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", "intruder", "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 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 "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, 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) 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 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)
```

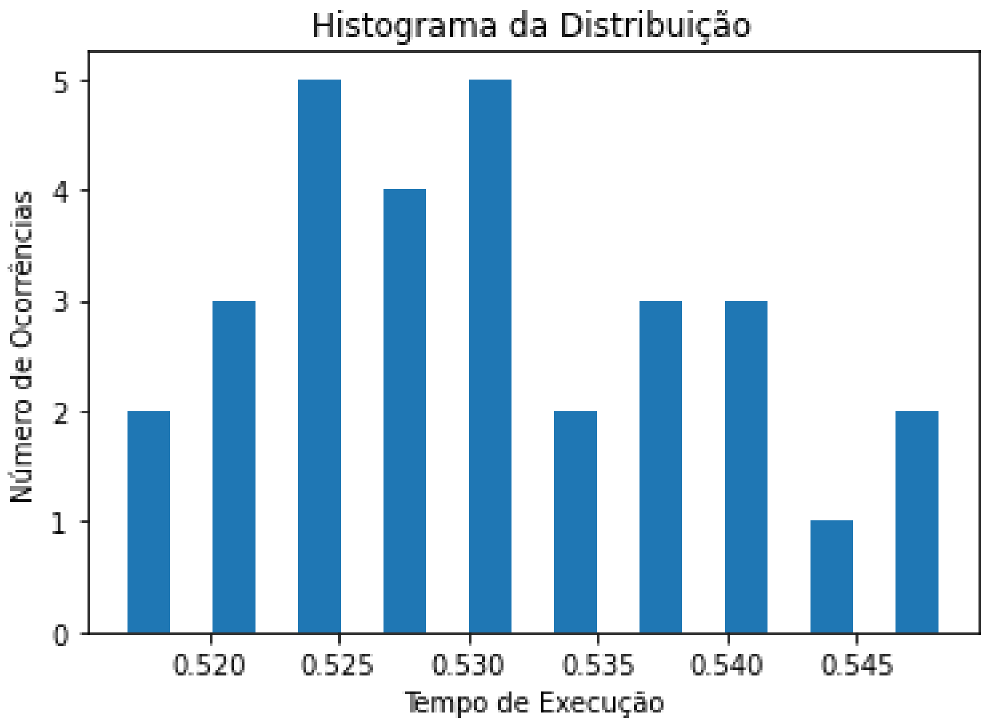
```
                RTM-5 - LowSequential - Low   RTM-5 - HighSequential - High
       count    30.00000000     30.00000000   30.00000000     30.00000000
        mean     0.53096667      0.53610000   56.59813103     56.51356410
         std     0.00851463      0.01454957    0.14572012      0.15757172
 error (95%)     0.00264138      0.00451352    0.04520482      0.04888138
         min     0.51600000      0.51600000   56.28825400     56.19578000
         25%     0.52400000     0.52300000    56.51786000    56.40603700
         50%     0.53100000     0.52700000    56.58098400    56.51611000
         75%     0.53600000     0.54700000    56.64980100    56.59235400
         max     0.54900000     0.56900000    56.97457300    56.85947600
     KS stat     0.14601058     0.24447309     0.11010598     0.07909818
        KS p     0.49886887     0.04595686     0.82179332     0.98435875
   KS p>0.05      Sample OK     Sample Bad      Sample OK      Sample OK
     SW stat     0.96506667     0.89004040     0.97652072     0.98104280
        SW p     0.41432220     0.00483474     0.72744626     0.85255736
   SW p>0.05      Sample OK     Sample Bad      Sample OK      Sample OK
```

1.2.2 KS Test

Low Contention

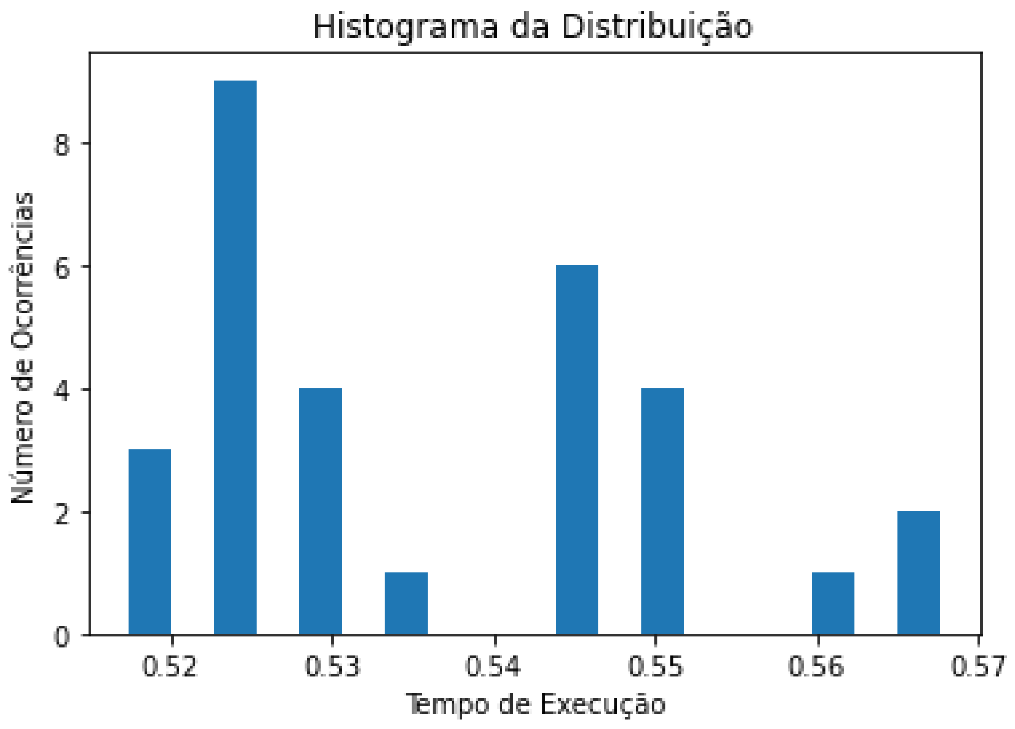
```
[9]: #bench_apply_ks_tests("B")
     #bench_apply_ks_tests("LoContention")
     bench_apply_ks_tests("Low")
```

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



