# Lab Course: distributed data analytics
# Exercise Sheet 4

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Submission deadline: Friday 23:59PM (on LearnWeb, course code: 3117)

## Instructions

Please following these instructions for solving and submitting the exercise sheet.

1. You should submit a zip or a tar file containing two things a) python scripts and b) a pdf document.
2. In the pdf document you will explain your approach (i.e. how you solved a given problem), and present your results in form of graphs and tables.
3. The submission should be made before the deadline, only through learnweb.
4. If you are M.Sc. Data Analytics summer 2017 intake student, you should submit to "First term students" link on LearnWeb.
5. And if you are M.Sc. Data Analytics winter 2016 intake student, you should submit to "Second term students" link on LearnWeb.
6. If you are not M.Sc. Data Analytics student, you can submit to anyone of the links above.

## Exercise 1: Calculating Pi using collective communication (10 Points)

In this exercise, you are going to calculate a very famous number, $\pi$, using a combination of several collective communication methods. As you might know, the number $\pi$ is a mathematical constant, the ratio of a circle's circumference to its diameter, commonly approximated as 3.14159 [1]. Since $\pi$ is an irrational number, it goes on forever. This means that any computation of $\pi$ is just an approximation. If you compute 1000 digits, I can compute 1001 digits and be more accurate. Some people have set aside super computers to try to compute the most accurate $\pi$ to date. An interesting experiment of calculating 12.1 trillion digits of $\pi$ can be found in [2]. A text file contains 1 billion digits of $\pi$ can be downloaded in [3].

There are a lot of different methods to calculate or to approximate $n$ digits of $\pi$: Bailey–Borwein–Plouffe [4], Bellard [5], Chudnovsky algorithm [6]. A tutorial on how to calculate $\pi$ can be found in [7].

In this exercise, you are going to calculate 1001 digits of $\pi$, including the digit 3 and one thousand digits after decimal point, by applying Bailey–Borwein–Plouffe formula

$$\pi = \sum_{i=0}^{\infty} \big[\frac{1}{16^i}\big(\frac{4}{8i+1} - \frac{2}{8i+4} - \frac{1}{8i+5} - \frac{1}{8i+6}\big)\big], \tag{1}$$

and collective communication methods. The value of $\infty$ can be set as $\{10^3, 10^4, 10^5\}$ in the experience.

## Exercise 2: Matrix - matrix multiplication using collective communication (10 Points)

The task of matrix - matrix multiplication is already discussed in previous tutorials and assignments which you apply the idea of multi-threading and multi-processing to solve it. In this exercise, you are going to use collective communication to solve this familiar task. The size of matrix can be set in range $[10^2, 10^3]$. You should report the time of calculation in case of using only one rank and in case of using multiple ranks.

# Annex

1. Pi https://en.wikipedia.org/wiki/Pi
2. 12.1 Trillion Digits of Pi http://www.numberworld.org/misc_runs/pi-12t/
3. One billion digits of pi https://stuff.mit.edu/afs/sipb/contrib/pi/
4. Bailey–Borwein–Plouffe formula https://en.wikipedia.org/wiki/Bailey%E2%80%93Borwein%E2%80%93Plouffe_formula
5. Bellard formula https://en.wikipedia.org/wiki/Bellard%27s_formula
6. Chudnovsky algorithm https://en.wikipedia.org/wiki/Chudnovsky_algorithm
7. Calculate Pi with Python http://blog.recursiveprocess.com/2013/03/14/calculate-pi-with-python/