Operating Systems
Constructor University
Dr. Jürgen Schönwälder

Module: CO-562
Date: 2024-09-20
Due: 2024-09-27

Problem Sheet #3

Problem 3.1: *perfect digital invariant numbers (multi-threading)* (4+4+2 = 10 points)

A *perfect digital invariant number* is a positive integer that is equal to the sum of its digits raised to some power p. For example, the number $153 = 1^3 + 5^3 + 3^3$ is a perfect digital invariant number as is $4210818 = 4^7 + 2^7 + 1^7 + 0^7 + 8^7 + 1^7 + 8^7$. The sequence of all perfect digital invariant numbers is known as the OEIS number sequence A023052.

Write a C program called `pdi-numbers` that finds perfect digital invariant numbers in a range for numbers. The default number range is $[1, 10000]$. The program accepts the `-s` option to set the lower bound and the `-e` option to set the upper bound. Hence, the invocation `perfect -s 100 -e 1000` will search for perfect numbers in the range $[100, 1000]$.

a) Write a program that searches for perfect digital invariant numbers in a range of numbers. Your program must support the `-s` and `-e` options to define non-default search intervals.

```
./pdi-numbers -s 100 -e 1000
153
370
371
407
```

b) Implement an option `-t` defining how many concurrent threads should be used to execute the search. If the `-t` option is not present, then a single thread is used to carry out the search. For debugging purposes, implement an option `-v` that writes trace information to the standard error. Below is an invocation with two threads and a verbose trace.

```
./pdi-numbers -t 2 -v
pdi-numbers: t0 searching [1,5000]
pdi-numbers: t1 searching [5001,10000]
1
2
3
4
5
6
7
8
9
153
370
371
407
1634
8208
4150
4151
9474
pdi-numbers: t0 finishing
pdi-numbers: t1 finishing
```

c) Determine how the `-t` option impacts the execution time. Pick a search interval that is a reasonable load for your computer hardware and then increase the threading level and determine how the execution time changes. Produce a plot presenting the measurements you have obtained and discuss the results.