Self-Stabilizing End-to-End Communication in

Bounded Capacity, Omitting, Duplicating and Non-FIFO

Dynamic Networks *

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Abstract. End-to-end communication over the network layer (or data link in overlay networks) is one of the most important communication tasks in every communication network, including legacy communication networks as well as mobile ad hoc networks, peer-to-peer networks and mash networks. We present self-stabilizing end-to-end algorithm that exchange packets to deliver (high level) messages in FIFO order without omissions or duplications. The algorithm is applicable to networks of bounded capacity that omit, duplicate and reorder packets. The algorithm is network topology independent, and hence suitable for always changing dynamic networks with any churn rate.

Motivation. A sender needs to transmit messages to a receiver in an exactly once fashion, where intromission of errors, omissions, duplications and reordering are not allowed. The error detection techniques are employed as an integral part of the transmission in the communication network. Error detection codes work with high probability, still facing a possibility for accepting undetected wrong message. Such a situation may bring the algorithm to an arbitrary state from which the algorithm may never recover unless it is automatic recoverable, i.e., self-stabilizing [1]. We present a self-stabilizing end-to-end communication algorithm that can be applied to dynamic networks of bounded capacity that omit, duplicate and reorder packets. Recently, Dolev et al. [2] presented a self-stabilizing data link algorithm for reliable FIFO message delivery over bounded non-FIFO and non-duplicating channel.

Solution. The proposed algorithm, S^2E^2C, *self-stabilizing end-to-end communication*, simulates FIFO behavior over the non-FIFO dynamic networks. It enables one time message delivery without omission, errors or duplications in the same order in which they are fetched at the sender.

The sender, infinitely often, sends n packets with distinct labels and unique alternative index 0, 1 or 2, until the sender gets sufficient amount of $capacity + 1$ acknowledgement packets of distinct labels, where $capacity$ is the overall network packet capacity allowed, at any time, on the channel from the sender to the receiver. The n packets are generated from a pl message window of some fixed bit length, ml, after inculcation of redundant error correcting bits. The i^{th} packet is formed by the i^{th} bit of all pl messages and also has an unique label and alternative index. In short, first packet holds first bit of each pl messages, and second packet holds second bit of each pl messages, and n^{th} packet holds n^{th} bit of each pl messages.

The receiver accumulates n packets of distinct labels that have an alternative index that is different from last delivered packet index by the receiver. When the receiver gets n distinct labels packets of identical alternative index, the receiver generates error free messages from the incoming packets and delivers the messages in the same order, as they were fetched at the sender. The receiver, in addition, sends $capacity + 1$ distinct labels as acknowledgments to the sender.

Proposed algorithm properties. The proposed algorithm provides topological independence and implicit synchronization between the sender and the receiver. The algorithm is self-stabilizing providing one time message delivery with handling of omission and reorder, i.e., simulate reliable FIFO message delivery over the non-FIFO networks, when started in an arbitrary state.

References

[1] Edsger W. Dijkstra. Self-stabilizing systems in spite of distributed control. *Commun. ACM*, 17(11):643–644, 1974.

[2] Shlomi Dolev, Swan Dubois, Maria Potop-Butucaru, and Sébastien Tixeuil. Stabilizing data-link over non-fifo channels with optimal fault-resilience. *Inf. Process. Lett.*, 111(18):912–920, 2011.

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