Time, Clocks, and the Ordering of Events in a Distributed System

The paper tries to solve the problem of ordering events in a distributed system. The problem is explained in brief and it is shown that the use of physical clocks to determine which event happened before another cannot be used due to physical clocks not being synched. The idea of partial ordering is introduced. A notation for representing a partial order is given as, a → b which means a "happened before" b. The partial ordering represented using a space-time diagram. Then the concept of logical clocks is introduced in order to keep track of time without the use of Physical clocks. To extend the idea of partial order or to the whole system, an algorithm is described for total ordering. It uses this algorithm to solve a common synchronization problem.

As the total ordering algorithm is somewhat arbitrary, it is shown that it can produce anomalous behaviour if it disagrees with the ordering perceived by the system's users. To solve this, the paper uses synchronized physical clocks. A theorem is then derived to show closely the clocks can be synchronized. The theorem states that, if the inequality $\varepsilon/(1-\kappa) \leq \mu$ is satisfied, the clocks can be synchronized to the required amount. The use of physical clocks with the algorithm of total order is show to solve the problem of anomalous behaviour.

Strong Points

- The paper shows how to use timestamps to provide a total ordering of events that is consistent with the causal order.
- It demonstrates how to implement a distributed system with an algorithm for totally ordering events by extending a partial order specific to processes.
- The paper is self-critical while discussing the anomalous behaviour problem. It finds a problem in an algorithm introduced by itself and tries to solve it.

Weak Points

- The paper assumes the communication channels are lossless and ordered. Although today we could use TCP to meet this requirement, I just wonder how harder it would be when relaxing this assumption.
- Disregarding the use of physical clocks and explaining the difficulty in synchronizing them in the beginning of the paper and later using synchronized clocks seems a little self-contradictory
- The paper could've also explained how it arrived at the inequality for synchronizing clocks in a more simple and easy to understand way.