NPB_statistics - Frederico

November 21, 2022

1 NPB Statistics

1.1 Utils

1.1.1 Imports

[1]:
```
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
```

[2]:
```
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

[3]:
```
##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 = ["RTM-INTEL-r50", "RTM-INTEL-r500", "STM-SWISS", "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

[4]:
```
# 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 "R1" in versao:
                                return "RTM-1"
                        if "R50" in versao:
                                return "RTM-50"
                        if "R500" in versao:
                                return "RTM-500"
                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

[5]:
```
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

[6]:
```
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
        for t in times:
                bar = ax.bar(np.array(class_ids)+idx, np.array(t), width=0.25)
                bars.append(bar)
                idx += 0.3

        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)+1)

        #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 = 0.15 if len(speedups) > 1 else 0.0
        value = idx * -1
        for s in speedups:
                bar = ax.bar(np.array(class_ids)+value, np.array(s), width=0.25)
                bars.append(bar)
                value *= -1

        ax.set_xlabel('Classes')
        ax.set_ylabel('Speedup')
        ax.set_xlim(0, 3)
        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)])
        #for v in VERSIONS:
        #        versoes_comp.append(idx_dicionario(v, classe))

        #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

[7]:
```
##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

[8]:
```
report_df_all(dic_dados)
```

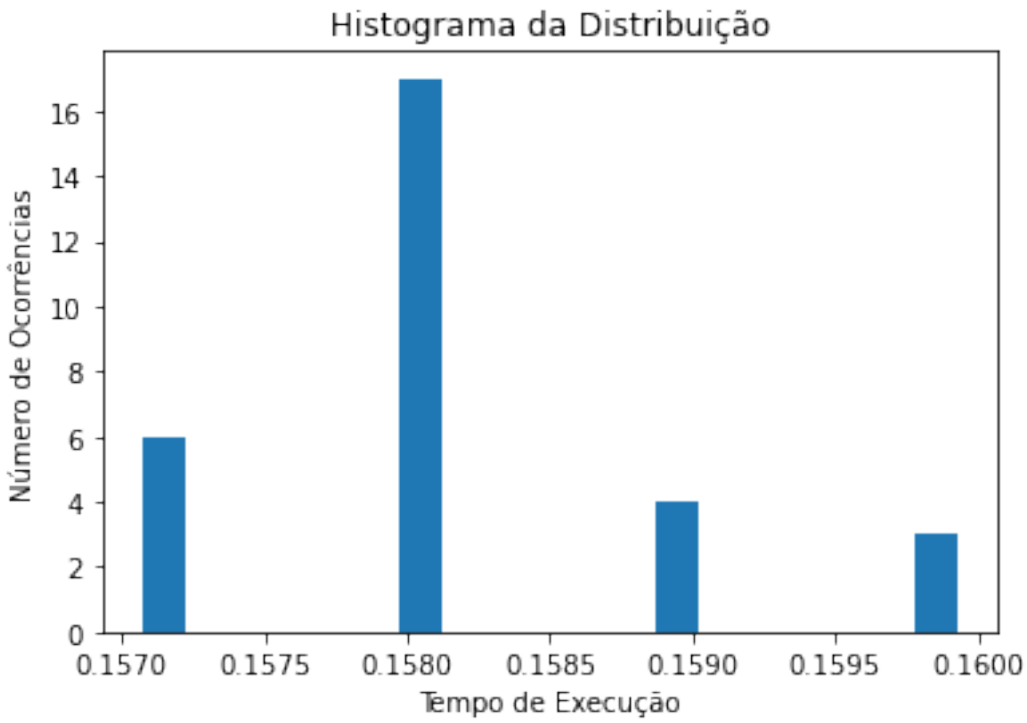
	- Low	TinySTM - Low	- High	TinySTM - High
count	30.00000000	30.00000000	30.00000000	30.00000000
mean	0.15813333	0.09640000	8.06883460	17.55868447
std	0.00084591	0.00055377	0.07509578	0.12975196
error (95%)	0.00026241	0.00017179	0.02329597	0.04025123
min	0.15700000	0.09600000	7.97327700	17.38628100
25%	0.15800000	0.09600000	8.01037900	17.44124400
50%	0.15800000	0.09600000	8.02558100	17.52216600
75%	0.15800000	0.09700000	8.10682000	17.60505800
max	0.16000000	0.09800000	8.21485600	17.82436600
KS stat	0.32928937	0.39828295	0.21768535	0.19473709
KS p	0.00212453	0.00008335	0.09966094	0.17978156
KS p>0.05	Sample Bad	Sample Bad	Sample OK	Sample OK
SW stat	0.81561947	0.66927099	0.85799658	0.89850789
SW p	0.00012799	0.00000057	0.00091592	0.00772318
SW p>0.05	Sample Bad	Sample Bad	Sample Bad	Sample Bad

