DDD Pacemaker Traceability Report

This traceability document of DDD Pacemaker establishes trace links from the UPPAAL model to Simulink model and then to C code.

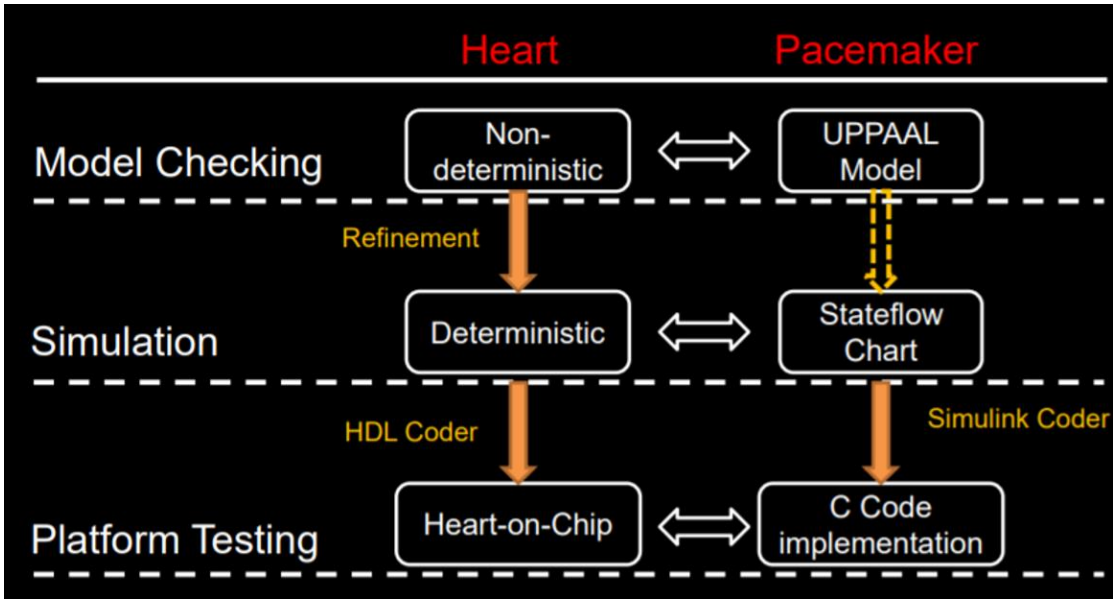

Fig0. Traceability: from verified model to verified code

Traceability indicates that the pacemaker implementation is consistent between requirements and UPPAAL model by model checking; UPPAAL model will be proved to be consistent with Simulink model after model transition; Also, consistency between model and code can be ensured by conformance testing.

