Coronavirus Supplement

Parallel Computing (Brief) Introduction

Not in Textbook

DRAFT

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         COVID-NJIT-1:    Terminology
MEDDIAG-1: Medical diagnostic facility MEDDIAG-1 has one COVID  device.
           The samples of up to (and including) 54 subjects can be
           combined and tested. Testing time is 1 day.
           A Test involves only 10% of the material collected from a
           person. Thus a person provides enough material for 10 TEST.

           Thus one subject or as many as 54 subjects can be tested using 1 TEST.
           A test with 54 subjects' samples is counted as   1 TEST.
           A test with 53 subjects' samples is counted as   1 TEST.
             ...
           A test with  1 subject's samples is counted as   1 TEST.
           After one day results are available.
           If the test involves 54 subjects and it is POSITIVE, it
           means one of 54 subjects has COVID; if it is NEGATIVE it
           means none of 54 subjects has COVID.
           (You may replace 54 with 53, 52, ... 2, 1.)

Rersource Optimization
         Number of Tests Performed
         Number of Days  to find Subject X.
```

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Problem NJIT-1-100.
Input. We have 100 test subjects (aka persons, students, etc). 1 of them has coronavirus; 99 of them do not have it. (Medical facility MEDDIAG-1 is used.)
Output. Find the subject who has coronavirus. (Call Subject with coronavirus, Subject X.)

Implicit requirement. Present an algorithm that is TEST efficient in addition to being TIME efficient! Thus for this problem measure of performance is still TIME. We do not have a SPACE RESOURCE (i.e. COMPUTER MEMORY) but we do have a TEST resource. We would be interested in minimizing BOTH at the same time!

Naive Solution for Problem NJIT-1-100.

```
NJIT-1-100
let subject Si be called i,  i=1,..100.
for(i=1 ; i<=99 ; i++) {
   Subject Si is tested (1 TEST involving 1 SUBJECT)
   if Si's test == POSITIVE   return(i has COVID)
}
return(100 has COVID);
```

Analysis. Number of tests performed is at most 99. Number of days to find Subject X is at most 99.
This is reminiscent of linear search!
(Note that writing $O(100)$ or $O(99)$ is nonsense and not equivalent to 'at most 99'.)

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Question for Problem NJIT-1-100. Can you solve this problem by performing 7 TESTS (and thus finding Subject X in 7 days)? Explain. Justify your answer.

Hint for Problem NJIT-1-100.
Use something akin to binary search!

```
         COVID-NJIT-2:    Terminology
MEDDIAG-2: Medical diagnostic facility MEDDIAG-2 has 10 COVID  devices.
           The samples of up to (and including) 54 subjects can be
           combined and tested in one device. Testing time takes 1 day.
           A Test involves only 10% of the material collected from a
           person. Thus a person provides enough material for 10 TEST.
           However the 10 devices allow the facility to perform 10 tests
           in one day. For example one test can involve 1 subject, another
           54, another 40, another 5, another 10, etc .
           The sample (aka nose juice) of one Subject  can be split
           (one tenth of it used) and tested 10 times MAX.

Rersource Optimization
         Number of Tests Performed
         Number of Days  to find Subject X.
```

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Problem NJIT-2-100.
Input. We have 100 test subjects (aka persons, students, etc). 1 of them has coronavirus; 99 of them do not have it. (Medical facility MEDDIAG-2 is used.)
Output. Find the subject who has coronavirus in the minimal number of tests.

Problem NJIT-3-100.
Input. We have 100 test subjects (aka persons, students, etc). 1 of them has coronavirus; 99 of them do not have it. (Medical facility MEDDIAG-2 is used.)
Output. Find the subject who has coronavirus in the minimal number of days.

Hint for Problem NJIT-2-100 and Problem NJIT-3-100.
Two different solutions might be needed! One might find Subject X in 7 days, the other might find Subject X in 2 days. But the number of tests might or might not be the number of days.

Reminder for Problem NJIT-2-100 and Problem NJIT-3-100.
Worst-case time / work (days / test) is important not best case. (In the best case by performing one test we can find Subject X ! Best case is not an interesting case!)

Parallel Computing.
In parallel computing we might utilize more than one processor. In this setup MEDDIAG-2 has 10 'processors' i.e. 10 devices. Doing multiple work by using multiple processors (devices) we might be able to speedup a computation by a factor of p where p is number of processors. We then say we have achieved a speedup of p.

Speedup.
In general the speedup of a parallel computation is the ratio of sequential time over parallel time.

Parallel Time.
A computing resource is then **parallel (computation) time** the time it takes to complete the task (and for our example identifying Subject X using MEDDIAG-2). In our case we measure time in **days**.

Parallel Work.
A computing resource in parallel computing is also **(computational) work** performed. We might identify Subject X in two days (and parallel time is 2 days), yet the number of tests performed, i.e. the amount of work, is not two but more. The first day we might utilize all p processors (i.e. 10 devices), yet the second day we might utilized a fraction of those p processors. Naturally in parallel computing we want to keep processors busy all the time!

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Question 2. Can you find Subject X performing 7 TESTS ? Can you find Subject X in 7 days?

Question 3. Can you find Subject X in 2 days?

Question 4. Can you find Subject X in 1 day? Can you find Subject X by performing 6 TESTS only ? Can you find Subject X in 2 days by performing 6 TESTS only (overall number of TESTS overall days would be 6)?

If you think the possibilities are confusing, WELCOME to PARALLEL COMPUTING. Can you find Subject X by performing 6 TESTS only ?

Generalization. What if we do not have 100 Subjects but n where $n > 100$. Say number of subjects is 1000, or 10000. Some of the tricks we used before do not work any more. Think...

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