1.2.2 KS Test

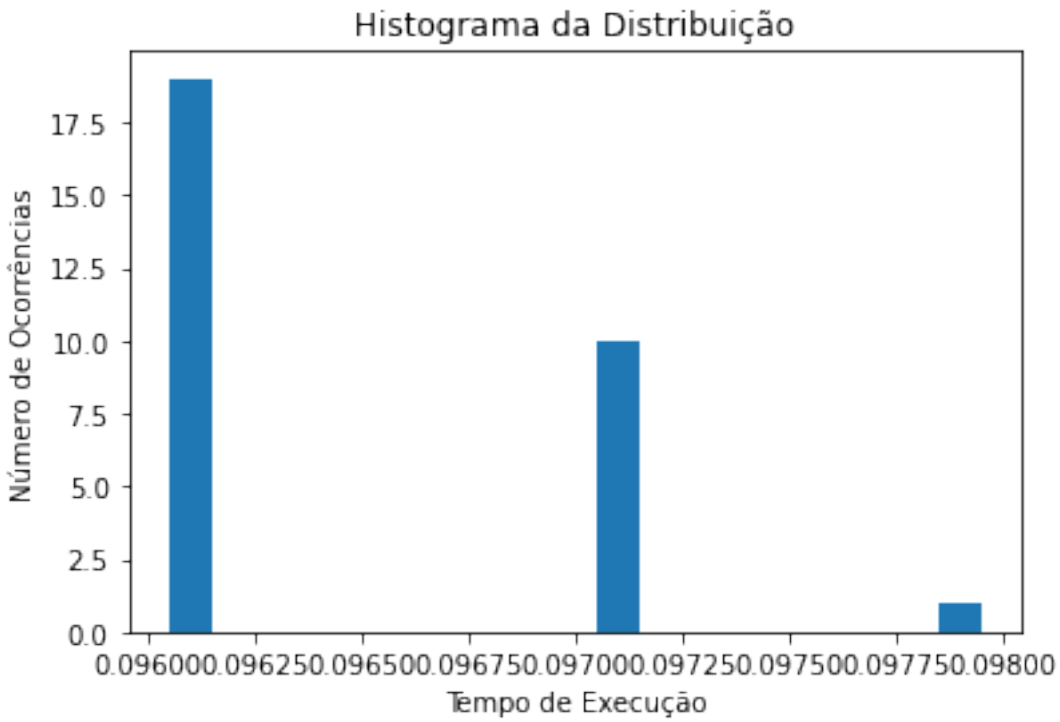
Low Contention

[9]:
```
#bench_apply_ks_tests("B")
#bench_apply_ks_tests("LoContention")
bench_apply_ks_tests("Low")
```

```
----------  - Low ----------
```




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

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

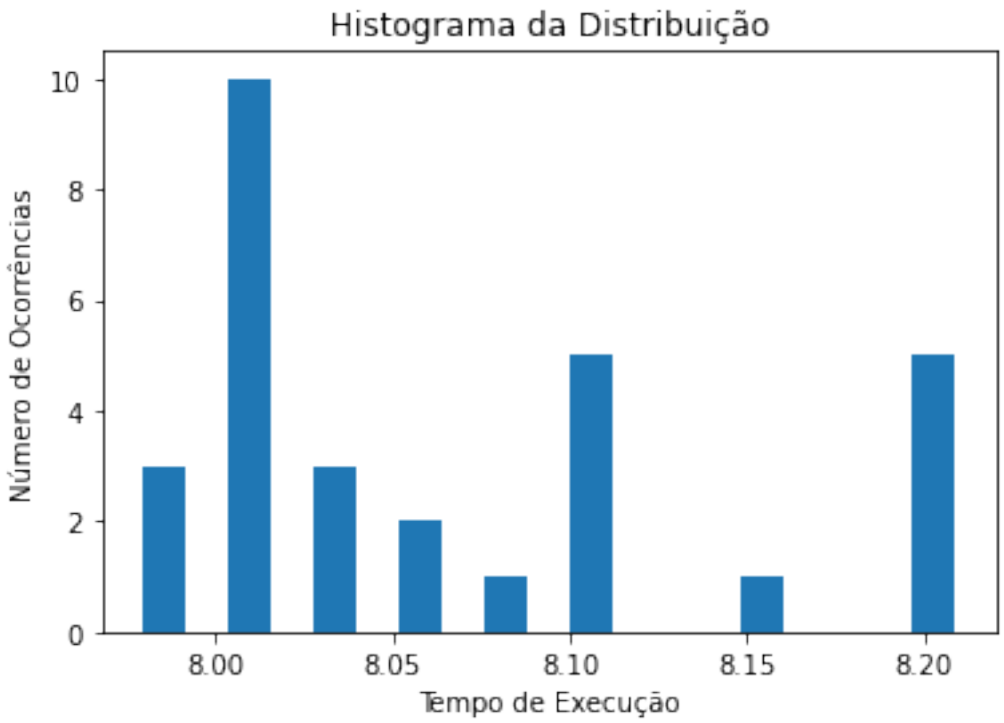



```
Statistics=0.39828, p=0.00008
Sample does not look Gaussian (reject H0)
```