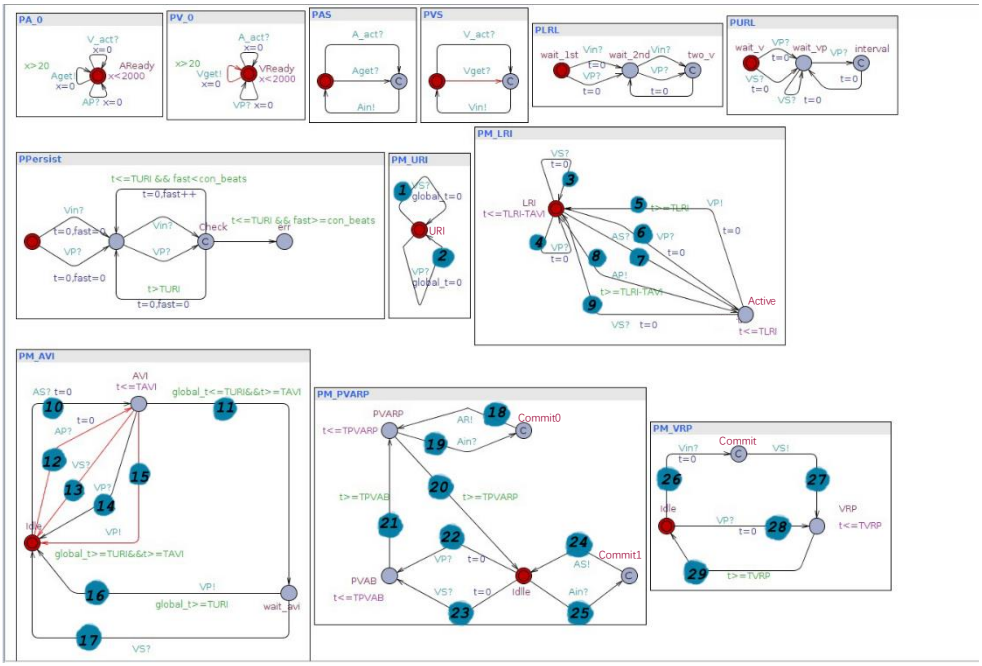

Fig1. UPPAAL Model

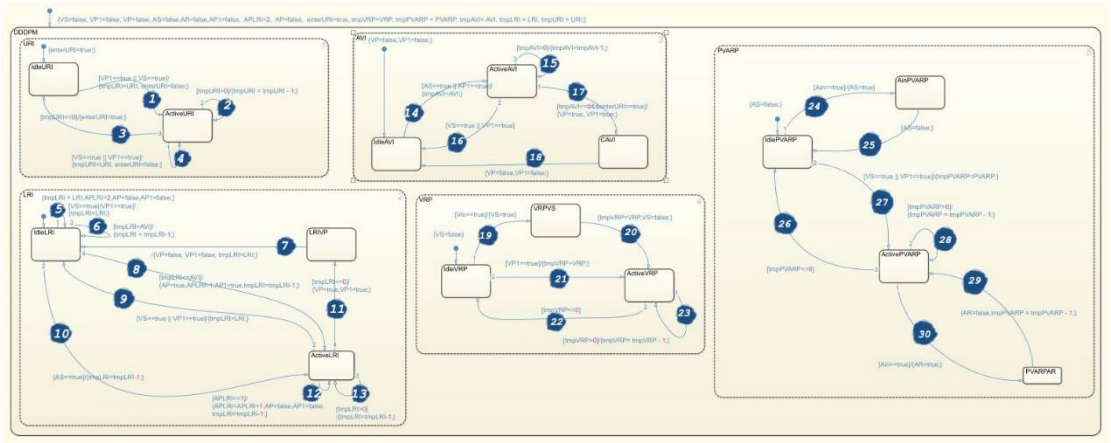

Fig2. Simulink Model

Each parameter, variable and state in UPPAAL model has corresponding ones in Simulink model.

	Specification	UPPAAL Model	Simulink Model	Generated Code	Indication
Parameter					
1	A-V synchrony	TAVI	AVI	uint8_T is_AVI	Minimum interval between an atrial and a ventricular event
2	Not pace on T wave	TVRP	VRP	uint8_T is_VRP	Refractory period after a ventricular event
3	A-V synchrony	TPVARP	PVARP	uint8_T is_PVARP	Refractory period after an atrial event
4	A-V synchrony	TAEI	AEI	uint8_T is_AEI	Minimum interval between a ventricular and an atrial event
5	Lower Rate Limit	TLRI	LRI	uint8_T is_LRI	Maximum interval between ventricular events
6	Upper Rate Limit	TURI	URI	uint8_T is_URI	Minimum interval between ventricular events
Clock/local variable					
1	A-V synchrony	Clock t in AVI	tmpAVI	uint16_T tmpAVI	Time passed in a AVI period
2	Lower Rate Limit	Clock t in LRI	tmpLRI	uint16_T tmpLRI	Time passed in a LRI period
3	A-V synchrony	Clock t in PVARP	tmpPVARP	uint16_T tmpPVARP	Time passed in a PVARP period
4	Not pace on T wave	Clock t in VRP	tmpVRP	uint16_T tmpVRP	Time passed in a VRP period
6	A-V synchrony	VS	VS	boolean_T VS	Ventricular sensing

