

Network Algorithms, Summer Term 2013

Problem Set 1

hand in by Thursday, May 2, 2013

Exercise 1: Vertex Coloring

In the lecture, a simple distributed algorithm (“Reduce”) which colors an arbitrary graph with $\Delta + 1$ colors in n synchronous rounds was presented (Δ denotes the largest degree, n the number of nodes of the graph).

1. What is the message complexity, i.e., the total number of messages the algorithm sends in the worst case?

Hint: Note that the “undecided” messages sent in Line 6 are actually not needed. A node could just as well send no message at all. Therefore neglect these messages in your analysis.

2. Does the algorithm also work in an asynchronous environment? If yes, formulate the asynchronous equivalent to the algorithm, if no, describe why.

Exercise 2: Coloring Trees

Algorithm 7 in the lecture notes colors any (directed) tree consisting of n nodes with 3 colors in $O(\log^* n)$ rounds. It consists of two phases: In the first phase (Line 2), the initial coloring consisting of all node IDs is reduced to 6 colors, in the second phase (Lines 3–8), the number of colors are further reduced to 3. Note that, in order to decide when to switch from Phase 1 to Phase 2, the nodes running Algorithm 7 actually count $\log^* n$ rounds. However, this is only possible if the nodes are aware of the total number of nodes n . If n is unknown the nodes do not know when the first phase is over: A node v running Algorithm 5 cannot simply decide to be done once its color is in $R = \{0, \dots, 5\}$ since its parent w might still change its color in the future. Even if the color of w is also in R , w might receive a message from its parent that forces w to change its color once more (potentially to node v 's color!). In the following, we want to overcome this problem, and make Algorithm 7 work even if the nodes are unaware of n . To make our lives easier we try to find a solution for the ring topology. Formally, a ring is a graph $G = (V, E)$, where $V = \{v_1, \dots, v_n\}$ and $E = \{\{v_i, v_j\} | j = i + 1 \pmod{n}\}$. You can assume that G is a directed ring, i.e., nodes can distinguish between “left” and “right”.

1. Show how the log-star coloring algorithm for trees can be adapted for the ring!
2. Once the color of node v in the ring is in \mathcal{R} , it wants to reduce the numbers of colors used to 3. Show how this reduction phase works even if the first phase may not have terminated in some other parts of the ring!¹

Hint: You can use additional colors to segment the ring and to solve the problem locally!

¹Note that a node cannot wait until it knows that all other nodes are ready to start the second phase as this would require time in the order of $n!$