

# 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_R5="RTM-INTEL-r5"
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"]

#"RTM-INTEL-r1", "RTM-INTEL-r50", "RTM-INTEL-r500", "STM-TINY", "STM-SWISS", "SEQ"
#"RTM-INTEL-r5", "SEQ"
#"Low", "High"
#"bayes", "genome", "intruder", "kmeans", "labyrinth", "ssca2", "vacation",
↳"yada"
ignoreVer = ["RTM-INTEL-r1", "RTM-INTEL-r500", "STM-SWISS"]
ignoreClss = []
ignoreBnch = ["bayes", "genome", "kmeans", "labyrinth", "ssca2", "vacation",
↳"yada"]

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(("RTM-INTEL-r5" in file) and not("RTM-INTEL-r5" in ignoreVer)):
    VERSIONS.append(VER_RTM_INTEL_R5)
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 cls in fullClssList:
#    if((cls in file) and not(cls in ignoreClss)):
#        CLASSES.append(cls)
for cls in fullClssList:
    if((cls in file) and not(cls in ignoreClss)):
        CLASSES.append(cls)

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 "r500" in versao:
                return "RTM-500"
            if "r50" in versao:
                return "RTM-50"
            if "r5" in versao:
                return "RTM-5"
            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, interaction, cpus, gpus, times):
    dic[idx] = {}
    dic[idx]["desc"] = desc
    dic[idx]["class"] = classe
    dic[idx]["size"] = size
    dic[idx]["interaction"] = interaction
    dic[idx]["cpus"] = cpus
    dic[idx]["gpus"] = gpus
    dic[idx]["times"] = times

#END

#Statistics
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):  $\mu_a = \mu_b$  (the means of both populations are equal)
# Alternate Hypothesis (Ha):  $\mu_a \neq \mu_b$  (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) and ("vacation" in BENCHS or "kmeans" in
↪ BENCHS):
            #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) and ("vacation" in BENCHS or "kmeans" in BENCHS):
        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) and ("vacation" in BENCHS or "kmeans" in
↪ BENCHS):
            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):
        for v2 in range(v+1, len(VERSIONS)):
            versoes_comp.append([idx_dicionario(VERSIONS[v],
    ↳classe), idx_dicionario(VERSIONS[v2], 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

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

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

Gerando intruder ...  
intruder OK

### 1.2.1 Report DF

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

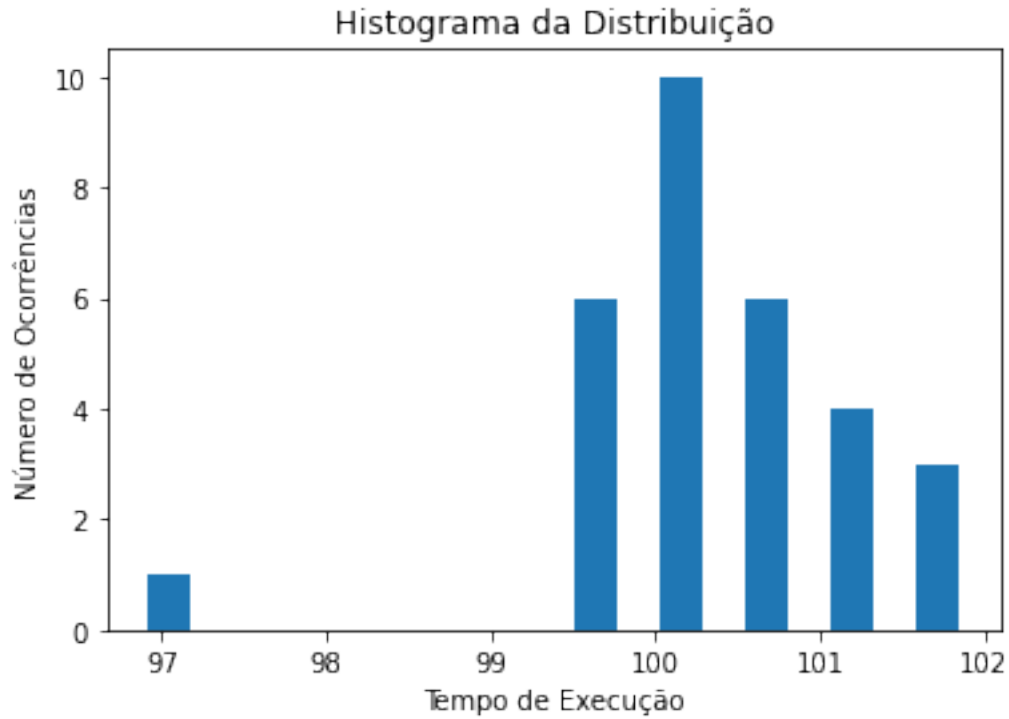
	RTM-5 - LowSequential - Low	
count	30.00000000	30.00000000
mean	100.30751847	100.65902297
std	0.91367308	0.74542343
error (95%)	0.28343668	0.23124282
min	96.78331500	98.89328600
25%	99.86258000	100.27998100
50%	100.20874900	100.67587300
75%	100.79081900	101.13984600
max	101.98005100	102.54140600
KS stat	0.13512150	0.12245777
KS p	0.59655846	0.71383017
KS p>0.05	Sample OK	Sample OK
SW stat	0.86238348	0.97262609
SW p	0.00113912	0.61324048
SW p>0.05	Sample Bad	Sample OK