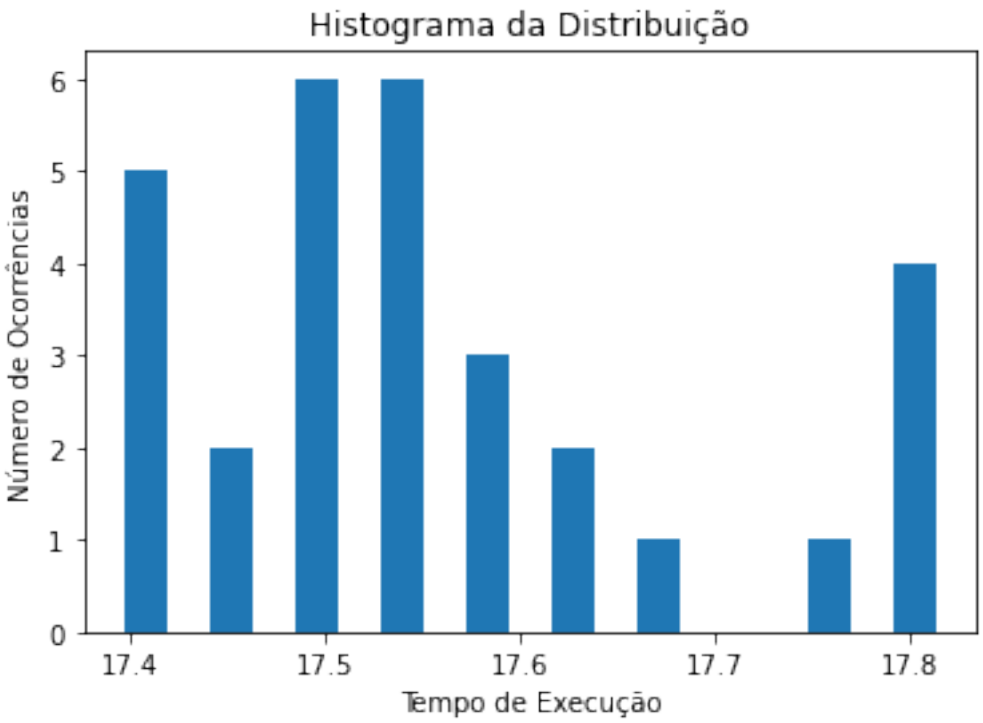
High Contention

[10]:
```
##bench_apply_ks_tests("C")
#bench_apply_ks_tests("HiContention")
bench_apply_ks_tests("High")
```

```
----------  - High ----------
```




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

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



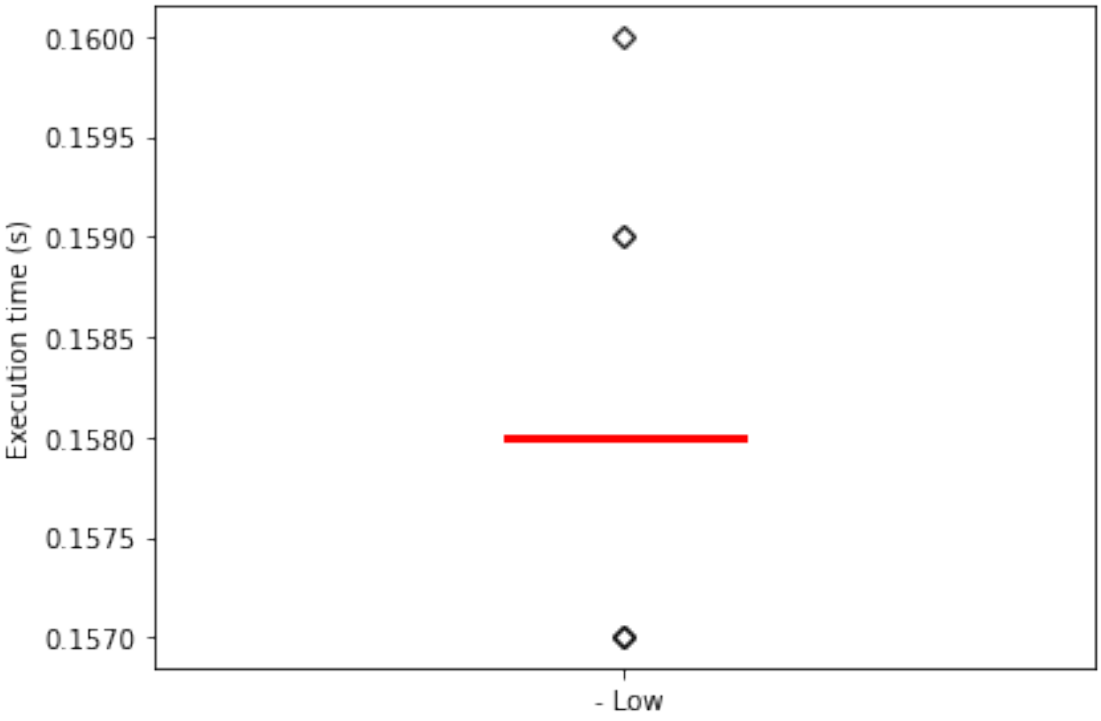

```
Statistics=0.19474, p=0.17978
Sample looks Gaussian (fail to reject H0)
```

