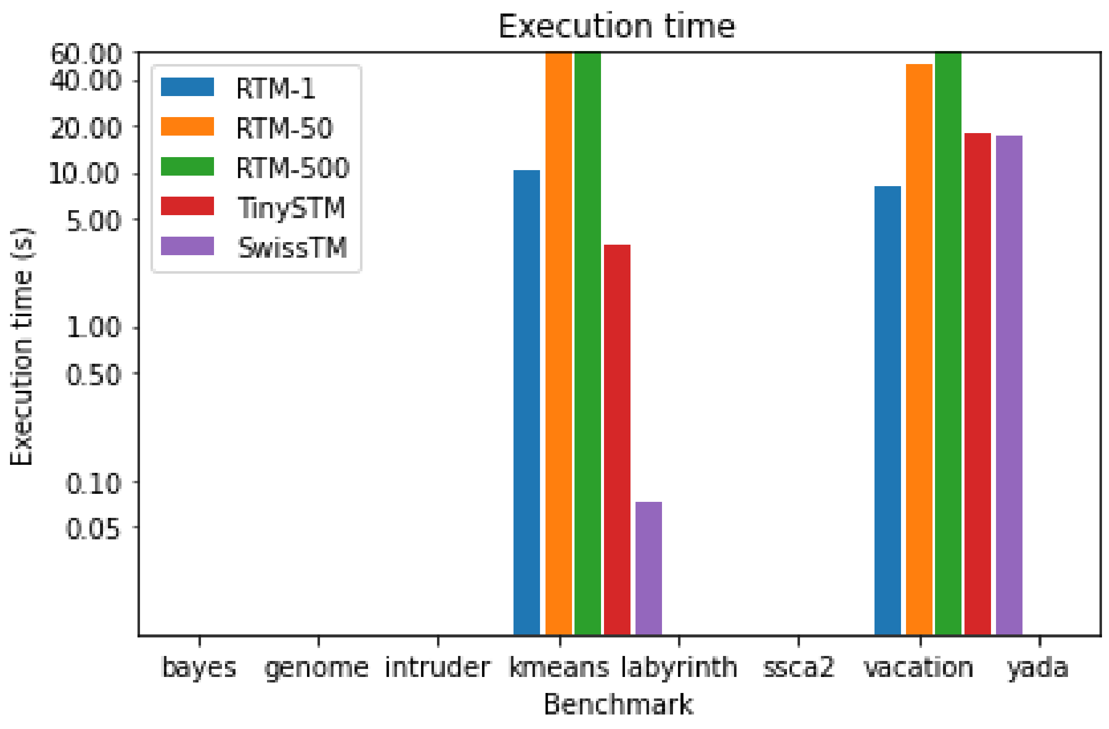
```
genome OK
Gerando intruder …
intruder OK
Gerando kmeans …
kmeans OK
Gerando labyrinth …
labyrinth OK
Gerando ssca2 …
ssca2 OK
Gerando vacation …
vacation OK
Gerando yada …
yada OK
```





```
[ ]: ##print('\n', '----------', "Class C", '----------')
     ##npb_speedup_chart("C")
     #if "HiContention" in CLASSES:
     #  npb_speedup_chart("HiContention")
     if "High" in CLASSES:
       npb_speedup_chart("High")

     ##npb_time_chart("C")
     #  npb_time_chart("HiContention")
       npb_time_chart("High")
```


Speedup
2000
1500
1000
500
100
50
10
5
1
Speedup
RTM-1
RTM-50
RTM-500
TinySTM
SwissTM
bayes
genome
intruder
kmeans
labyrinth
ssca2
vacation
yada
Benchmark


Execution time
60.00
40.00
20.00
10.00
5.00
1.00
0.50
0.10
0.05
Execution time (s)
RTM-1
RTM-50
RTM-500
TinySTM
SwissTM
bayes
genome
intruder
kmeans
labyrinth
ssca2
vacation
yada
Benchmark

```
[ ]: import os
get_ipython().system(
    "apt update >> /dev/null && apt install texlive-xetex␣
 ↪texlive-fonts-recommended texlive-generic-recommended >> /dev/null"
)

notebookpath="/content/drive/MyDrive/Colab Notebooks/"
file_name = "NPB_statistics - Frederico.ipynb"
drive_mount_point = "/content/drive/"
gdrive_home = os.path.join(drive_mount_point, "My Drive/Colab Notebooks/
 ↪Arquivos")

if not os.path.isfile(os.path.join(notebookpath, file_name)):
  raise ValueError(f"file '{file_name}' not found in path '{notebookpath}'.")

pdfNum = 0
while os.path.isfile(os.path.join(gdrive_home, file_name.split(".")[0] +␣
 ↪str(pdfNum) + ".pdf")):
  pdfNum = pdfNum + 1
filename = file_name.split(".")[0] + str(pdfNum)# + ".pdf"

try:
    get_ipython().system(
        "jupyter nbconvert --output-dir=\""+gdrive_home+"\"␣
 ↪\""+notebookpath+file_name+"\" --to pdf --output=\""+filename+"\""
    )
except:
    print("nbconvert error")

try:
    from google.colab import files

    file_name = file_name.split(".")[0] + ".pdf"
    files.download(gdrive_home + file_name)
except:
    print("File Download Unsuccessful. Saved in Google Drive")

print("File ready to be Downloaded and Saved to Drive")
```

```
WARNING: apt does not have a stable CLI interface. Use with caution in scripts.


WARNING: apt does not have a stable CLI interface. Use with caution in scripts.

[NbConvertApp] Converting notebook /content/drive/MyDrive/Colab
Notebooks/NPB_statistics - Frederico.ipynb to pdf
```

```
[NbConvertApp] Support files will be in NPB_statistics - Frederico15_files/
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico15_files
[NbConvertApp] Writing 130315 bytes to ./notebook.tex
[NbConvertApp] Building PDF
[NbConvertApp] Running xelatex 3 times: ['xelatex', './notebook.tex', '-quiet']
[NbConvertApp] Running bibtex 1 time: ['bibtex', './notebook']
[NbConvertApp] WARNING | bibtex had problems, most likely because there were no
citations
[NbConvertApp] PDF successfully created
[NbConvertApp] Writing 253253 bytes to /content/drive/My Drive/Colab
Notebooks/Arquivos/NPB_statistics - Frederico15.pdf
File Download Unsuccessful. Saved in Google Drive
File ready to be Downloaded and Saved to Drive
```