### 1.2.2 KS Test

## Low Contention

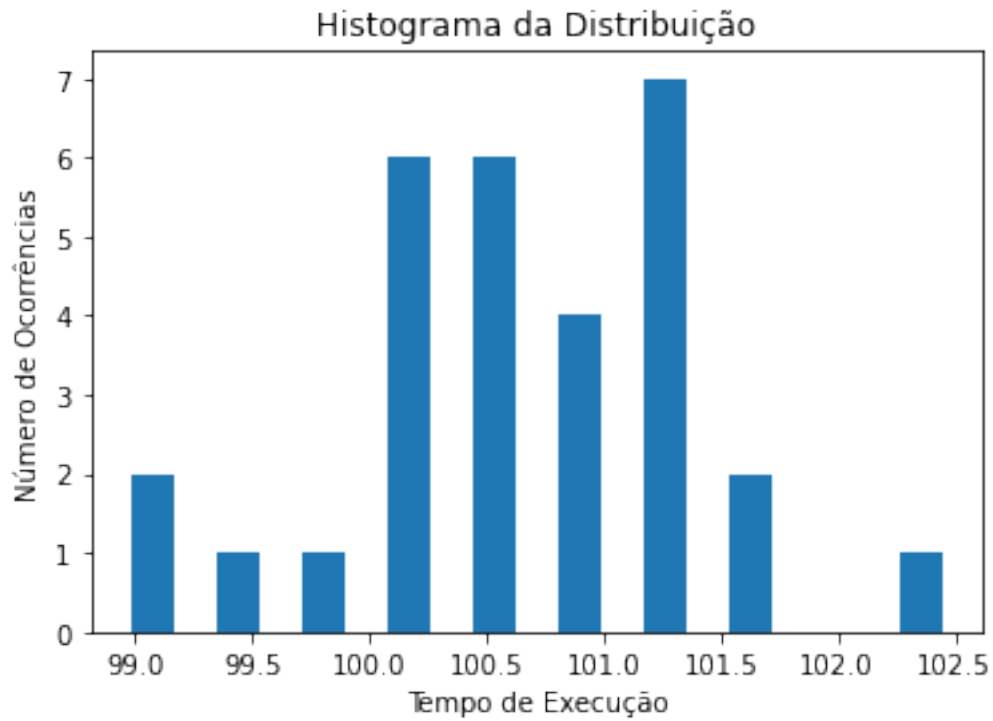
```
[9]: #bench_apply_ks_tests("B")  
#bench_apply_ks_tests("LoContention")  
bench_apply_ks_tests("Low")
```

