Paper Review

"Time, clocks and the ordering of events in a distributed system"

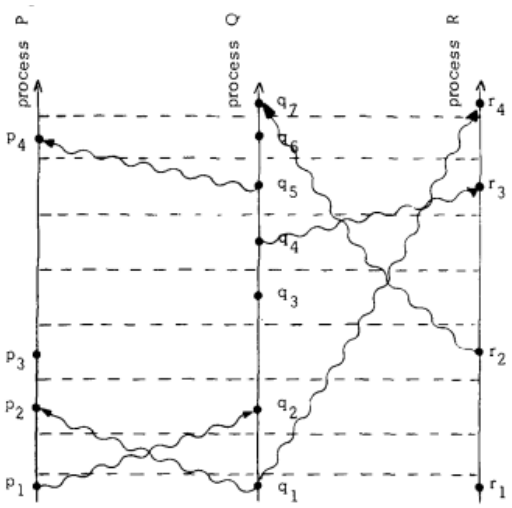
1. Summary

In this pivotal paper authored by the Turing Award Winner L.Lamport, the author discussed the time, clocks, and the ordering of events in a distributed system. The main inspiration of this paper for me is to maintain a logical clock through the message passing of multiple nodes.

It first defines the happening of an event with the following definition:

$$\text{If } a \to b \text{ then } C(a) < C(b)$$

By this definition, we can compare two events from different processes, which eventually gives an insight into the order of some global events, especially those transferred to another process, which will use an example to describe.



In Figure1, we can conclude that $C(p_1) < C(q_2) < C(q_3) < C(q_4) < C(r_3) < C(r_4)$ on the sight of processes. The conclusion is valid by comparing the preset timeline in the Cartesian coordinate system. Furthermore, the clock is the measure of time, the vertical axis of this Cartesian coordinate system can be seen as a precise physical clock, and the conclusion we derived can be seen as a logical clock.

In the real world, the physical clock is not precise, which may cause anomalous behavior when two events are reached with an order different from what they are sent due to how they are transferred. This paper offered a solution that we can maintain a logical clock. Take Figure1 as an example, if the physical clock of process Q is much slower than P, and p1 was sent to process Q with a timestamp representing the physical clock of process P, then process Q can adjust its logical clock to a value larger than the timestamp

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according to the rules described in th paper. By **Strong Clock Condition**, it requires frequent exchange of information to adjust the logical clock to an acceptable value (for example, PTP).

This paper evolved to Precision Time Protocol, which produces four different timestamps for picosecond-level synchronization. Moreover, google spanner maintains a global clock and uses a timestamp to resolve database conflicts and improve performance.

2. Advantages

+ It is the very basic of distributed systems and inspires the development of distributed system design, PTP, and google spanner.
+ The idea of combining the clock in distributed systems with a space-time view of special relativity is inspiring.
+ Apparent instructions with rules, graphs, and actual cases

3. Disadvantages

– There can be a deviation in transferring and original physical clock. For example, when a mobile phone with precise clock and GPS devices. GPS can get time by correcting for deviations from satellite signals. However, the deviation represents the time consumed for the GPS signal to cross the ionosphere; the clock is not precise. The paper has not considered this situation since it introduced max deviation and commit wait.

4. Brainstorming

I am now working on the time-syncing of BLE devices. In my recent research, I was inspired by a distributed database called Bedrock which uses a Paxos-based election scheme to fix sync issues. In google spanner, a ”global timer” can help improve the performance of a distributed database by timestamp ordering. The same techniques can be used on Bedrock to avoid hash conflicts and reduce the election time or help the election scheme.

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