Time and Concurrency - Three Approaches for Intertwining Time and Petri Nets

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Time and Petri nets - do they not contradict each other? While time determines the occurrences of events in a system, classic Petri nets consider their causal relationships and represent events as a concurrent system. At first, these two appear to be at odds with each other, but taking a closer look at how time and causality are intertwined, one realizes that time actually enriches Petri nets. There are many possible ways in which time and Petri nets interact, this talk will take a short look at three time-dependent Petri nets: Time Petri nets, Timed Petri nets, and Petri nets with time-windows. For the first nets that we will take a look at, Time Petri nets, enabled transitions may fire only during specified time intervals. The transitions must fire the latest at the end of their intervals if they are still enabled then. At any given moment only one transition may fire. This firing does not take time. For the second class of nets, Timed Petri nets, a maximal set of just-enabled transitions fires, and the firing of each transition takes a specific amount of time. The third class of nets, Petri nets with time-windows, portrays time as a minimum and maximum retention for tokens on places. In these nets tokens can be used for firing only during their minimum and maximum retention. At the end of the maximum retention time for a token its time is reset to zero if it was not used for firing. The next period of its retention time on this place then restarts. This repetition can continue indefinitely. For Time Petri nets, we provide an algorithm which proves the behavioral equivalence of a net where time is designed once with real and once with natural numbers. One can also say that the dense semantics of Time Petri nets can be replaced with discrete semantics. For Timed Petri nets, we introduce two time-dependent state equations. These provide a sufficient condition for the non-reachability of states. Last but not least, we prove that Petri nets with time-windows have the ability to realize every transition sequence fired in the net omitting time restrictions. Despite the first experience that time has no influence on the behavior of such nets, we verify that the time can change the liveness behavior of Petri nets with time-windows. We choose these three classes of time-dependent Petri nets to show that time alone does not change the power of a Petri net. In fact, time can or cannot be used to force firing. For Time Petri nets and Timed Petri nets we can say that they are Turing-powerful, and thus more powerful than classic Petri nets. In contrast to these two nets, Petri nets with time-windows have no compulsion to fire. Their expressiveness power is less than that of Turing-machines.