```
Statistics=0.14601, p=0.49887
Sample looks Gaussian (fail to reject H0)

---------- Sequential - Low ----------
```

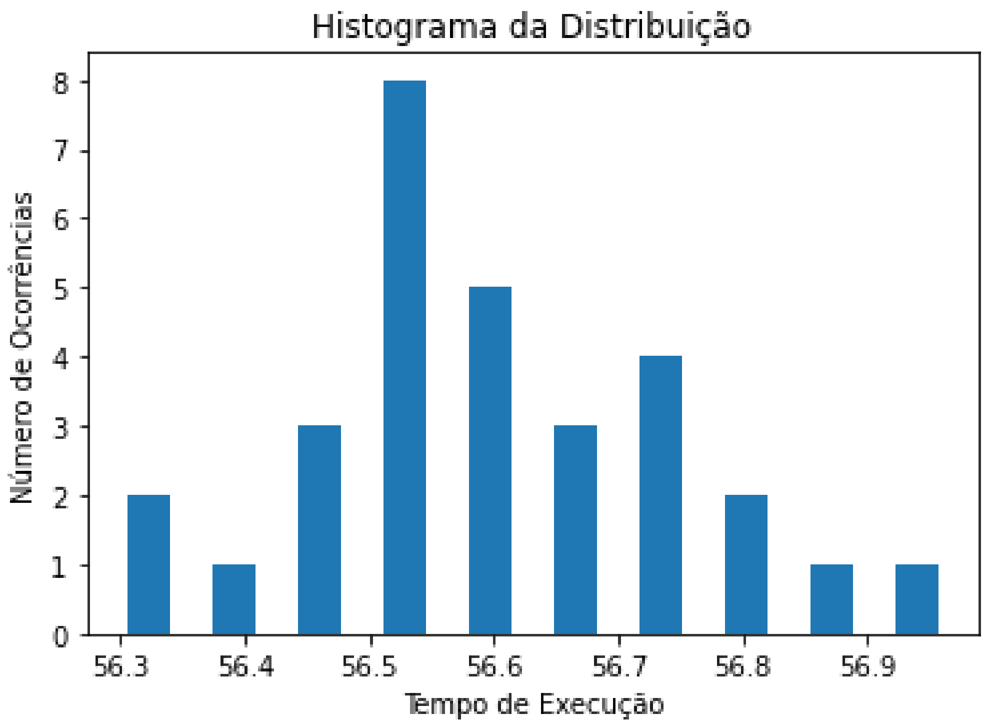


```
Statistics=0.24447, p=0.04596
Sample does not look Gaussian (reject H0)
```

High Contention

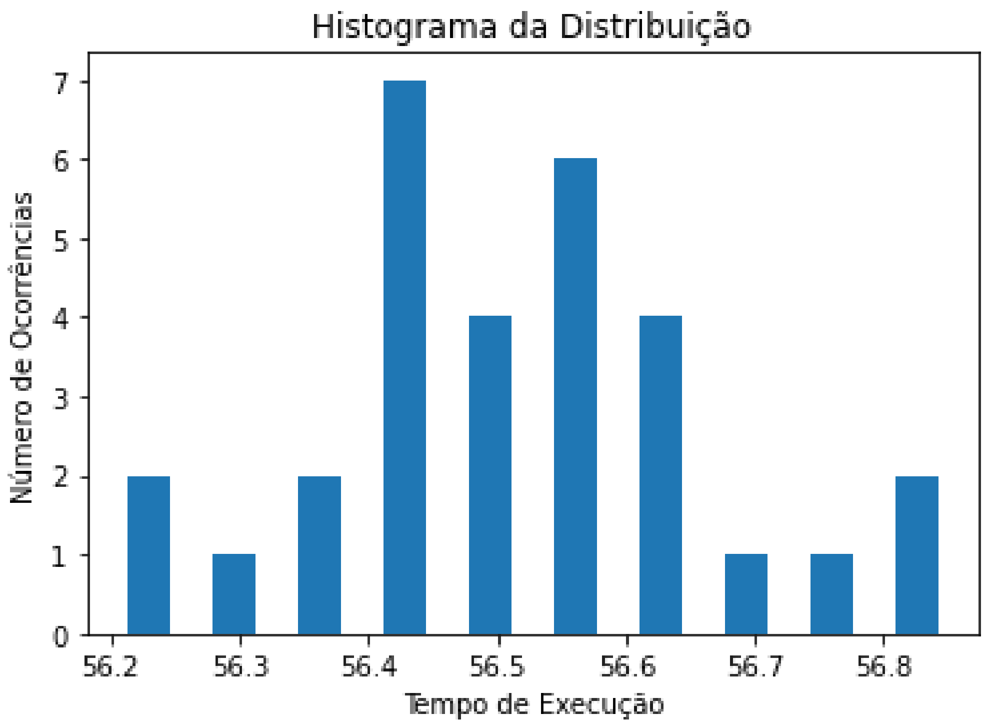
[10]:
```
##bench_apply_ks_tests("C")
#bench_apply_ks_tests("HiContention")
bench_apply_ks_tests("High")
```

