

GreatSPN & MC4CSL^{TA}

Corso di
Linguaggi e Modelli Computazionali LM

26 ottobre 2013

- 1 GreatSPN
 - Modellazione
 - Analisi

- 2 $MC4CSL^{TA}$
 - Analisi

Reti di Petri - PNs

Una rete di Petri è descrivibile da una tupla di cinque elementi: (P, T, I, O, H)

- P : insieme di Places
- T : insieme di Transizioni
- I : insieme degli archi entranti da places a transizioni $I: T \rightarrow Bag(P)$
- O : insieme degli archi di uscita da transizioni a places $O: T \rightarrow Bag(P)$
- H : insieme degli archi inibitori da places a transizioni $H: T \rightarrow Bag(P)$
(vi è al più un arco inibitore da un place P a una transizione T)

Si definisce *marking* una funzione $M: P \rightarrow \{0, 1, 2, \dots\}$, con M_0 *marking iniziale* la distribuzione dei tokens all'interno dei places.

Definiscono *Reachability Set* (RS) e *Reachability Graph* (RG)

Reti di Petri Stocastiche - SPNs

Estensione della formulazione precedente: (P, T, I, O, H, W, M_0)

- W : introduzione di aspetti temporali $W: T \rightarrow R^+$, il ritardo associato alla transizione è una variabile aleatoria distribuita come un esponenziale negativo con rate $W(t) \rightarrow$ proprietà dell'*assenza di memoria*.

Le SPNs sono isomorfe alle catene di Markov tempo continue (CTMCs).
Il RG è etichettato anche con il *rate* di transizione.

Reti di Petri Generalizzate - GSPNs

- introducono gli archi inibitori
- sono SPNs in cui vi sono transizioni che scattano in tempo nullo: *transizioni immediate*. Si distinguono da quelle *temporizzate* che hanno un ritardo di scatto una volta che sono state abilitate
- il marking nel RS può essere di due tipi: *vanishing* o *tangible*.

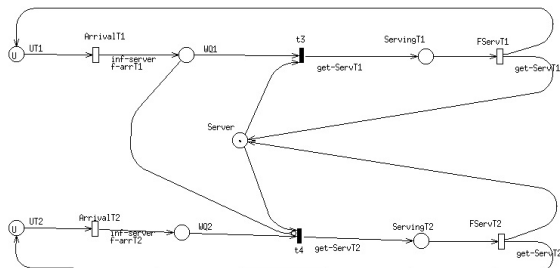
Reti di Petri Colorate

- estensione delle SPNs
- consentono una rappresentazione compatta e parametrica dei sistemi simmetrici
- i tokens non sono più indistinguibili, si possono creare dei domini colorati

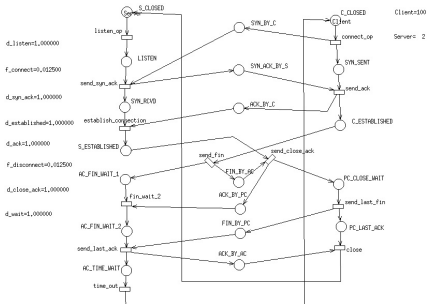
Caso di studio: sistema a coda M/M/1

U= 10

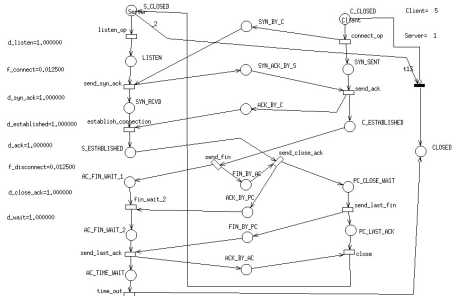
f-arrT1=0,500000
 f-arrT2=0,500000
 get-ServT1=0,750000
 get-ServT2=0,250000



Caso di studio: protocollo TCP



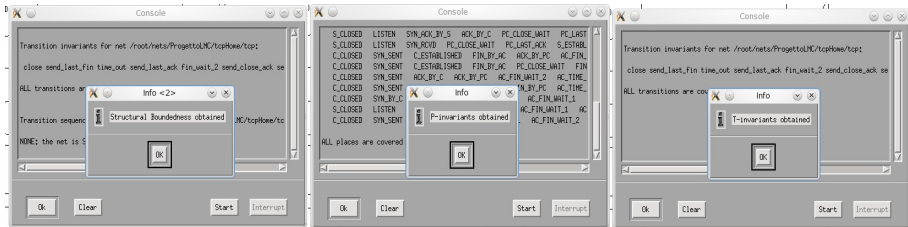
Caso di studio: protocollo TCP con perdita



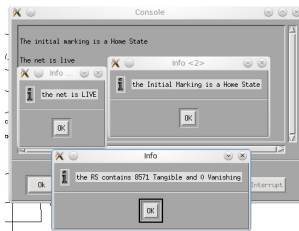
Strumenti

- Place invariants
- Transition invariants
- Structural Boundness
- Simulazione interattiva
- Computazione del Tangible Reachability Graph/Set (TRG/TRS)
- Computazione dell'Embedded Markov Chain (EMC)
- Risoluzione Steady State
- Risoluzione in Transitorio
- Model checking con ord_rgMEDD (logica CTL)