1.2.3 Boxplots

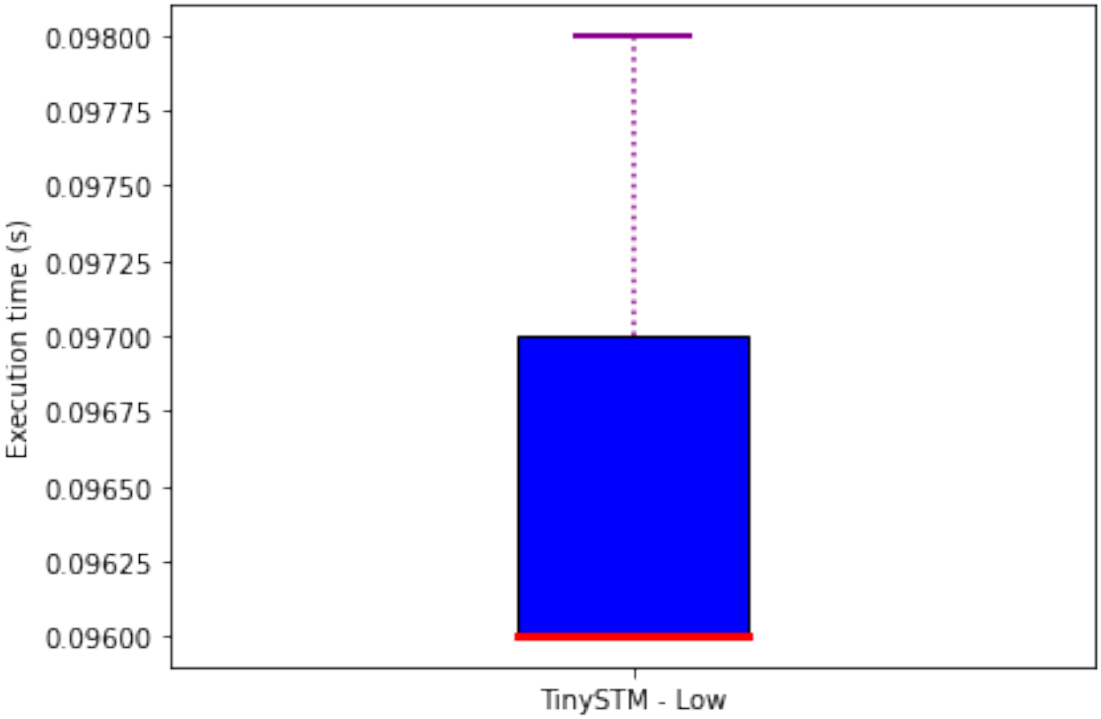
Low Contention

[11]:
```
#bench_apply_boxplots("B")
#bench_apply_boxplots("LoContention")
bench_apply_boxplots("Low")
```

```
----------  - Low ----------
```


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

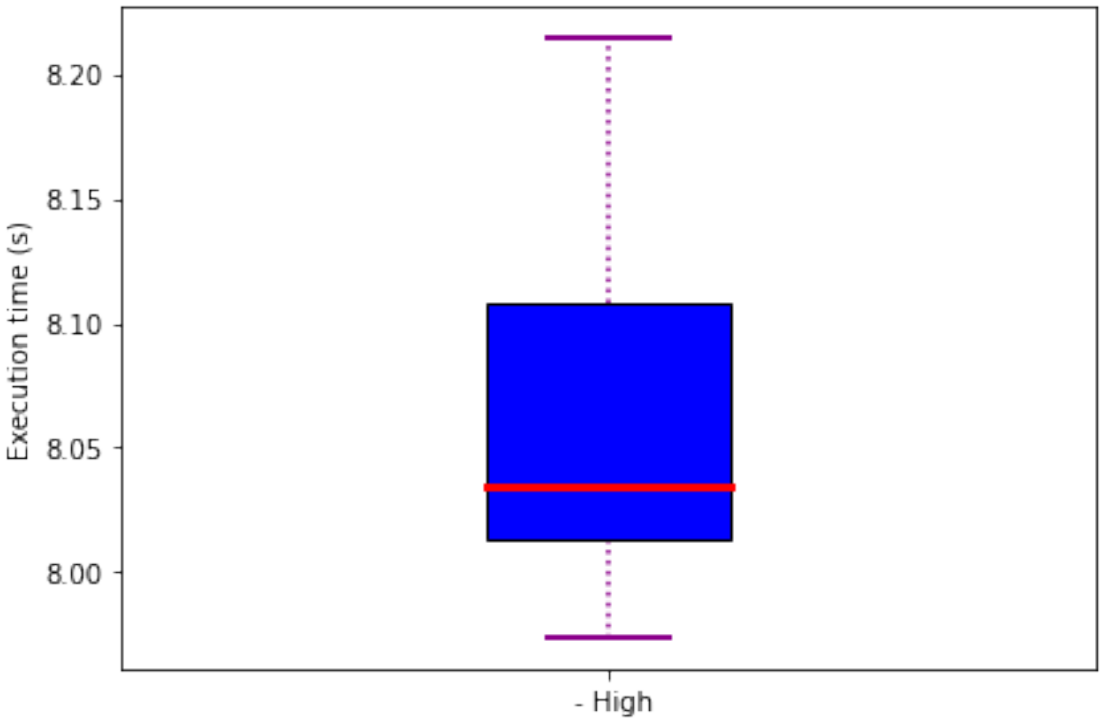
```
---------- TinySTM - Low ----------
```


