Institut for Matematik og Datalogi
Syddansk Universitet

Study Start Project — Computer Science 2014

This is your "studiestartsopgave". This project is based on your courses DM549, DM550, and DM534, though most directly on DM534 since it overlaps with both of the other two. It covers stating algorithms precisely and being able to follow the execution of an algorithm (as is required in programming) and circuit design (Boolean algebra and logic). The project will be graded on a Pass/Fail basis.

The project is due at **8:15 on Monday, September 15**.

You may write it either in Danish or English. Write your full name, your section number (D1 or D2), and your "instruktor"s name (Christian Kudahl or Magnus Gausdal Find) clearly on the first page of your project (on the top, if it is not a cover page). You should turn in your project as a PDF file (possibly scanned from your original) via Blackboard. The assignment/project hand-in is in the menu for the course DM534 and is called "SDU Assignment". Turn in using your correct section, D1 or D2. Keep the receipt it gives you proving that you turned your project in on time. **Blackboard will not allow you to turn in an assignment/project late.** (Ask for help early if you need help for submitting.)

You will be able to pick up your graded project from Joan Boyar in her office, starting at 15:00 on Monday, September 22. (Check your email to see if it is available earlier in the day.) If your assignment is not approved, you must redo it (even though you will have other assignments to work on in this course and your others at the same time) and turn in a corrected version by 8:15 on Thursday, September 25, again turning in a PDF file through SDU Assignment via Blackboard. The corrected versions will be graded by 10:00 on September 30.

Note that it is important to always pick up your projects (or later in the course, assignments), since this is how you will find out if they have been approved and there will generally be useful comments on them to help you improve your performance.

Note that this is not the only part to your "studiestartsopgave". The "studietekniske opgaver" are handled through FF500. They will be available at 18:00 on September 18 and will be due at 23:59 on September 21. Check FF500 in Blackboard.

Cheating on this project is viewed as cheating on an exam. You are allowed to talk about course material with your fellow students, but working together on this project is cheating. If you have questions about the project, come to Joan Boyar or your "instruktor" for DM534.

Please note that this project is a compulsory part of your first-year examination. If you fail to hand in the project on time or do not pass it, you will be called in to talk with an administrator and may not be able to continue your studies. If you do not pass this project, the re-exam will be a different project, which will be available through the course homepage by 14:00 on October 1. It will be due at 23:59 on October 10. Again, it should be turned in as PDF file through Blackboard for DM534.

The Project

Do the following problems. Do not include the statements of the problems or other information not asked for in the problems. Write complete, clear, concise answers.

1. Write down the algorithm for the second performer in "magic trick" described in class in DM534 (and practiced in discussion section), where the first performer passes four of five playing cards to the second performer, so that the second can tell what the fifth card is. (Note that you must use the algorithm presented in class, not one you know of or make up yourself.)

   Let $V = \{2, 3, 4, 5, 6, 7, 8, 9, 10, J, Q, K, A\}$ be the set of values of the cards. Define the following ordering on these values:

   $$2 < 3 < 4 < 5 < 6 < 7 < 8 < 9 < 10 < J < Q < K < A.$$

   Let $S = \{\text{club, diamond, heart spade}\}$ be the set of suits, and define the following ordering on these values:

   $$\text{club} < \text{diamond} < \text{heart} < \text{spade}.$$

   Assume that the two performers have agreed in advance on the following ordering of all 52 cards in the deck: For two cards (s_1, v_1) and (s_2, v_2), where $s_1, s_2 \in S$ and $v_1, v_2 \in V$, we say that $(s_1, v_1) < (s_2, v_2)$ if and only if $v_1 < v_2$ or $(v_1 = v_2$ and $s_1 < s_2)$.

   The input to the second performer's algorithm is four cards,

   $$(s_1, v_1), (s_2, v_2), (s_3, v_3), (s_4, v_4),$$

where $s_1, s_2, s_3, s_4 \in S$ and $v_1, v_2, v_3, v_4 \in V$, and the output should be one card $(s', v') \in (S, V)$ defining which card the first performer has remaining. Write this as an algorithm, so that all steps are completely specified, without ambiguity. (Do not explain why the algorithm works, just what the algorithm is.)

2. The version of Figure 0.2 from the textbook which was presented on the slides for DM534 is as follows:

GCD(M, N):
{ Input: two positive integers M, N }
{ Output: gcd(M, N) }

$A \leftarrow \max(M, N)$
$B \leftarrow \min(M, N)$

$Q \leftarrow A$ div B
$R \leftarrow A - (Q \cdot B)$
while $R \neq 0$ **do**
    $A \leftarrow B$
    $B \leftarrow R$
    $Q \leftarrow A$ div B
    $R \leftarrow A - (Q \cdot B)$
return(B)

Note that "div" is integer division, so the result in this case is the largest nonnegative integer, Q, such that $A \geq Q \cdot B$.

(a) Suppose that as input to this is $M = 33$ and $N = 24$. Show the sequence of values for A and B that are computed by the algorithm and also the result.

(b) Suppose that the algorithm is simplified as follows:

GCD(M, N):
{ Input: two positive integers M, N }
{ Output: gcd(M, N) }

$Q \leftarrow M$ div N
$R \leftarrow M - (Q \cdot N)$
while $R \neq 0$ **do**
    $M \leftarrow N$

$N \leftarrow R$
$Q \leftarrow M$ div N
$R \leftarrow M - (Q \cdot N)$
return(N)

Find values for M and N, where the sequence of values for Q and R is different in the traces of the executions of the two different algorithms. Explain the effect of the change in the algorithm generally.

3. Either do the first two problems below or the third one. The third one is somewhat more challenging. In all cases, explain your solutions.

   (a) Design and draw a circuit containing only AND, OR and NOT gates (each gate having at most two inputs) which takes three bits as input and outputs a 1 if the input is 000, 111, 001 or 110, and a 0 otherwise. (In the student resources for the DM534 textbook, under the Activities for Chapter 1, there is a simulator for logic circuits which you could use to check your circuit. It is time consuming to use, though.) The circuit you create should be clearly marked as to which input goes where.

   (b) Design and draw a circuit containing only AND, OR and NOT gates (each gate having at most two inputs) which takes four bits as input and outputs a 1 if the input is 1001, 1011 or 0110, and a 0 otherwise.

   (c) Design and draw a circuit containing only AND and XOR gates (each gate having two inputs) which takes seven bits as input and outputs a 1 if the input has at least four ones, and a 0 otherwise. Use only four AND gates. How many XOR gates do you need? Hint: Look at (and use) the problem from the discussion section where you were asked to minimize the number of AND gates. Then consider how to represent in binary how many ones there are in a set of three bits. Then add two numbers, each of which has two bits, plus one extra bit.