State Classes vs Essential States

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Kosmos Workshop, Berlin, November 29, 2013

Finding Essential States in State Classes

Approximately

Essential states are the discrete points in state classes

Not quite ...

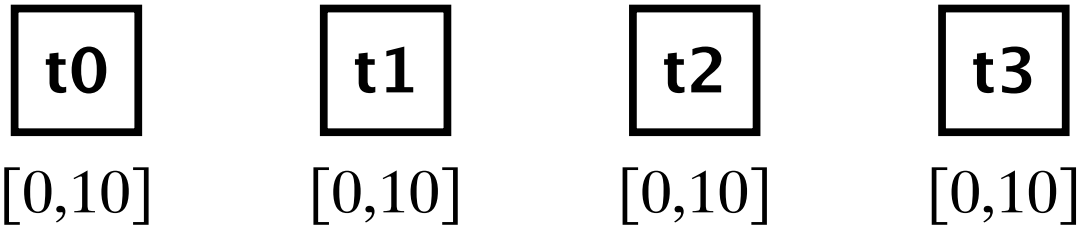
Not all discrete states are essential states

State classes denote firing domains, not clock domains.

But one can bijectively map discrete states to discrete points in classes (when right endpoints of intervals are finite)

Example 0010

Consider the net :



Sizes

1 state class, 4 transitions

$(10+1)^4 = 14641$ discrete states

but 4641 essential states

Example 0710

Consider the net :

Same with intervals $[7, 10]$

Sizes

89687 state classes

4641 essential states

Why ?

Counting integer states in classes

number of integer points in union of classes (per marking)

= number of discrete states

0010 example

a single class (a single marking, sc partitions the state space)

0710 example

same essential states appear in many classes (sc covers sp)

from 0010 to 1010

Interval	*ES*	*SC*
$0, 10$	$4641/58564$	$1/4$
$1, 10$	$4641/53240$	$10175/38872$
$2, 10$	$4641/47916$	$2245/8352$
$3, 10$	$4641/42592$	$28563/99192$
$4, 10$	$4641/37268$	$4791/16312$
$5, 10$	$4641/31944$	$415/1464$
$6, 10$	$4641/26620$	$8249/25556$
$7, 10$	$4641/21296$	$89687/255628$
$8, 10$	$4641/15972$	$12751/36480$
$9, 10$	$4641/10648$	$144591/375120$
$10, 10$	$15/32$	$15/32$

scaling intervals

Interval	*ES*	*SC*
$0, 10$	$4641/58564$	$1/4$
$2, 10$	$4641/47916$	$2245/8352$
$4, 10$	$4641/37268$	$4791/16312$
$6, 10$	$4641/26620$	$8249/25556$
$8, 10$	$4641/15972$	$12751/36480$

Interval $*$ 5	*ES*	*SC*
$0, 50$	$515201/27060804$	$1/4$
$10, 50$	$515201/21754764$	$2245/8352$
$20, 50$	$515201/16448724$	$4791/16312$
$30, 50$	$515201/11142684$	$8249/25556$
$40, 50$	$515201/5836644$	$12751/36480$

Observations (preliminary !)

Essential States

+ implementation easy
+ compatible with “symbolic” exploration methods (bdd style)
- does not handle open bounds, priorities (could however)

: non-deterministic construction

best when small lft’s

State Classes

+ natively handles open bounds ; variant handles priorities
+ variety of possible abstractions
- “symbolic” exploration difficult

: deterministic construction ; covers state space rather than partitions

best when eft = 0, lft/eft small, lft and eft not relatively prime

Observations ...