Proprietà strutturali



TRG e TRS



```
Initial marking is #5 :
[ 2 @ S_CLOSED, 15 @ C_CLOSED ]

*** Start of TRG ***

From #1 (2 timed trans) [ 2 @ S_CLOSED, 15 @ C_CLOSED ]
-Timed-> listen_op -to_tang-> #2
-Timed-> connect_ap (enabl=15) -to_tang-> #3

From #2 (2 timed trans) [ 5_C_CLOSED, 15 @ C_CLOSED, LISTEN ]
-Timed-> listen_op -to_tang-> #4
-Timed-> connect_ap (enabl=15) -to_tang-> #5

From #3 (2 timed trans) [ 2 @ S_CLOSED, 14 @ C_CLOSED, SYN_BY_C, SYN_SENT ]
-Timed-> listen_op -to_tang-> #5
-Timed-> connect_ap (enabl=14) -to_tang-> #6

From #4 (1 timed trans) [ 15 @ C_CLOSED, 2 @ LISTEN ]
-Timed-> connect_ap (enabl=15) -to_tang-> #7

From #5 (3 timed trans) [ 5_C_CLOSED, 14 @ C_CLOSED, SYN_BY_C, SYN_SENT, LISTEN ]
-Timed-> send_syn_ack -to_tang-> #6
-Timed-> listen_op -to_tang-> #7
-Timed-> connect_ap (enabl=14) -to_tang-> #6

From #6 (2 timed trans) [ 2 @ S_CLOSED, 13 @ C_CLOSED, 2 @ SYN_BY_C, 2 @ SYN_SENT ]
-Timed-> listen_op -to_tang-> #9
-Timed-> connect_ap (enabl=13) -to_tang-> #10

From #7 (2 timed trans) [ 14 @ C_CLOSED, SYN_BY_C, SYN_SENT, 2 @ LISTEN ]
-Timed-> send_syn_ack -to_tang-> #11
-Timed-> connect_ap (enabl=14) -to_tang-> #12

From #8 (3 timed trans) [ 5_C_CLOSED, 14 @ C_CLOSED, SYN_SENT, SYN_RECV, SYN_ACK_BY_S
```

```
Initial marking is #5 :
[ 2 @ S_CLOSED, 15 @ C_CLOSED ]

*** Start of TRG ***

From #1 (2 timed trans) [ 2 @ S_CLOSED, 15 @ C_CLOSED ]
-Timed-> listen_op -to_tang-> #2 [ 5_C_CLOSED, 15 @ C_CLOSED, LISTEN ]
-Timed-> connect_ap (enabl=15) -to_tang-> #3 [ 2 @ S_CLOSED, 14 @ C_CLOSED, SYN_BY_C, SYN_SENT ]

From #2 (2 timed trans) [ 5_C_CLOSED, 15 @ C_CLOSED, LISTEN ]
-Timed-> listen_op -to_tang-> #4 [ 15 @ C_CLOSED, 2 @ LISTEN ]
-Timed-> connect_ap (enabl=15) -to_tang-> #5 [ 5_C_CLOSED, 14 @ C_CLOSED, SYN_BY_C, SYN_SENT, LISTEN ]

From #3 (3 timed trans) [ 2 @ S_CLOSED, 14 @ C_CLOSED, SYN_BY_C, SYN_SENT ]
-Timed-> listen_op -to_tang-> #5 [ 5_C_CLOSED, 14 @ C_CLOSED, SYN_BY_C, SYN_SENT, LISTEN ]
-Timed-> connect_ap (enabl=14) -to_tang-> #6 [ 2 @ S_CLOSED, 13 @ C_CLOSED, 2 @ SYN_BY_C, 2 @ SYN_SENT ]

From #4 (1 timed trans) [ 15 @ C_CLOSED, 2 @ LISTEN ]
-Timed-> connect_ap (enabl=15) -to_tang-> #7 [ 14 @ C_CLOSED, SYN_BY_C, SYN_SENT, 2 @ LISTEN ]

From #5 (3 timed trans) [ 5_C_CLOSED, 14 @ C_CLOSED, SYN_BY_C, SYN_SENT, LISTEN ]
-Timed-> send_syn_ack -to_tang-> #6 [ 5_C_CLOSED, 14 @ C_CLOSED, SYN_SENT, SYN_RECV, SYN_ACK_BY_S ]
-Timed-> listen_op -to_tang-> #7 [ 14 @ C_CLOSED, SYN_BY_C, SYN_SENT, 2 @ LISTEN ]
-Timed-> connect_ap (enabl=14) -to_tang-> #6 [ 5_C_CLOSED, 13 @ C_CLOSED, 2 @ SYN_BY_C, 2 @ SYN_SENT, LISTEN ]

From #6 (2 timed trans) [ 2 @ S_CLOSED, 13 @ C_CLOSED, 2 @ SYN_BY_C, 2 @ SYN_SENT ]
-Timed-> listen_op -to_tang-> #9 [ 5_C_CLOSED, 13 @ C_CLOSED, 2 @ SYN_BY_C, 2 @ SYN_SENT, LISTEN ]
-Timed-> connect_ap (enabl=13) -to_tang-> #10 [ 2 @ S_CLOSED, 12 @ C_CLOSED, 3 @ SYN_BY_C, 3 @ SYN_SENT ]

From #7 (2 timed trans) [ 14 @ C_CLOSED, SYN_BY_C, SYN_SENT, 2 @ LISTEN ]
-Timed-> send_syn_ack -to_tang-> #11 [ 14 @ C_CLOSED, SYN_SENT, LISTEN, SYN_RECV, SYN_ACK_BY_S ]
-Timed-> connect_ap (enabl=14) -to_tang-> #12 [ 13 @ C_CLOSED, 2 @ SYN_BY_C, 2 @ SYN_SENT, 2 @ LISTEN ]
```