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

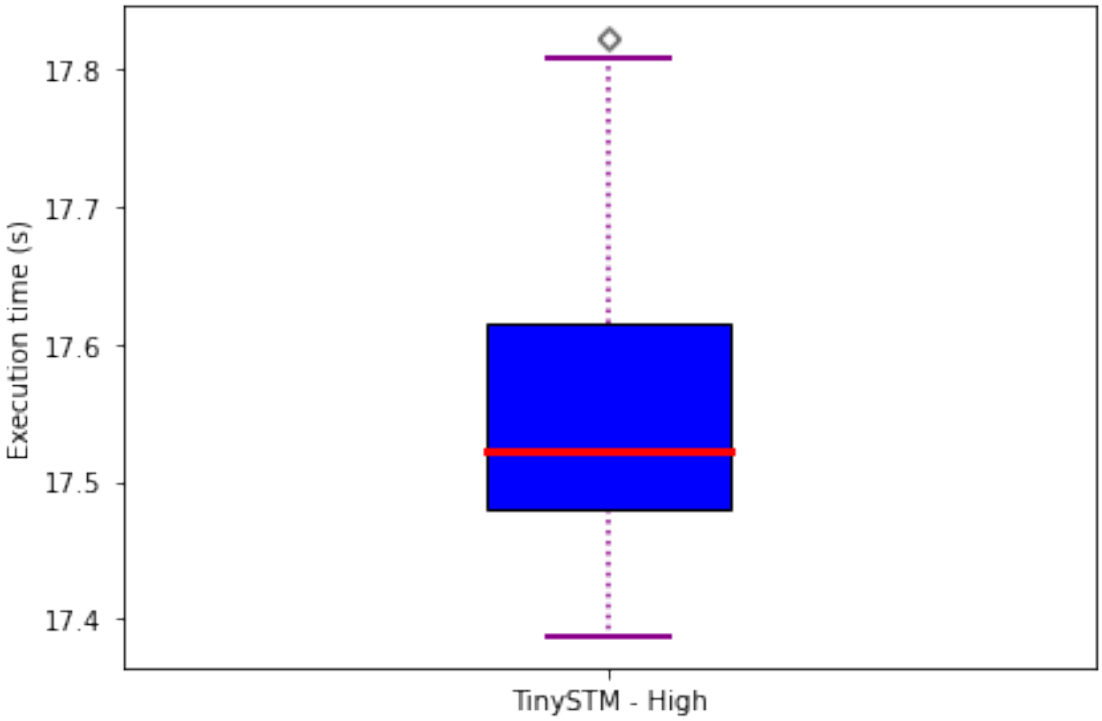
High Contention

[12]:
```
##bench_apply_boxplots("C")
#bench_apply_boxplots("HiContention")
bench_apply_boxplots("High")
```

```
----------  - High ----------
```




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



1.2.4 T-Test and U-Test

Low Contention

[13]:
```
#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")
```

```
                ([Low]) x (TinySTM[Low])
       KS OK?                         No
     T-Test p          4.702264111288e-85
  T-Test stat                328.81079534
T-Test p<=0.05      Not normally distrib.
     U-Test p          6.737635900891e-12
  U-Test stat                900.00000000
U-Test p<=0.05                  U-Test OK
```