----- RTM-5 - Low -----



Statistics=0.13512, p=0.59656  
Sample looks Gaussian (fail to reject H0)

----- Sequential - Low -----



Statistics=0.12246, p=0.71383  
 Sample looks Gaussian (fail to reject H0)

### High Contention

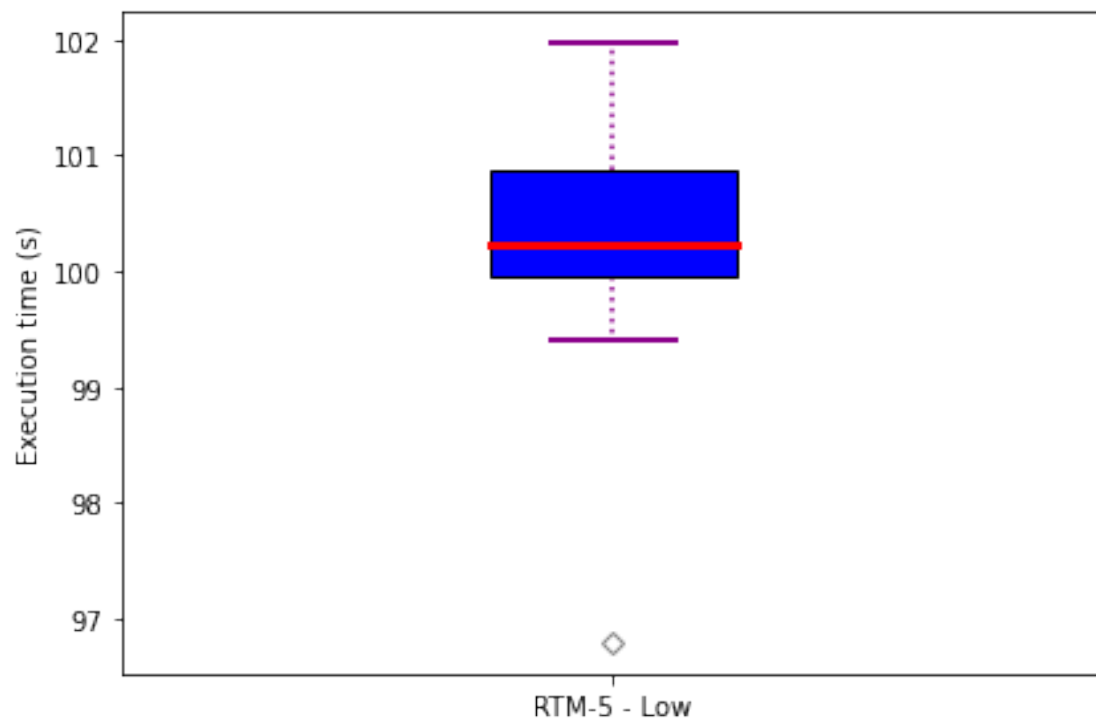
```
[10]: ##bench_apply_ks_tests("C")
      #bench_apply_ks_tests("HiContention")
      bench_apply_ks_tests("High")
```