7	A-V synchrony	VP	VP	boolean_T VP	Ventricular pacing
8	A-V synchrony	AS	AS	boolean_T AS	Atrial sensing
9	A-V synchrony	VS	VS	boolean_T VS	Ventricular sensing
			States		
1	Upper Rate Limit	PM_URI-URI	ActiveURI	#define YixuanMeng_SL_imp_IN_ActiveURI ((uint8_T)1U)	In a URI period
2	Lower Rate Limit	PM_LRI-LRI	IdleLRI	#define YixuanMeng_SL_imp_IN_IdleLRI ((uint8_T)2U)	In a LRI period, waiting to send AP
3	Lower Rate Limit	PM_LRI-Active	ActiveLRI	#define YixuanMeng_SL_imp_IN_ActiveLRI ((uint8_T)1U)	In a LRI period, waiting to send VP
4	A-V synchrony	PM_AVI-AVI	ActiveAVI	#define YixuanMeng_SL_imp_IN_ActiveAVI ((uint8_T)1U)	In an AVI period, waiting to send VP
5	A-V synchrony	PM_AVI-Idle	IdleAVI	#define YixuanMeng_SL_imp_IN_IdleAVI ((uint8_T)3U)	After a ventricular event, waiting to reset AVI period upon an atrial event
6	A-V synchrony	PM_AVI-wait_avi	ActiveAVI	#define YixuanMeng_SL_imp_IN_ActiveAVI ((uint8_T)1U)	In an AVI period, waiting to send VP
7	A-V synchrony	PM_PVARP-PVARP	ActivePVARP	#define YixuanMeng_SL_imp_IN_IdlePVARP ((uint8_T)3U)	In refractory period after an atrial event
8	A-V synchrony	PM_PVARP-commit0	PVARPAR	#define YixuanMeng_S_IN_NO_ACTIVE_CHILD ((uint8_T)0U)	After an Ain is unsensed during a refractory period
9	A-V synchrony	PM_PVARP-commit1	AinPVARP	#define YixuanMeng_SL_imp_IN_AinPVARP ((uint8_T)2U)	An Ain is sensed
10	A-V synchrony	PM_PVARP-Idle	IdlePVARP	#define YixuanMeng_SL_imp_IN_IdlePVARP ((uint8_T)3U)	Waiting for Ain, VS or VP
11	A-V synchrony	PM_PVARP-PVAB	ActivePVARP	#define YixuanMeng_SL_im_IN_ActivePVARP ((uint8_T)1U)	Atrial is in refractory period after a ventricular event
12	A-V synchrony	PM_VRP-commit	VRPVS	Not found	A Vin is sensed
13	A-V synchrony	PM_VRP-Idle	IdleVRP	#define YixuanMeng_SL_imp_IN_IdleVRP ((uint8_T)2U)	Waiting for Vin or VP

14	Not pace on T wave	PM_VRP-VRP	ActiveVRP	#define YixuanMeng_SL_imp_IN_ActiveVRP ((uint8_T)1U)	Ventricular in refractory period after a ventricular event

Table0. corresponding specifications, parameters, variables and states in models

For consistency between transitions and the corresponding Test Case coverage(specified in test report):

	UPPAAL transition	Simulink transition	test case overage
1	1	1/4	1.5, 1.13, 2.5, 2.10, 3.5
2	2	1/4	1.5, 1.13, 2.5, 2.10, 3.5
3	3	5	2.10
4	4	5	2.10
5	5	11->7	3.12->3.13
6	6	9	1.4, 1.13, 2.4, 2.4
7	7	10	1.2, 2.2, 3.2
8	8	8	1.10, 3.10
9	9	9	1.4, 1.13, 2.4, 2.4
10	10	14	1.2, 1.10, 2.2, 3.2, 3.10
11	11	15	1.3, 1.11, 1.12, 2.3, 3.3, 3.11
12	12	14	1.2, 1.10, 2.2, 3.2, 3.10
13	13	16	1.13
14	14	16	1.13
15	15	17->18	1.4->1.5, 2.4->2.5, 3.4->3.5, 3.12->3.13
16	16	17->18	1.4->1.5, 2.4->2.5, 3.4->3.5, 3.12->3.13
17	17	16	1.13
18	18	29	1.16
19	19	30	1.15
20	20	26	1.7, 2.7, 3.7
21	21	27	1.5, 1.13, 2.5, 2.10, 3.5
22	22	27	1.5, 1.13, 2.5, 2.10, 3.5
23	23	27	1.5, 1.13, 2.5, 2.10, 3.5
24	24	25	1.3, 2.3, 3.3
25	25	24	1.2, 2.2, 3.2
26	26	19	1.13
27	27	20	1.14
28	28	21	1.5, 2.5, 3.5
29	29	22	1.8, 2.8, 3.8

Table1. corresponding transitions in UPPAAL and Simulink models

(1.1 in test case column indicates 1 in Test Case1)

Full traceability report can be found in attached file YixuanMeng_TracebilityCodeGen.zip/ YixuanMeng_SL_imp_codegen_rpt.html