Modeling and Analysis Suite for Real Time Applications (MAST 1.3.7)

Restrictions

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1. Introduction

The MAST model has some general restrictions, that affect all application models, and other restrictions that affect specific analysis tools. Some of the restrictions are marked as temporary, because they will be eliminated in the near future.

In addition to the restrictions, there are some consistency checks that are made to determine if a MAST description is correct. They are based on a set of rules.

2. Consistency Checks

They are used to determine whether a MAST description is correct and if it covers the most basic general restrictions. They are based on the following set of rules, which are checked for each transaction in the system:

1. At least one external event

2. Each external event link directed at one event handler, and with an external event.

3. Each internal event link comes from an event handler

4. Each simple event handler has an input event link and an output event link

5. Each input event_handler has 2 or more input event links and an output event link

6. Each output event handler has 2 or more output event links and an input event link

7. No circular dependencies in the transaction graph

8. No isolated event links

9. No isolated event handlers

10. All activities have an operation

11. All activities have a scheduling server

12. All scheduling servers have a scheduler

13. All scheduling servers have scheduling parameters

14. All rate divisors, offset and delay event handlers are only followed by activities

15. All primary schedulers have a processing resource

16. All secondary schedulers have a scheduling server

17. All schedulers have a scheduling policy

18. All schedulers with a scheduling policy of the type `FP_Packet_Based` are associated with a primary scheduler located on a network

19. All scheduling servers with parameters of the fixed priority family (excluding interrupts) are associated with schedulers having a policy of the fixed priorities family

20. All scheduling servers with parameters of the EDF family are associated with schedulers having a policy of the EDF family

21. All scheduling servers with parameters of the type `Interrupt_FP_Policy` are associated with primary schedulers

22. All message transmission operations are executed by scheduling servers executing on a network

23. Each processing resource has at most one primary scheduler

24. Each scheduling server has at most one secondary scheduler

3. Restrictions Related to the Use of Shared Resources

The following restrictions ensure a proper usage of shared resources through the transaction graphs. The following rules are checked for each transaction in the system:

1. All locked resources are unlocked

2. No resource is locked if it was already locked

3. No resource is unlocked if not previously locked

4. All locked resources in a segment are unlocked in that segment[1]

The following rules have been added to facilitate the calculation of remote blocking terms:

5. All global shared resources (i.e., those that are shared by operations executed by different processors) use the *Immediate_Ceiling_Protocol*, for mutually-exclusive synchronization.

6. The priority ceiling of all global shared resources is such that the tasks that are involved in the calculation of the remote blocking (i.e., those tasks that have priorities above or the same as the priority ceiling) do not use shared resources.

The latter restriction is imposed because, otherwise, there would be a circular dependency among the remote blockings of the different tasks, which would make calculations very complex. But we allow some degree of remote blocking, for example by interrupt service routines, or by very high priority tasks that do not need shared resources.

When the *Immediate_Ceiling_Protocol* is used, if the tools are invoked with the "Calculate Ceilings" option set, then the optimum priority ceilings are calculated for each shared resource using this protocol. If the option is not set, then a check is made to determine that all priority ceilings are correct:

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1. A segment is a set of consecutive activities executed by the same scheduling server

7. Consistent priority ceilings: no task locks an immediate ceiling resource having a priority lower than the ceiling.

In addition, we have a temporary restriction caused by the fact that no analysis techniques have been developed to calculate remote blocking effects in multiprocessors, when the blocking terms in one processor depend on the results of the blocking calculations in the other processors. We expect to eliminate this restriction in the near future:

8. All resources locked in a code segment are unlocked in that segment. A *segment* is defined as an uninterrupted sequence of activities that are all executed by the same scheduling server (and thus, by the same processing resource).

4. System-Kind Restrictions

The following are system restrictions that apply to some of the tools only:

- *Monoprocessor Only*: only one processing resource, which is a *Processor*

- *Fixed Priority Only*: All Scheduling Servers have Fixed Priority Parameters, all overridden parameters in operations are Fixed Priority, and all priorities are within the appropriate ranges for their processing resources. There are no secondary schedulers.

- *EDF_Only*: All Scheduling Servers have EDF or Interrupt Parameters, there are no overridden parameters in operations, and all interrupt priorities are within the appropriate ranges for their processing resources. There are no secondary schedulers.