Essential States

If semantics is discrete time, preserves :

markings and traces (LTL)
branching properties, CTL and liveness in particular

If semantics is dense time (ES seen as an abstraction) :

preserves LTL [if no open bounds nor priorities] but not CTL

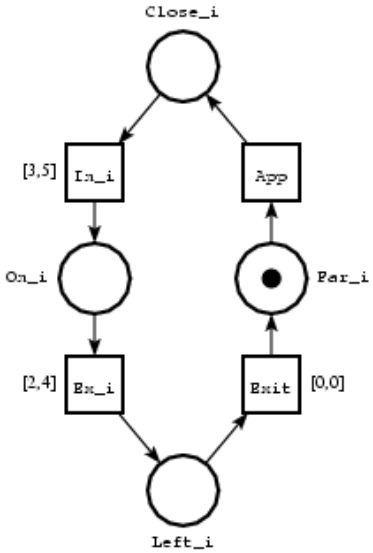
State Classes

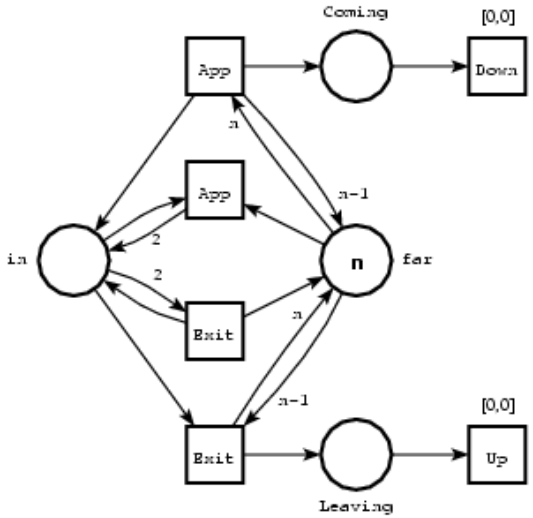
Basic construction preserves markings and traces (LTL)

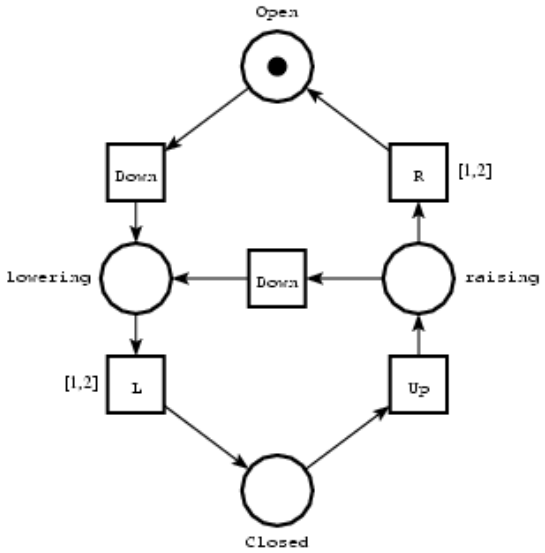
Variants available that preserve either :

markings only
states only
states and traces
states and branching properties

Level crossing







		M tina -M	*M* + *LTL* tina -W	*E* tina -E	*E* + *LTL* tina -S	*E* + *CTL* tina -A	*M* + *LTL* (*discret*) tina -D	*M* + *LTL* (*discret*) tina -F
(1 *train*)	*Classes*	10	11	10	11	12	13	23
	Transitions	13	14	13	14	16	27	36
(2 *trains*)	*Classes*	37	123	41	141	195	116	382
	Transitions	74	218	82	254	849	198	373
(3 *trains*)	*Classes*	172	3101	232	5051	6973	1550	2280
	Transitions	492	7754	672	13019	49818	5823	5275
(4 *trains*)	*Classes*	1175	134501	1807	351271	356940	22268	28830
	Transitions	4534	436896	7062	1193376	1447835	91256	81077
(5 *trains*)	*Classes*	10972	8557621	18052	35945411	23081275	313214	372264
	Transitions	53766	34337748	89166	151908273	279572133	1397517	1245355
(6 *trains*)	*Classes*	128115	697913229	217647	?	?	4299116	4830558
	Transitions	760538	3334109864	1297730	?	?	20886774	18833697