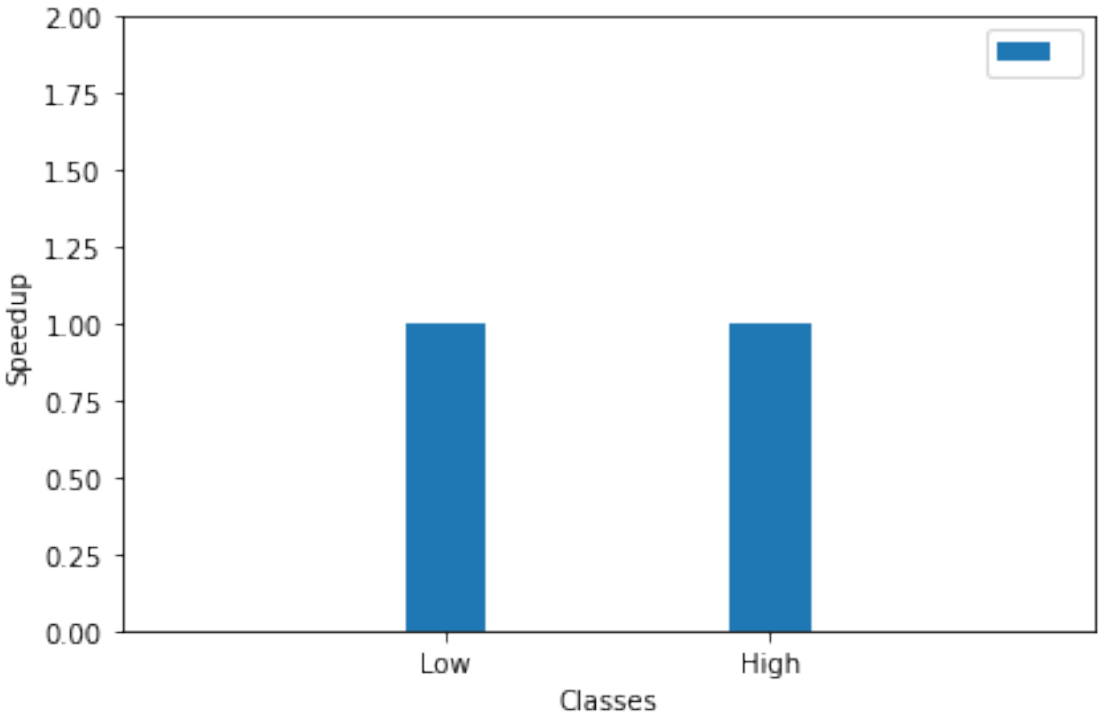
High Contention

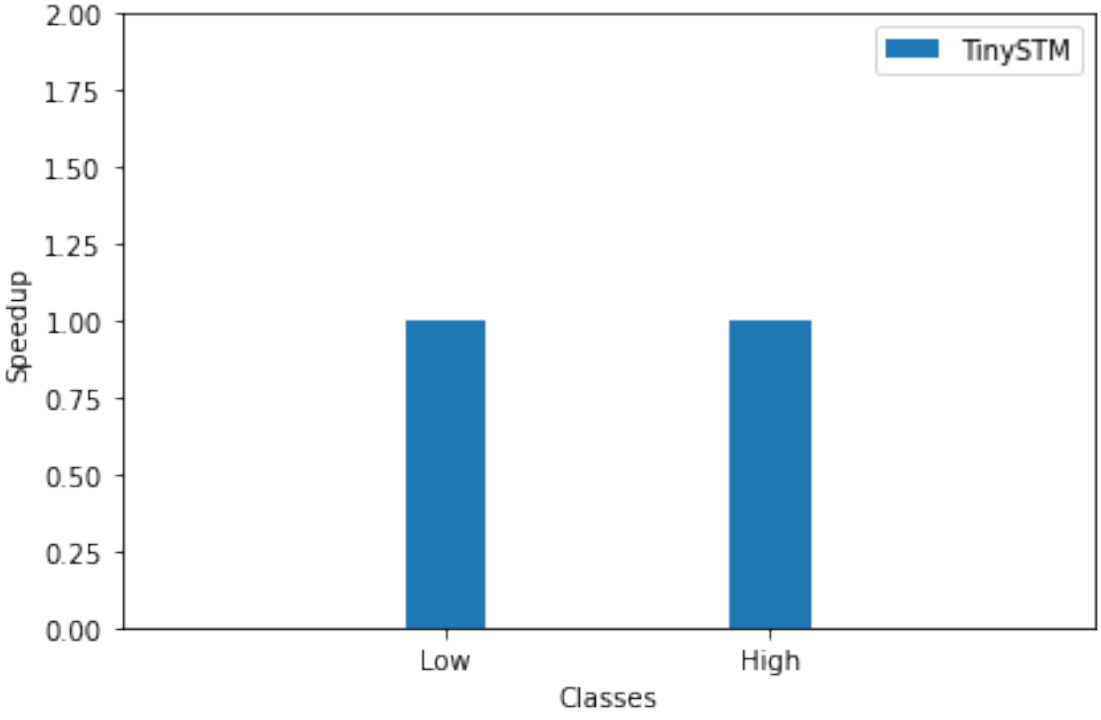
[14]:
```
##bench_report_t_u_tests("C")
#if "HiContention" in CLASSES:
#  bench_report_t_u_tests("HiContention")
if "High" in CLASSES:
  bench_report_t_u_tests("High")
```

```
                ([High]) x (TinySTM[High])
        KS OK?                         Yes
      T-Test p           1.291906743302e-80
   T-Test stat                -340.88587149
T-Test p<=0.05                    T-Test OK
      U-Test p           2.871949066320e-11
   U-Test stat                   0.00000000
U-Test p<=0.05                    U-Test OK
```

1.2.5 Speedup charts

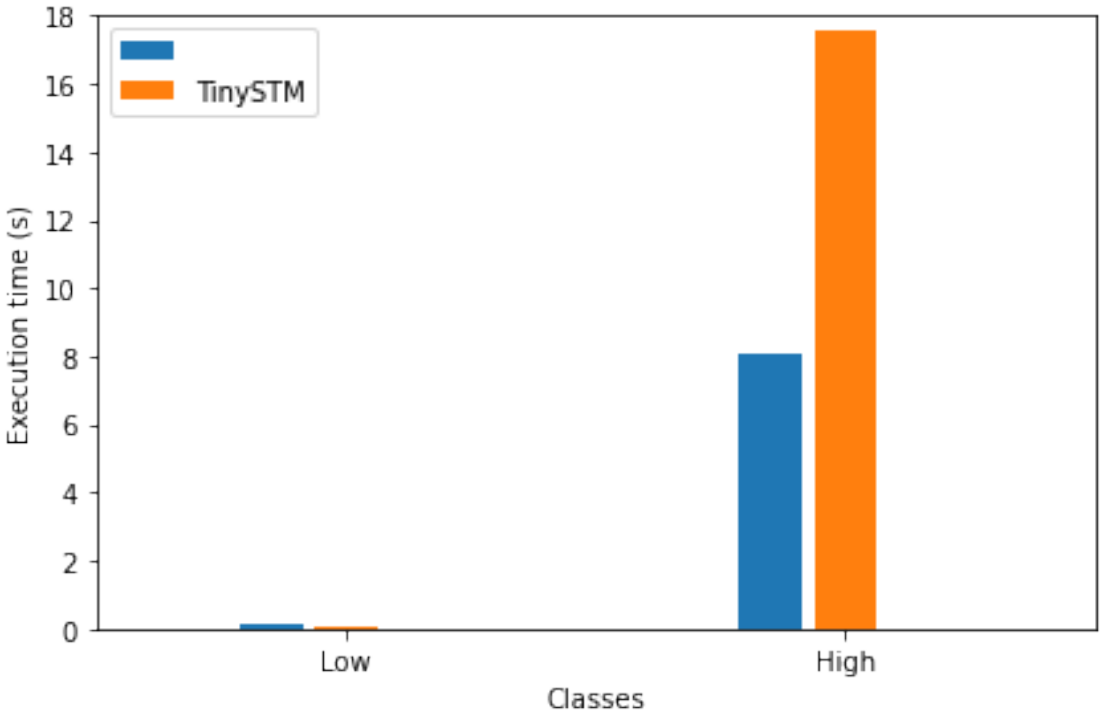
[15]:
```
#O speedup to comparando uma execução com ela mesma, isso preciso mudar

##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]
versions = [VER_RTM_INTEL_R1]

#bench_speedup_chart(VER_PYTHON_SERIAL, versions_gpu)
#bench_speedup_chart(VER_RTM_INTEL, versions)
bench_speedup_chart(VER_RTM_INTEL_R1, 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)
```


2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Speedup
Low
High
Classes


TinySTM
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Speedup
Low
High
Classes