```
---------- RTM-5 - High ----------
```



```
Statistics=0.11011, p=0.82179
Sample looks Gaussian (fail to reject H0)

---------- Sequential - High ----------
```



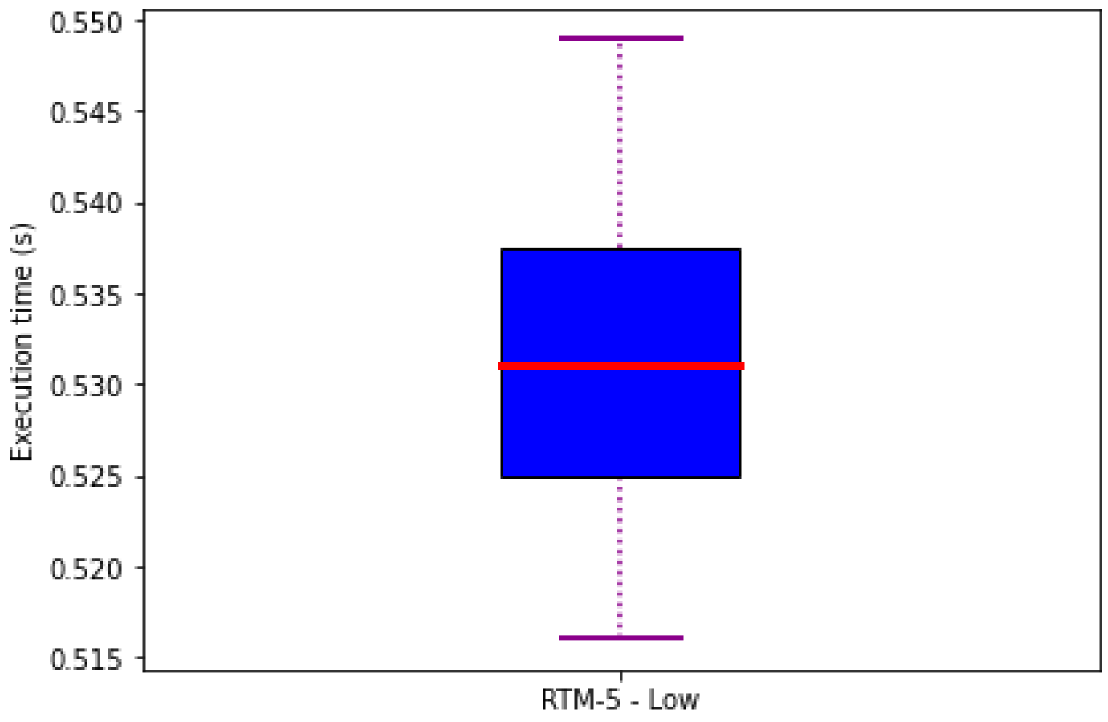
```
Statistics=0.07910, p=0.98436
Sample looks Gaussian (fail to reject H0)
```

1.2.3 Boxplots

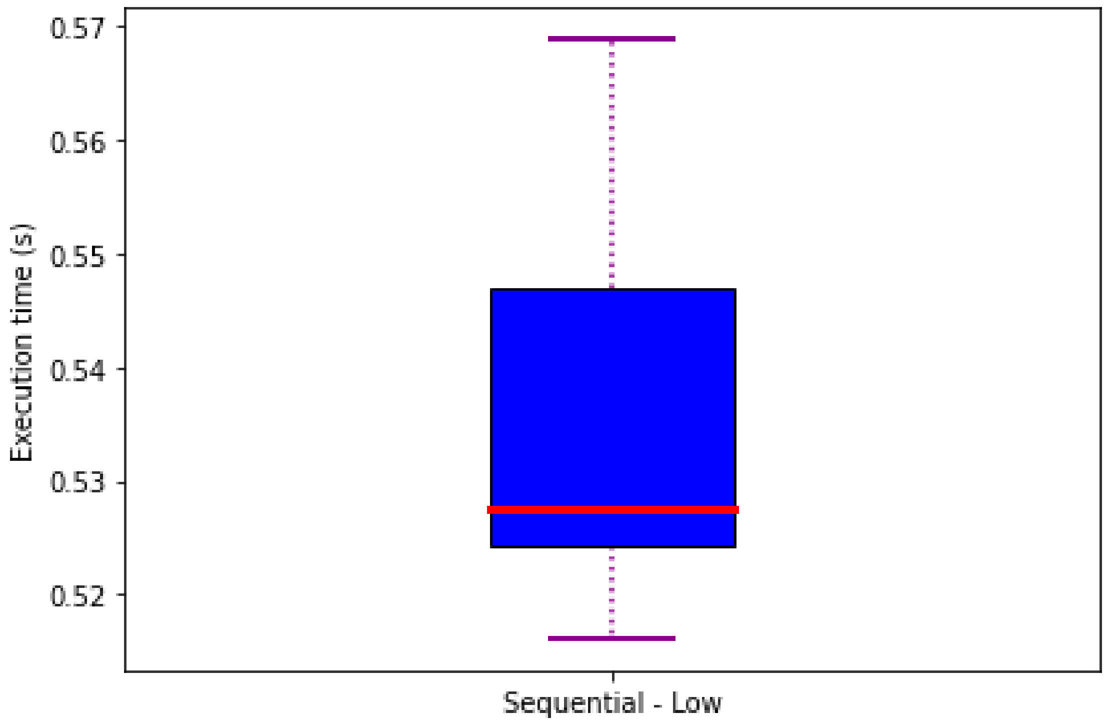