### 1.2.3 Boxplots

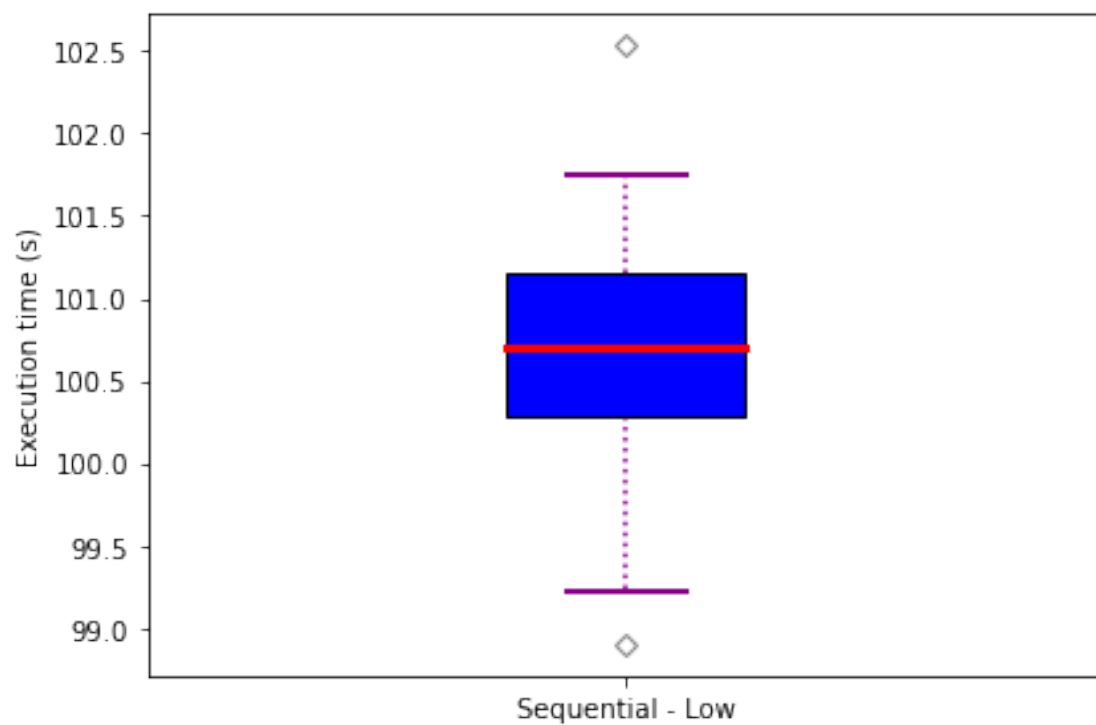
#### Low Contention

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

----- RTM-5 - Low -----



----- Sequential - Low -----



## High Contention

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

	(RTM-5[Low]) x (Sequential[Low])
KS OK?	Yes
T-Test p	1.140816947787e-01
T-Test stat	-1.60528255
T-Test p<=0.05	T-Test Failed
U-Test p	7.362842906529e-02
U-Test stat	329.00000000
U-Test p<=0.05	U-Test Failed

#### High Contention

```
[14]: ##bench_report_t_u_tests("C")
      #if "HiContention" in CLASSES:
      #    bench_report_t_u_tests("HiContention")
      if ("High" in CLASSES) and ("vacation" in BENCHS or "kmeans" in BENCHS):
          bench_report_t_u_tests("High")
```