1.2.6 GPU comparison chart

[16]:
```
bench_time_chart()
```



1.3 Main general view

1.3.1 Utils

[17]:
```
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
```

[18]:
```
##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())
```

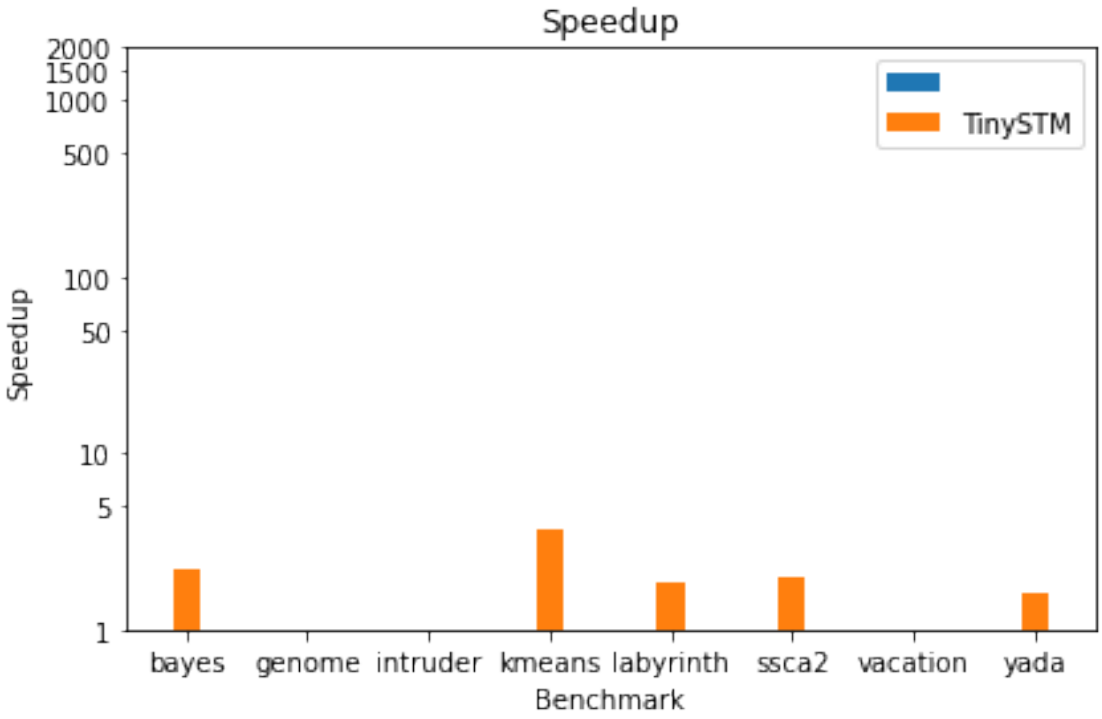
```
        #for b in bars:
        #        ax.bar_label(b, padding=3, fmt='%4.2f')

        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()
```

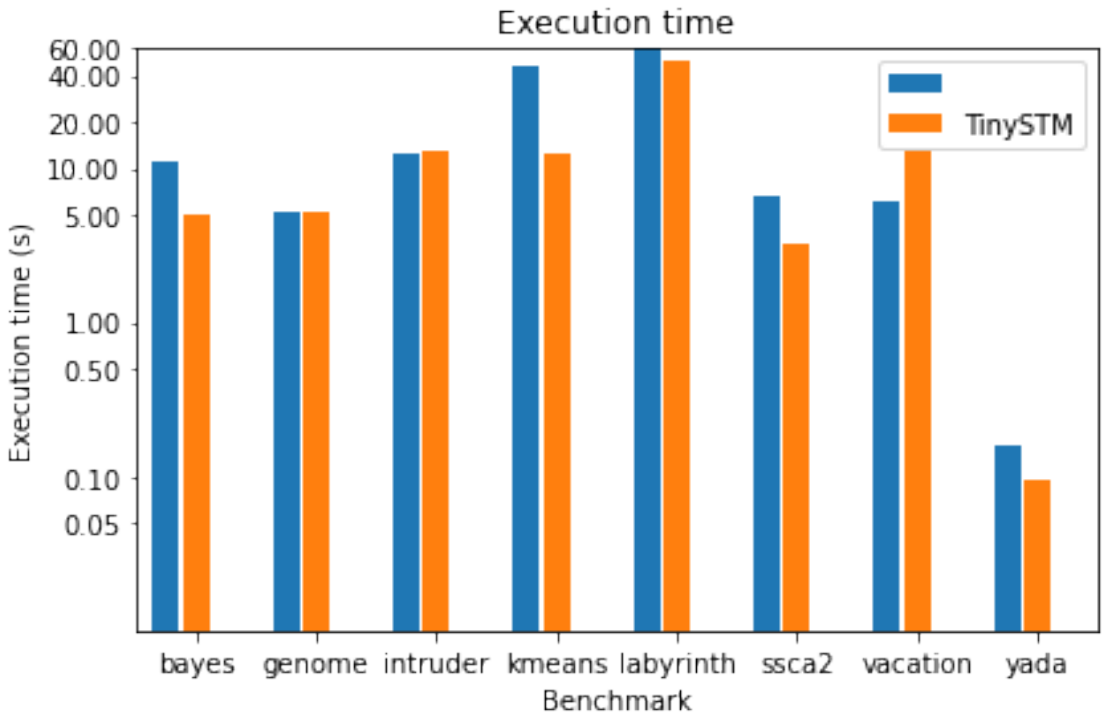
```
        bars = []
        idx = -0.5
        for s in speedups:
                bar = ax.bar(np.array(bench_ids)+idx, np.array(s), width=0.45)
                bars.append(bar)
                idx += 0.5

        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

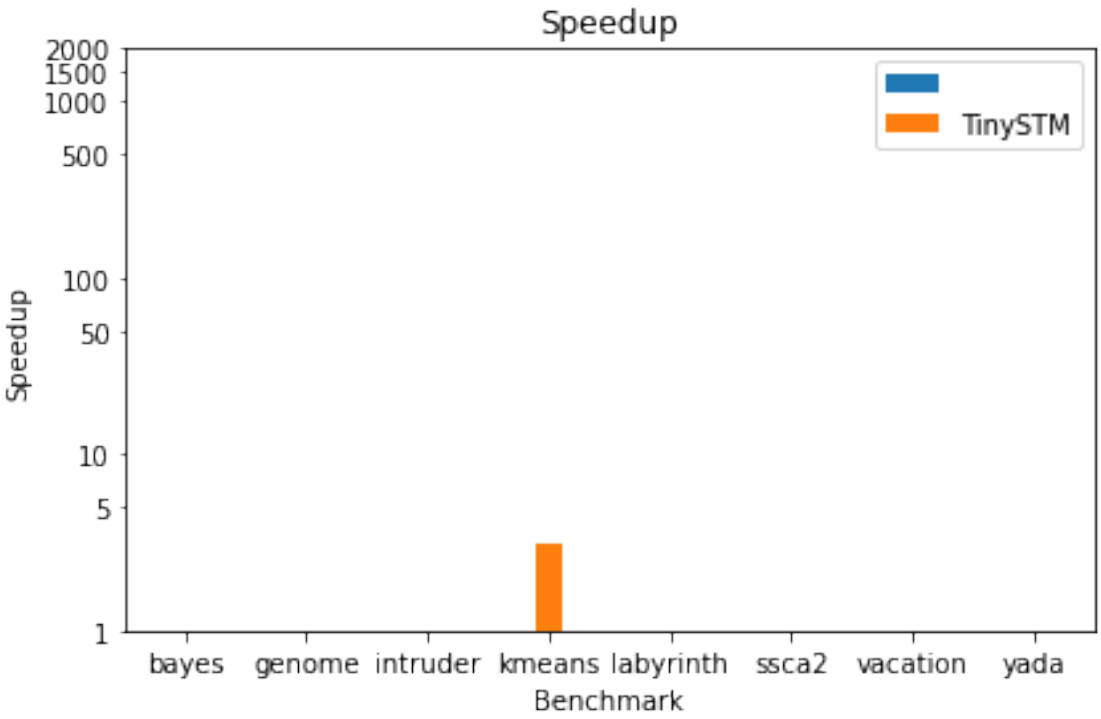
[19]:
```
load_npb_data_dictinary()