Low Contention

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

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



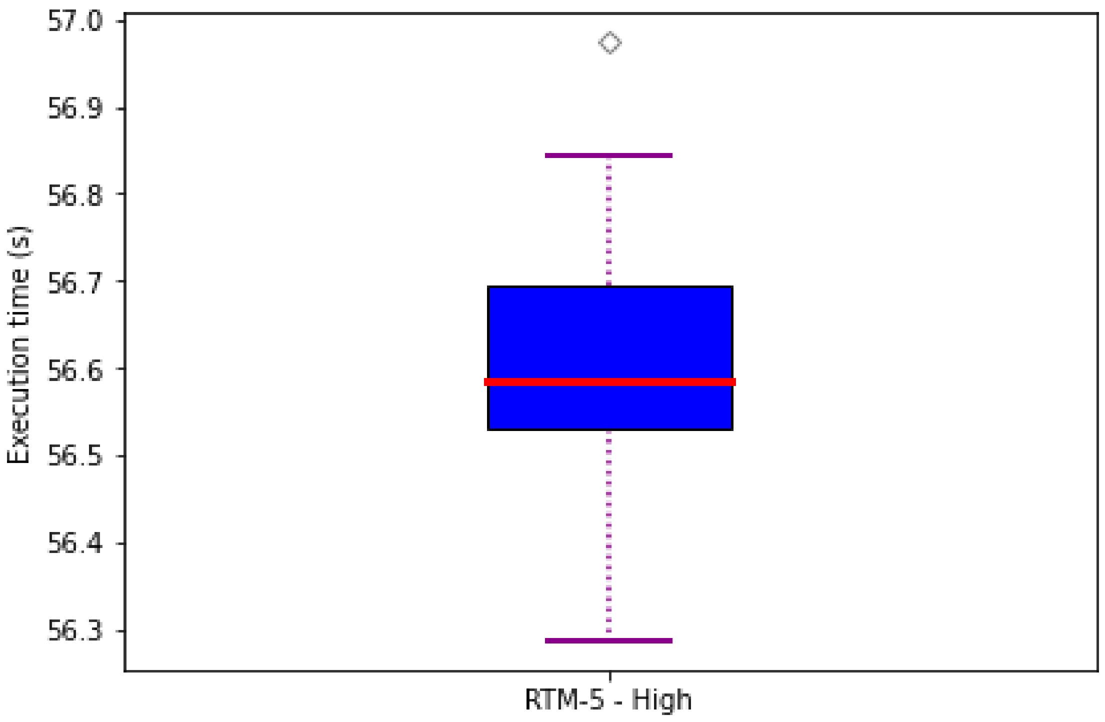
```
---------- Sequential - Low ----------
```



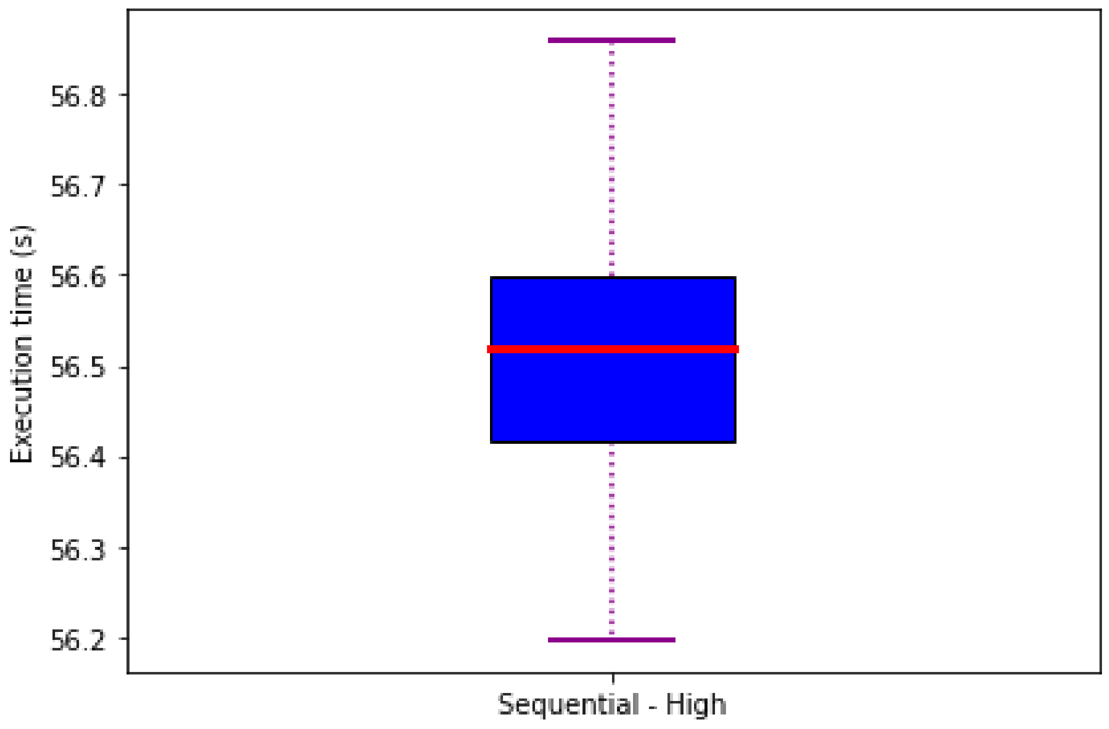
High Contention

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