### 1.2.5 Speedup charts

```
[15]: #0 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]
```

```

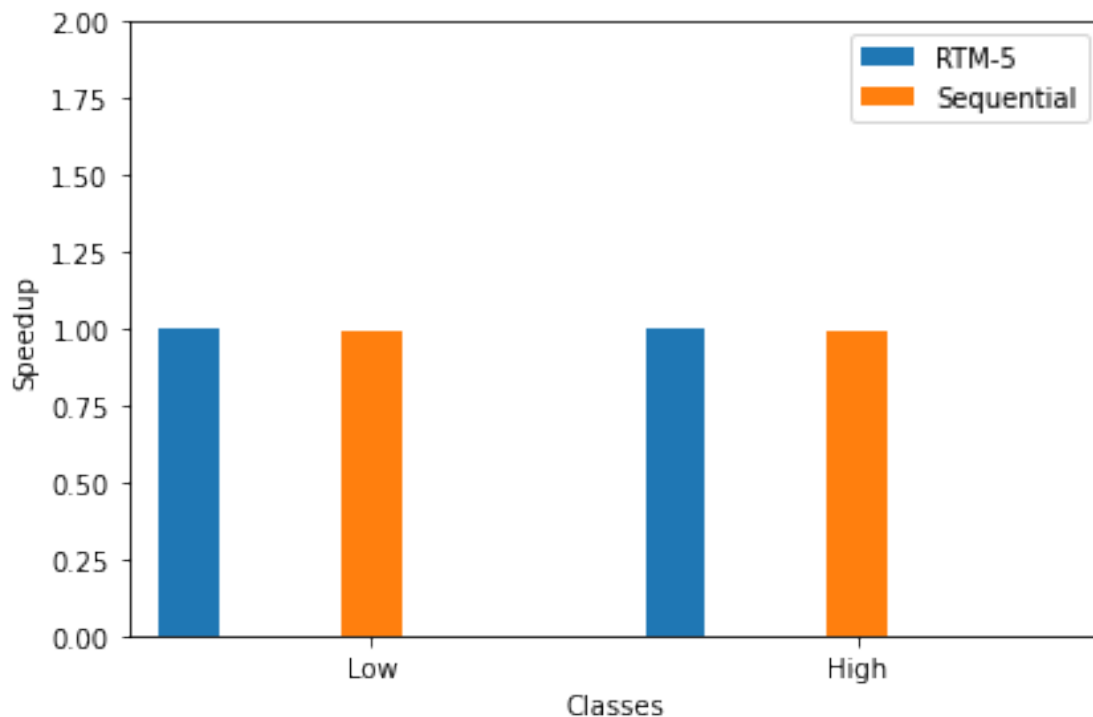
#versions = [VER_RTM_INTEL_R1]
#versions2 = ["VER_RTM_INTEL_R1", "VER_STM_TINY", "VER_STM_SWISS"]

#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]

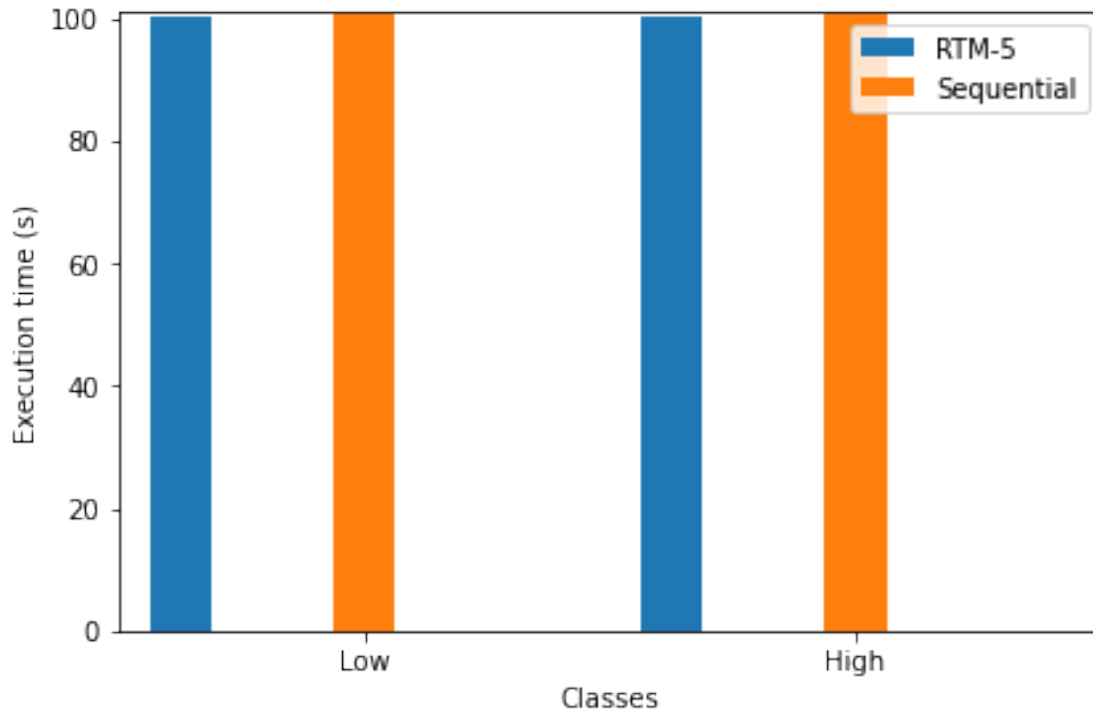
#bench_speedup_chart(VER_CPP_SERIAL, versions_gpu)
#bench_speedup_chart(VER_SEQ, versions)
#bench_speedup_chart(VER_STM_TINY, versions)