- *EDF_Within_Priorities_Only*: The primary schedulers have a fixed priority policy. All secondary schedulers have an EDF policy and are scheduled under a scheduling server that is directly attached to a primary scheduler. All operations with overridden priorities are executed by fixed-priority scheduling servers. All priorities are in range.

- *Flat_FP_Or_EDF_Only*: Each node is *Fixed_Priorities_Only* or *EDF_Only*. All operations with overridden priorities are executed by fixed-priority scheduling servers. All priorities are in range.

- *PCP_Or_Priority_Inheritance_Only*: all resources are PCP (i.e., Immediate_Ceiling_Resource) or Priority Inheritance resources

- *PCP_SRP_Or_Priority_Inheritance_Only*: all resources are PCP (i.e., Immediate_Ceiling_Resource), SRP, or Priority Inheritance resources. In addition, we restrict SRP resources to be used only by EDF tasks, and Priority inheritance resources to be used only by fixed priority tasks.

- *SRP_Only*: all resources are SRP resources

- *SRP_Or_PCP_Only*: All resources are SRP or PCP.

- *Referenced_Events_Are_External_Only*: No internal events are referenced by global timing requirements.

- *Simple_Transactions_Only*: Checks that every transaction has only one segment. A segment is a continuous sequence of activities executed by the same server.

- *Linear_Transactions_Only*: checks that every transaction only has one external event and that its event handlers are all Activities.

- *Linear_Plus_Transactions_Only*: Checks that every transaction is regular and has no *Concentrators* or *Delivery_Servers*, or *Query_Servers* or *Multicasts,* or *Barriers*

- *Multiple_Event_Transactions_Only*: Checks that every transaction is regular.

- *No_Permanent_Overridden_Priorities*: Checks that there are no operations with permanent overridden priorities.

- *No_Permanent_FP_Inside_Composite_Operations*: Checks that there are no operations with overridden priorities inside composite operations. If this would be required, the composite operation would have to be broken up into several activities.

All schedulability analysis tools require:

- *Referenced_Events_Are_External_Only.*

- *No_Permanent_Overridden_Priorities* (except *Varying_Priorities_Analysis*).

In addition, some tools require other restrictions, as shown in the following table. Unimplemented tools are shaded:

TABLE 1. Response Time Analysis Tools

Tool	Restrictions
Classic_RM_Analysis	Monoprocessor_Only, Simple_Transactions_Only, Fixed_Priorities_Only
Varying_Priorities_Analysis	Monoprocessor_Only, Linear_Transactions_Only, No_Permanent_FP_Inside_Composite_Operations, Fixed_Priorities_Only
EDF_Monoprocessor_Analysis	Monoprocessor_Only, Simple_Transactions_Only, EDF_Only
EDF_Within_Priorities_Analysis	Monoprocessor_Only, Simple_Transactions_Only, EDF_Within_Priorities_Only
Holistic_Analysis	Linear_Plus_Transactions_Only, Flat_FP_Or_EDF_Only
Offset_Based_Analysis	Linear_Plus_Transactions_Only, Flat_FP_Or_EDF_Only
Offset_Based_Priority_Optimized_Analysis	Linear_Plus_Transactions_Only, Flat_FP_Or_EDF_Only
Multiple_Event_Analysis	Multiple_Event_Transactions_Only, Flat_FP_Or_EDF_Only

The Shared resources analysis tools have the following restrictions:

- *PCP_SRP_Or_Priority_Inheritance_Only*

In addition, each tool has the following additional restrictions:

TABLE 2. Shared Resource Analysis Tools

Tool	Restrictions
Calculate_Ceilings_And_Levels	Linear_Plus_Transactions_Only
Calculate_Blocking_Times	Linear_Plus_Transactions_Only

The scheduling parameters assignment tools have the same restrictions as the response time analysis tools they use. In addition, each tool has the following additional restrictions:

TABLE 3. Scheduling Parameters Assignment Tools

Tool	Restrictions
Monoprocessor_Priority_Assignment	Fixed_Priorities_Only, Monoprocessor_Only, Simple_Transactions_Only
Linear_HOPA	Linear_Plus_Transactions_Only, Flat_FP_Or_EDF_Only
Multiple_Event_HOPA	Multiple_Event_Transactions_Only, Flat_FP_Or_EDF_Only
Linear_Simulated_Annealing_Assignment	Linear_Plus_Transactions_Only, Flat_FP_Or_EDF_Only
Multiple_Event_Simulated_Annealing_Assignment	Multiple_Event_Transactions_Only, Flat_FP_Or_EDF_Only