```
---------- RTM-5 - High ----------
```



```
---------- Sequential - 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?                                 No
    T-Test p         1.077522592954e-01
 T-Test stat                -1.63981524
T-Test p<=0.05      Not normally distrib.
    U-Test p         2.966602101928e-01
 U-Test stat               379.50000000
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")
```

```
              (RTM-5[High]) x (Sequential[High])
        KS OK?                                Yes
      T-Test p           3.815633616626e-02
   T-Test stat                     2.12188836
T-Test p<=0.05                      T-Test OK
      U-Test p           4.757860204720e-02
   U-Test stat                   584.00000000
U-Test p<=0.05                      U-Test OK
```

1.2.5 Speedup charts

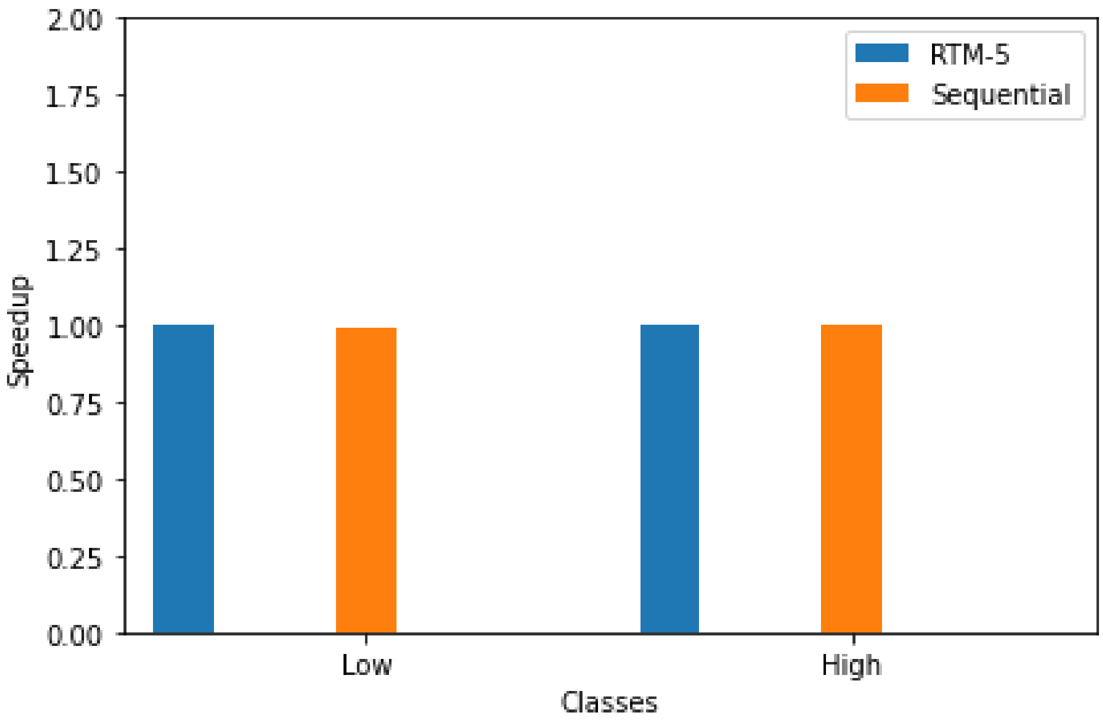
```
[15]: #O speedup to comparando uma execução com ela mesma, isso preciso mudar

