The Poster Session of SSS 2005

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The 2005 Symposium on Self-Stabilizing Systems (SSS 2005) took place October 26 and 27, 2005, in Barcelona, Spain. The proceedings of the Symposium are published in the Springer Lecture Notes on Computer Science Series, as Volume 3764. In addition to the presentations contained in the proceedings, there were five short presentations in a “poster session” on 26 October. Two of the presenters kindly provided short abstracts of their presentations (their names are listed as co-authors of this technical report). The five presentations of the poster session were:

1. \textit{Self-stabilizing Coloration in Anonymous Planar Networks}, presented by Shing-Tsaan Huang. This presentation described research published in \textit{Information Processing Letters}, Volume 95, Issue 1, 16 July 2005, Pages 307-312.

2. \textit{Self-Stabilizing Maximum Matching using Multi-Wave Synchronization} was presented by Mehmet Hakan Karaata, Kuwait University.

3. \textit{Electronic Business with Security Modules}, presented by Lucia Draque Penso, showed an application of a result later appearing in Opodis 2005: \textit{Optimal Randomized Omission-Tolerant Uniform Consensus in Message Passing Systems}, by Felix Freiling, Maurice Herlihy, and Lucia Penso.

4. \textit{A Formal Model for Snap-Stabilization in Distributed Systems} was presented by Brahim Hamid, and a brief abstract of that presentation appears later in this report.

5. \textit{Self-stabilizing K-packing and K-domination on tree graphs}, was presented by Morten Mjelde, and a brief abstract of the results appears later in this report.
A Formal Model for Snap-stabilization in Distributed Systems

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Informally, snap-stabilizing algorithms ensure that after some transient failures, the system will automatically recover to reach a correct configuration in 0 steps. Therefore, a snap-stabilizing protocol ensures that the system is in the desirable behavior incessantly. The most researches about this area are confronted with the space complexity. In this work, we present a formal method to deal with snap-stabilization using local computations and particularly graph rewriting systems: a powerful model to encode and to prove distributed algorithms. The method requires the identification of local transient faults. Once identified, predicates can be formulated to detect the illegitimate configurations from the state information and corrective rules can be added to the algorithm to eliminate each illegitimate configuration. These corrective rules are formulated such that they do not introduce any further illegitimate configurations with regards to the algorithm. Therefore, the new graph relabeling system is a snap-stabilizing protocol.

A distributed system is modeled by a graph \( G = (V(G), E(G)) \) where nodes represent processes and edges represent bidirectional communication links. The networks are asynchronous, the links are reliable and the process can fail and recover in a finite time. Every time, each node and each edge is in some particular state and this state will be encoded by a node label or an edge label. According to its own state and to the states of its neighbors, each node may decide to realize an elementary computation step. After this step, the states of this node, of its neighbors and of the corresponding edges may have changed according to some specific computation rules. Let \( L \) be an alphabet and let \( G \) be a graph. We denote by \((G, \lambda)\) a graph \( G \) with a relabeling function \( \lambda : V(G) \cup E(G) \to L \). A graph relabeling system is a triple \( \mathcal{R} = (L, I, P) \) where \( L \) is a set of labels, \( I \) is a subset of \( L \) called the set of initial labels and \( P \) a finite set of relabeling rules.

Local configurations will be defined on balls of radius 1 denoted by \( B \) (the corresponding node and the set of its neighbors). For a labeled graph \((G, \lambda)\), we say that a local configuration \( f = (B_f, \lambda_f) \) is illegitimate for \((G, \lambda)\), if there is no ball (neither sub-ball) of radius 1 in \( G \) which has the same labeling as \( f \). A graph relabeling system with illegitimate configuration is a quadruple \( \mathcal{R}_c = (L, I, P, \mathcal{F}) \) where \( \mathcal{F} \) is a set of illegitimate configurations. A local snap-stabilizing graph relabeling system is denoted by \( \mathcal{R}_{sn} = (L, P) \) where \( P \) a finite set of relabeling rules composed of the set of relabeling rules \( P \) and some correction rules \( P_c \). The rules of the set \( P_c \) are introduced in order to eliminate the illegitimate configurations. Therefore, these rules delay the safe computation which is a computation without fault of components. Our approach is easy to understand and its translation from the initial algorithm requires little changes and can be applied in practical applications as a generic and automatic method to deal with transient faults in distributed systems.
Self-stabilizing $K$-Packing and $K$-Domination on tree graphs

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The self-stabilizing algorithms presented here solves the problems of maximum $K$-packing and minimum $K$-domination on a tree graph in $O(n^3)$ moves (assuming an adversarial daemon). Previously known algorithms were able to solve maximal 2-packing and minimal $k$-domination (as opposed to maximum and minimum), both on general graphs, and both in exponential time. The algorithms presented here solves the problems by using two passes through the tree. The first one finds the size of the optimal solution for the entire tree, and the second pass finds the actual solution.

$K$-packing is defined as follows: Assume a graph $G = (V, E)$. A $K$-packing algorithm selects a subset $S$ (black vertices) of the vertices $V$ such that for every pair $(v, u) \in S$ the shortest distance between them is always greater than $K$ (that is, there has to be $K$ or more vertices between $v$ and $u$). Maximum $K$-packing means that no subset of $V$ that is a legal solution has a large cardinality than $S$. Maximum $K$-packing is NP-Hard for a general graph.

The self-stabilizing algorithm presented here solves maximum $K$-packing on a tree graph. It is assumed that every vertex knows which of its neighbours is closest to the root (ie. its parent) (there are however self-stabilizing algorithms that can find this without effecting the asymptotic running time). The algorithm solves the problem in two phases: Phase 1 finds the optimal solution for the subtree $T[v]$ (the subtree with the vertex $v$ as the root) for every $v \in V$. The calculation is performed using information about the optimal solution found in $v$’s children. Phase 2 sets appropriate vertices to black based on what was found in Phase 1. The algorithm can be shown to stabilize in no more then $O(n^3)$ moves.

For each $v \in V$, there exists a table $M_v[0 : K]$. When the table has been computed, each index $i$ holds the size of the optimal solution for the subtree $T[v]$ assuming that there are at least $i$ levels of white vertices (ie. vertices not belonging to $S$) below $v$ (including $v$ itself). $i = 0$ implies that $v$ can be black, $i = 1$ implies that $v$ is white, but a child may be black and so on. The table for a vertex $v$ is computed using the tables $M_c[]$ for every child $c$ of $v$. When the table $M_r[]$ for the root $r$ is computed, position 0 shows the size of the optimal solution for the entire tree.

Phase 2 finds the actual vertices belonging to $S$ by backtracking from Phase 1. It sets a vertex $v$ to black depending on which position in the table $M_v[]$ was found to house the optimal solution for the subtree $T[v]$.

$K$-domination is similar to $K$-packing, and is defined as follows: A subset $S$ of the vertices in $G$ is selected such that for every vertex $v \in V$ there exists at least one vertex $s \in S$ where the distance between $v$ and $s$ is less than or equal to $K$. Minimum $K$-domination means that no subset of $V$ that is a legal solution has a smaller cardinality than $S$. Minimum $K$-domination is NP-complete on a general graph. Because of the similarities with $K$-packing, $K$-domination can be solved by using much the same algorithm as described above. The number of moves will be the same in both cases.