```



### 1.2.6 GPU comparison chart

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



## 1.3 Main general view

### 1.3.1 Utils

```
[17]: def load_npb_data_dictionary():  
    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(VERSIONS[0], 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

```

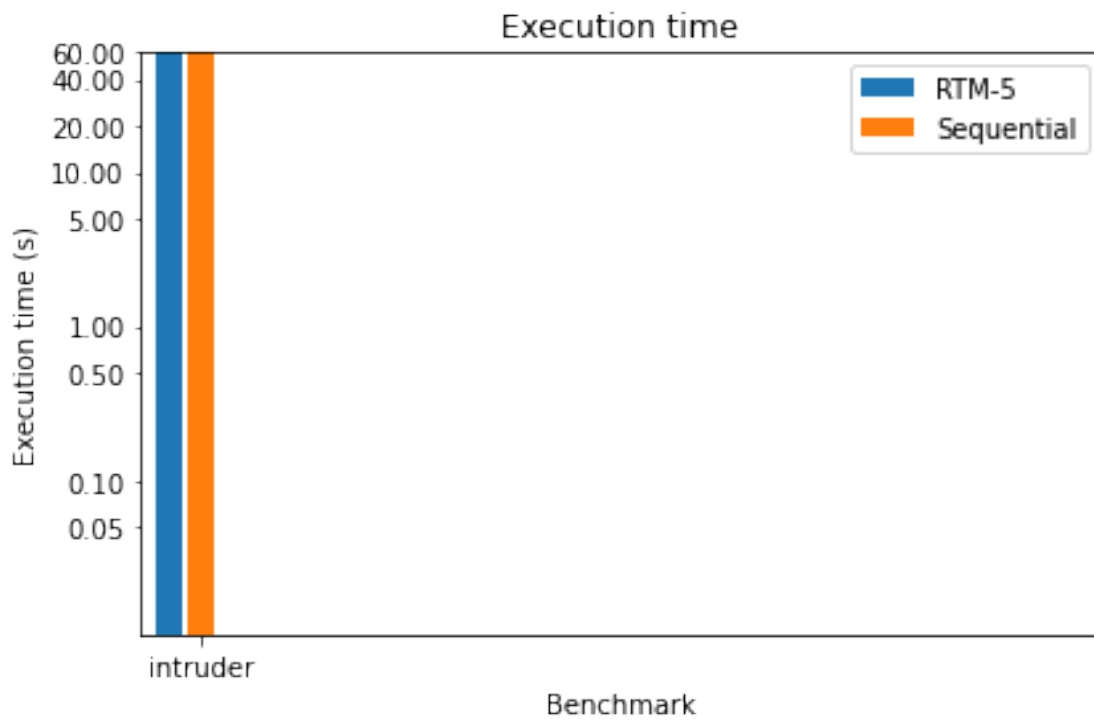
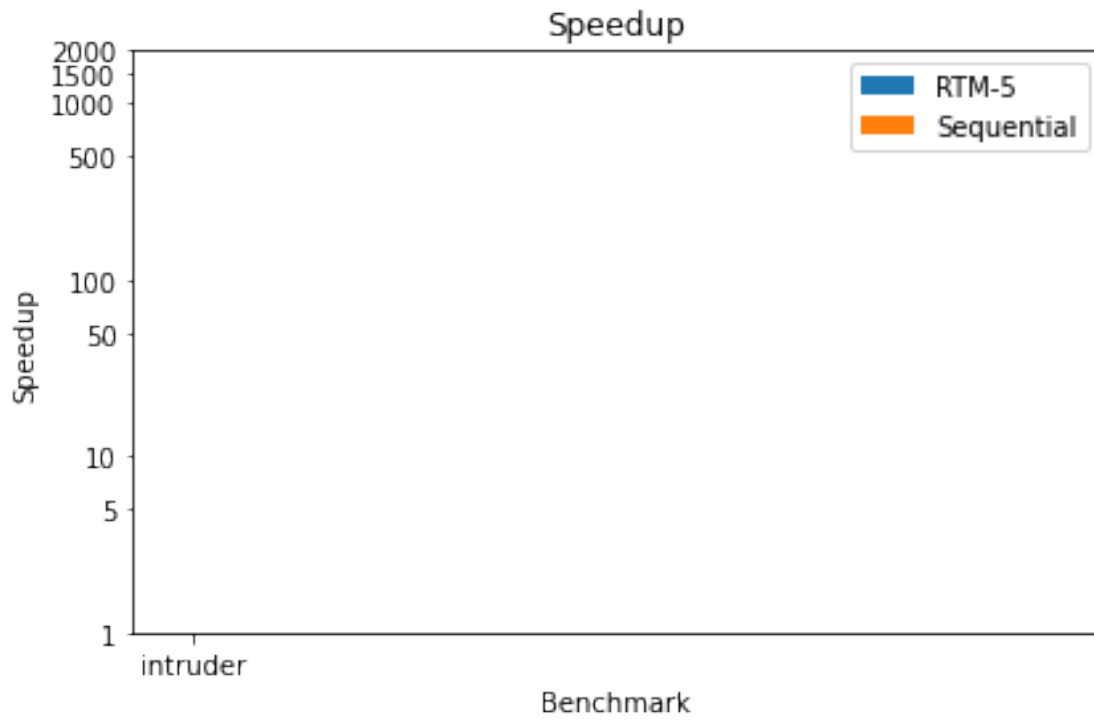
[19]: load_npb_data_dictionary()