      ##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_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)

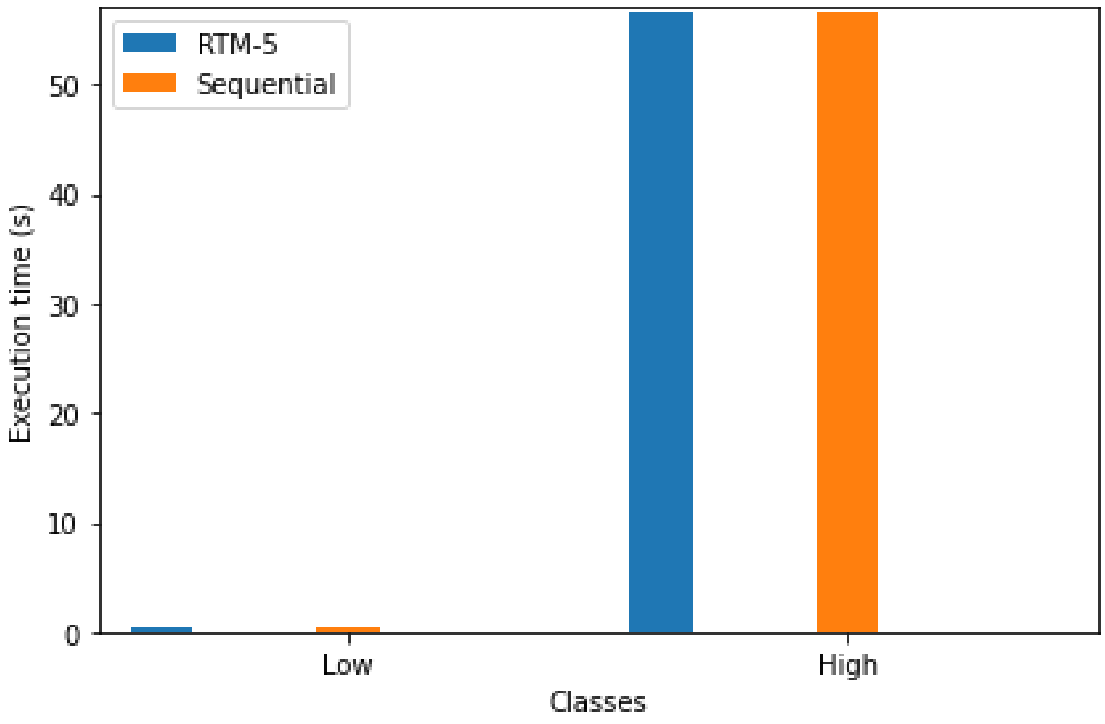

      #print("\n\n", '----------', "C++", '----------')
      #if g_bench == "IS":
      #    versions_gpu = [VER_CUDA]
      #else:
      #    versions_gpu = [VER_CUDA, VER_OPENACC]
      #versions = [VER_SEQ]
      #versions = [VER_STM_TINY]

      #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_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(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

