Temperature Control (HSCC 2011)

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1 Description of the Model

In this case study, we consider a temperature control system extended from a previous case study [4], originally studied by Alur et al. [1]. In this model, continuous distributions are used. The abstraction of a guarded command with a continuous probability distribution into one with a discrete probability distribution is described in a recent publication [2]. In Figure 1 we depict the system structure. We ask whether using an

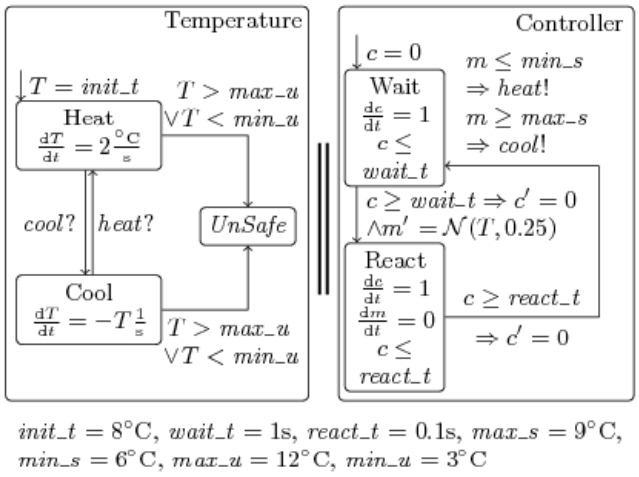

Figure 1: Model of the Temperature Control System

air conditioning control system we are able to keep the temperature of a room within a certain range. In contrast to the water level case study, we use a non-linear model of the temperature evolution, and instead of varying the splitting of the normal distribution, we vary the refine interval used by *PHAVer* [3] to analyse non-linear hybrid systems. A smaller refine interval leads to a more precise abstraction of the state-space.

Time bound	Interval length ∞			Interval length 2		
	Prob.	Build (s)	States	Prob.	Build (s)	States
2s	1	0.03	7	0	0.17	16
4s	1	0.05	23	1	1.26	269
6s	1	0.07	39	1	5.79	1518
8s	1	0.10	55	1	19.27	4655
10s	1	0.12	71	1	53.25	10442

Time bound	Interval length 1			Interval length 0.5		
	Prob.	Build (s)	States	Prob.	Build (s)	States
2s	0	0.21	21	0	0.30	31
4s	0.284643	1.61	316	0.284643	2.97	546
6s	0.360221	8.66	2233	0.360221	17.39	3797
8s	1	35.62	8261	0.488265	81.39	16051
10s	1	119.33	20578	0.590683	507.12	44233

Table 1: Temperature control results. To abstract $N(T, 0.25)$, we used $T + \{[-0.25, 0.25], (-\infty, -0.25], [0.25, \infty]\}$

2 Results

We applied *ProHVer* [2] to this model and give the probability bounds and performance statistics in Table 1. We used a refine interval on variable T which models the temperature. The interval lengths are also given in the table. For all instances there is an interval length small enough to obtain a probability bound that is the best possible, using the given abstraction of the normal distribution. Smaller intervals were of no use in this case. The drastic discontinuities in probability bounds obtained are a consequence of non-linearity, and abstraction by *PHAVer*.

References

[1] Rajeev Alur, Thao Dang, and Franjo Ivancic. Predicate abstraction for reachability analysis of hybrid systems. *ACM Transactions on Embedded Computing Systems*, 5(1):152–199, 2006.

[2] Martin Fränzle, Ernst Moritz Hahn, Holger Hermanns, Nicolás Wolovick, and Lijun Zhang. Measurability and safety verification for stochastic hybrid systems. In *HSCC*, pages 43–52, New York, NY, USA, 2011. ACM Press.

[3] Goran Frehse. PHAVer: Algorithmic Verification of Hybrid Systems Past HyTech. pages 258–273. Springer, 2005.

[4] Lijun Zhang, Zhikun She, Stefan Ratschan, Holger Hermanns, and Ernst Moritz Hahn. Safety verification for probabilistic hybrid systems. In *CAV*, volume 6174 of *LNCS*, pages 196–211. Springer, 2010.