#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")

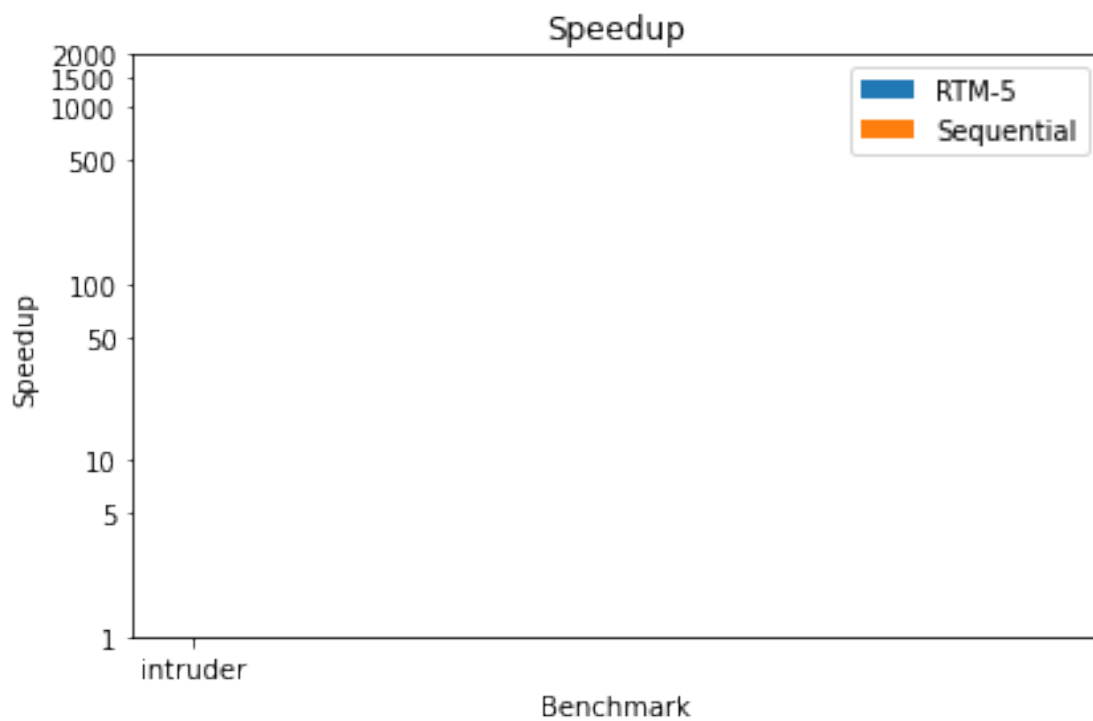
```

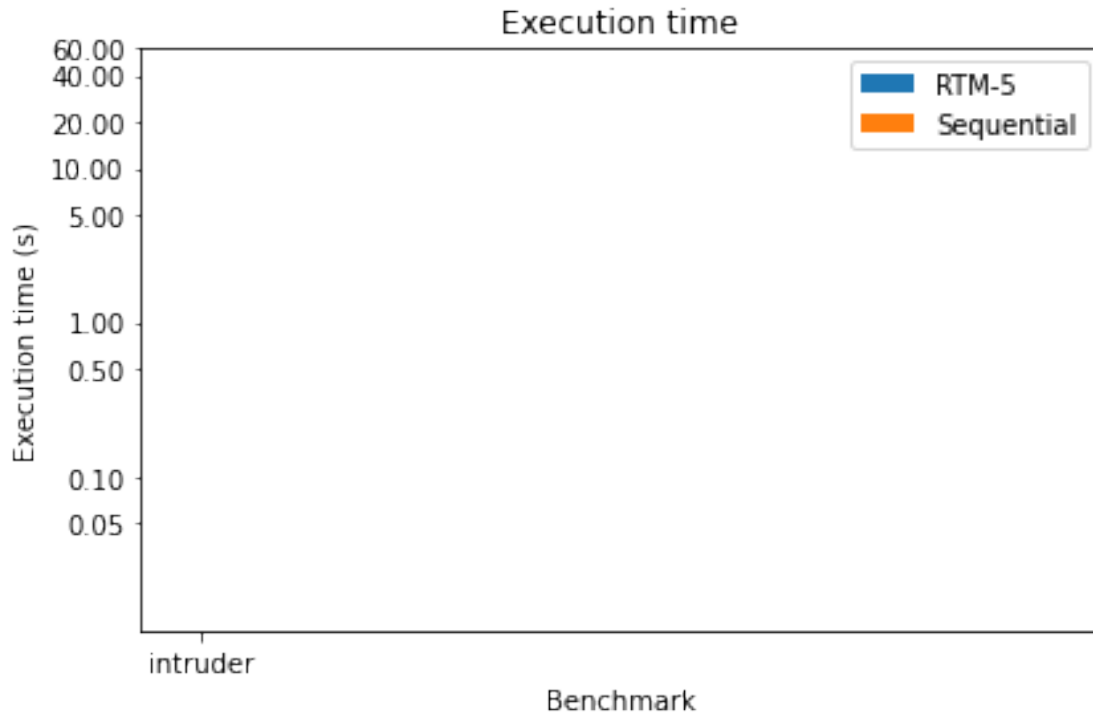
Gerando intruder ...  
intruder OK



```
[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")
```





```
[ ]: 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 - Frederico3_files/
[NbConvertApp] Making directory ./NPB_statistics - Frederico3_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico3_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico3_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico3_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico3_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico3_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico3_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico3_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico3_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico3_files
[NbConvertApp] Writing 127893 bytes to ./notebook.tex
[NbConvertApp] Building PDF
[NbConvertApp] Running xelatex 3 times: ['xelatex', './notebook.tex', '-quiet']

```