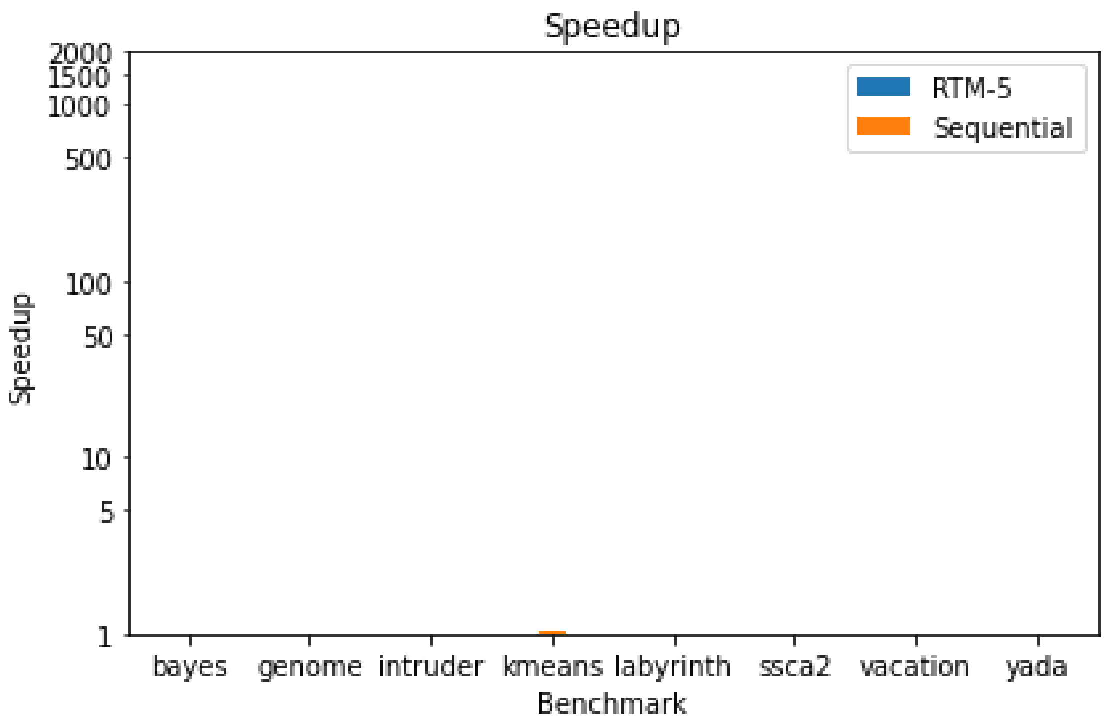
[19]:
```
load_npb_data_dictinary()

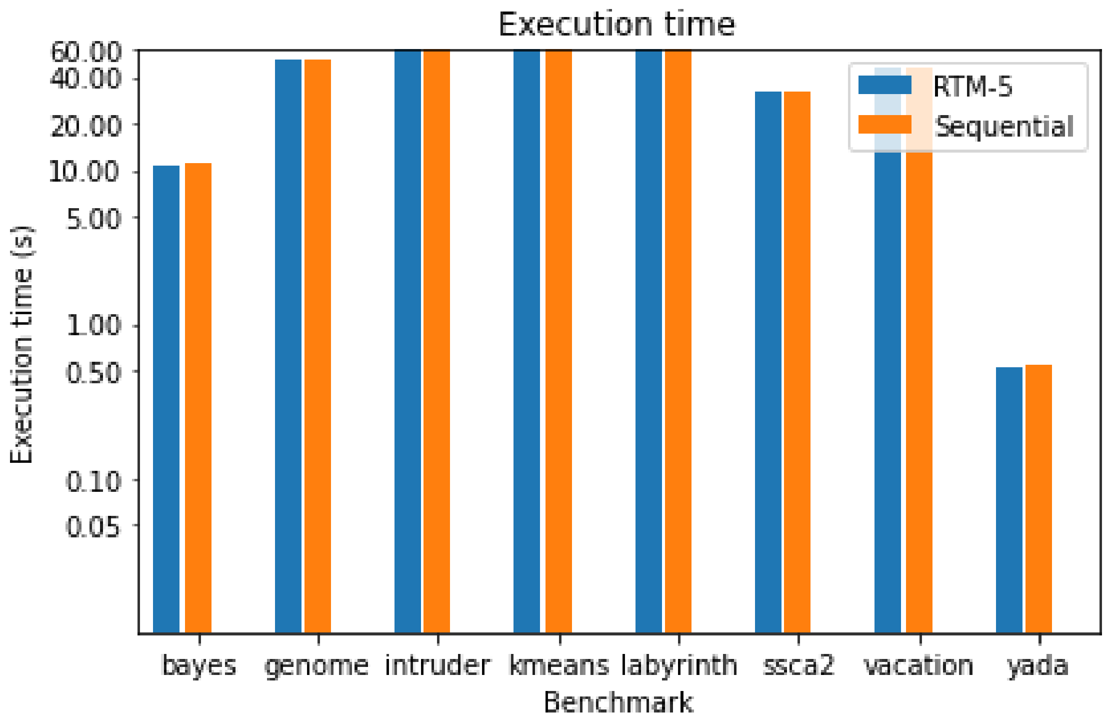
#print('\n', '----------', "Class B", '----------')
#npb_speedup_chart("B")
#npb_speedup_chart("LoContention")
npb_speedup_chart("Low")

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

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

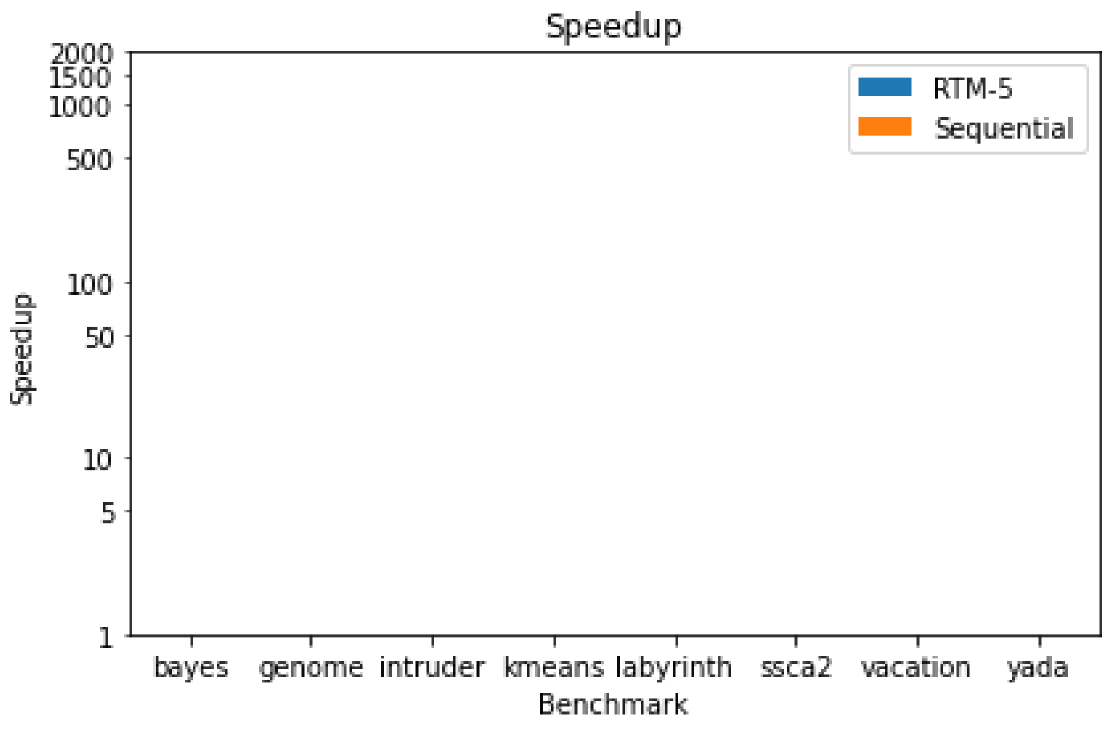
```
genome OK
Gerando intruder …
intruder OK
Gerando kmeans …
kmeans OK
Gerando labyrinth …
labyrinth OK
Gerando ssca2 …
ssca2 OK
Gerando vacation …
vacation OK
Gerando yada …
yada OK
```

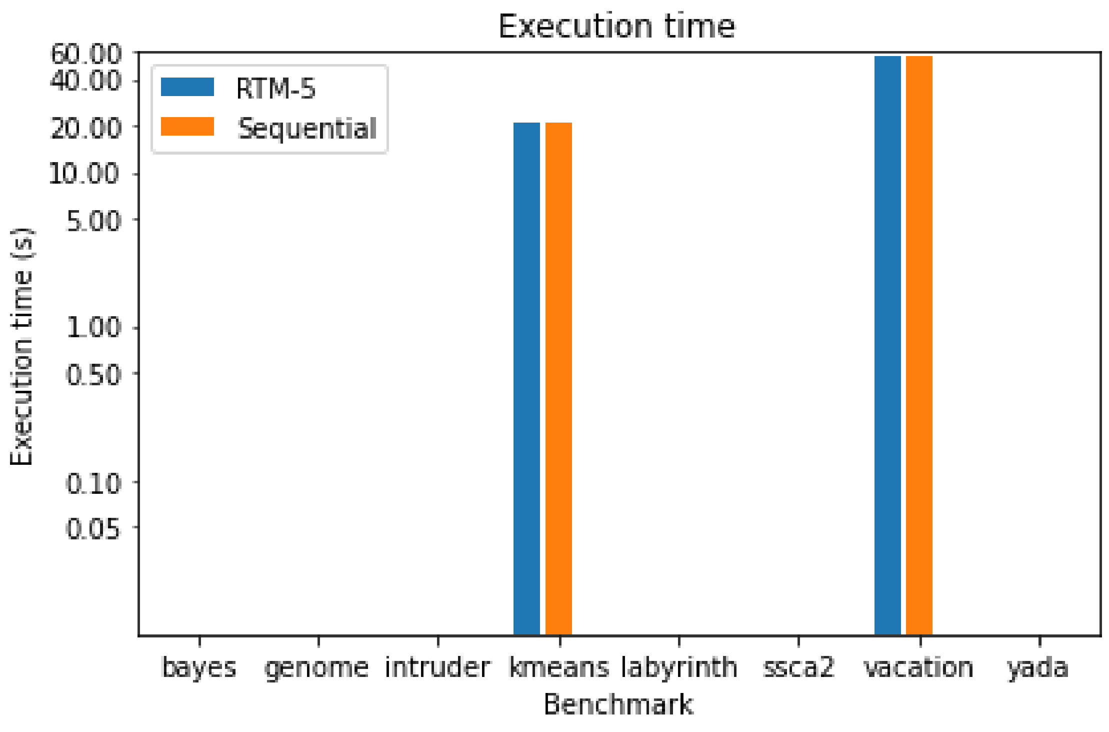




[20]:
```
##print('\n', '----------', "Class C", '----------')
##npb_speedup_chart("C")
#if "HiContention" in CLASSES:
#  npb_speedup_chart("HiContention")
if "High" in CLASSES:
  npb_speedup_chart("High")

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


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


Execution time
RTM-5
Sequential
60.00
40.00
20.00
10.00
5.00
1.00
0.50
0.10
0.05
Execution time (s)
bayes
genome
intruder
kmeans
labyrinth
ssca2
vacation
yada
Benchmark

```
[21]: 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%
[NbConvertApp] Converting notebook /content/drive/MyDrive/Colab
```

```
Notebooks/NPB_statistics - Frederico.ipynb to pdf
[NbConvertApp] Support files will be in NPB_statistics - Frederico0_files/
[NbConvertApp] Making directory ./NPB_statistics - Frederico0_files
[NbConvertApp] Making directory ./NPB_statistics - Frederico0_files
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[NbConvertApp] Writing 128830 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 211904 bytes to /content/drive/My Drive/Colab
Notebooks/Arquivos/NPB_statistics - Frederico0.pdf
File Download Unsuccessful. Saved in Google Drive
File ready to be Downloaded and Saved to Drive
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