Feasibility of Dual Switched Systems

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Abstract: Externally switched systems occur frequently in cases where user inputs, system faults, environmental changes, and other uncontrollable phenomena cause sudden changes to the system. These changes can come in the form of altered dynamics, tightened or loosened constraints, shifted objectives, or larger-than-normal disturbances. These sudden changes introduce a serious challenge for constrained systems: though a feasible input sequence may exist in the current mode, an unexpected switch may remove all feasible input sequences. This situation can be avoided by constraining the system to states where all modes are feasible, thereby allowing arbitrary switching. This, however, is very restrictive and sometimes even impossible. This conservatism can be reduced by ensuring that switches occur slowly. This prevents a switch from violating state constraints and gives the system time to recover before the next switch. This has the further benefit of expanding the class of systems for which persistent feasibility is possible. However, these solutions are inapplicable if any modes have diverging dynamics or large disturbances, as is often the case in faulty systems or inhospitable environments. This work develops an approach that constrains how rapidly the system must switch in addition to constraining how rapidly it can switch. This indicates how long the system can remain in a poorly behaving mode before switching out of it. In addition to this contribution, this work implements two separate switching signals to further expand the class of valid systems. One signal switches the system dynamics while the other enables and disables additive disturbances. Several systems of interest can be modeled within this framework, such as distributed switched systems and systems with lagging switch detection. Using this framework, 2D safe-set arrays, indexed by the amount of time since the latest switches, are introduced. These sets are designed to contain the persistently feasible states regardless of the realized future switching sequence. By constraining the states within these safe-sets, persistent feasibility is reestablished without conservatism. This work was completed under the guidance of Dr. Leila Bridgeman.