#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")
```

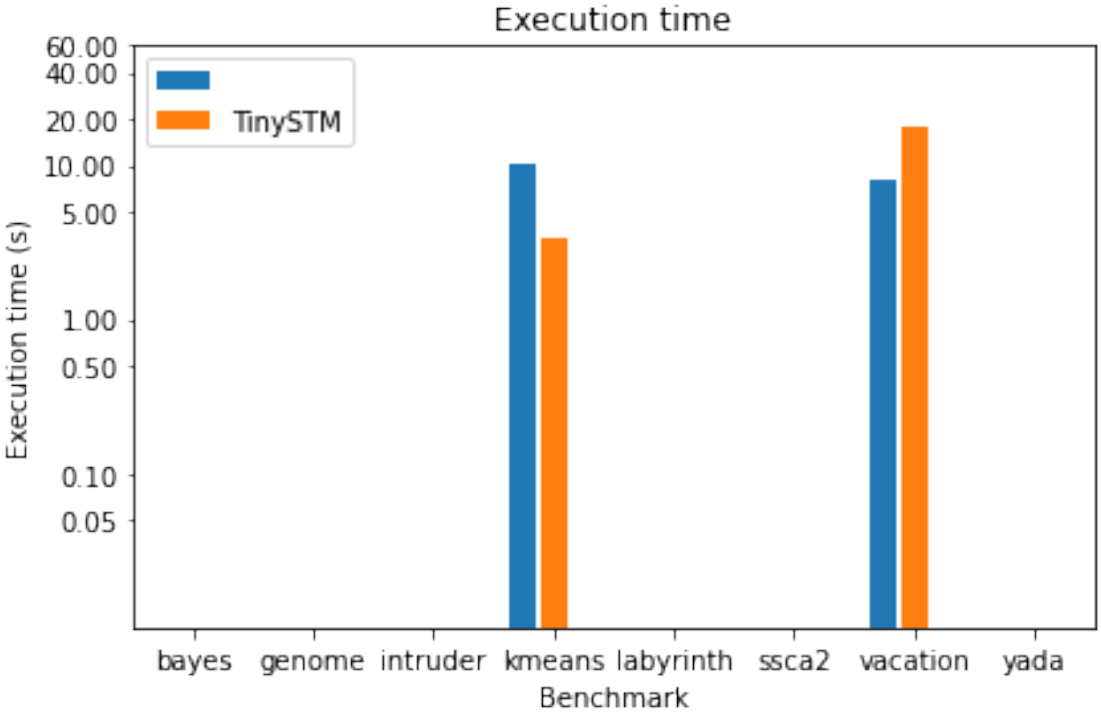
```
Gerando bayes …
bayes OK
Gerando genome …
genome OK
Gerando intruder …
intruder OK
Gerando kmeans …
kmeans OK
Gerando labyrinth …
labyrinth OK
Gerando ssca2 …
ssca2 OK
Gerando vacation …
vacation OK
Gerando yada …
yada OK
```





[20]:
```
##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
TinySTM
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)
TinySTM
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.

Extracting templates from packages: 100%
```