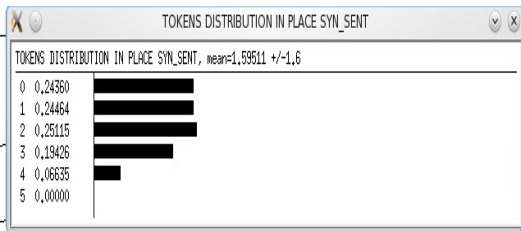
EMC e Analisi Steady State

```

>> to mark #8565, weight #154, 1 entries
    from mark #8561, rate #198
>> to mark #8566, weight #154, 3 entries
    from mark #8562, rate #154
    from mark #8563, rate #126
    from mark #8564, rate #198
>> to mark #8567, weight #198, 2 entries
    from mark #8564, rate #198
    from mark #8565, rate #154
>> to mark #8568, weight #154, 2 entries
    from mark #8566, rate #154
    from mark #8567, rate #198
>> to mark #8569, weight #154, 1 entries
    from mark #8567, rate #198
>> to mark #8570, weight #154, 2 entries
    from mark #8568, rate #154
    from mark #8569, rate #154
>> to mark #8571, weight #6, 1 entries
    from mark #8570, rate #154

229 rate values:
Double# 1 -> 0.842105
Double# 2 -> 0.157895
Double# 3 -> 0.851064
Double# 4 -> 0.148936
Double# 5 -> 5.333333
Double# 6 -> 1.000000
Double# 7 -> 0.459770
Double# 8 -> 0.080460

```



Model checking

**** E F(LISTEN > 0 or SYN_SENT > 0) ****

Evaluation: true

**** A X(LISTEN > 0 or SYN_SENT > 0) ****

Evaluation: true

**** A G(SYN_SENT > 0 $\rightarrow$ A F(C_ESTABLISHED > 0)) ****

Evaluation: true

**** A G(SYN_SENT > 0 $\rightarrow$ A F(S_ESTABLISHED > 0)) ****

Evaluation: true

**** A G(AC_FIN_WAIT_1 > 0 $\rightarrow$ A F(AC_TIME_WAIT > 0)) ****

Evaluation: true

**** A G not(SYN_RCVD > 2) ****

Evaluation: true

**** E F (CLOSED > 0) ****

Evaluation: true

**** E F(C_CLOSED = 0 and SYN_SENT > 0 and S_CLOSED = 0) ****

Evaluation: true

Model checking

```
./DSPN-Tool-Release -load
/User.../Progetto/Model/caso2/SingleServer-MultiUser-Prio -cslta
"#ServingT1>1" -wrsat statfile
./DSPN-Tool-Release -load
/Users.../Model/caso2/SingleServer-MultiUser-Prio -dta-path ../DTA/
-cslta PROB_TA > 0.10 until _0B (3 || #WQ1>=0, #ServingT1=1)
-wrsat mm1_ex1.txt
./DSPN-Tool-Release -load
/Users.../Model/caso2/SingleServer-MultiUser-Prio -dta-path ../DTA/
-cslta PROB_TA > 0.10 until _0B (1 || #WQ2>=0, #ServingT2=1)
-wrsat mm1_ex2.txt
./DSPN-Tool-Release -load
/Users.../Model/caso2/SingleServer-MultiUser-Prio -dta-path ../DTA/
-csltaN 10 PROB_TA > 0.10 until _0B (3 || #WQ1>=0,
#ServingT1=1) -wrsat forwardN_mm1_ex1.txt
./DSPN-Tool-Release -load
```

Model checking

```
./DSPN-Tool-Release -load /Users.../Model/casoTcp/tcp -cslta  
#C_ESTABLISHED>0 && #S_ESTABLISHED>0 -wrsat statfiletcp1.txt  
./DSPN-Tool-Release -load /Users.../Model/casoTcp/tcp -dta-path  
../DTA/ -cslta PROB_TA > 0.10 until_0B (3 || #SYN_SENT>0,  
#C_ESTABLISHED>0) -wrsat tcp_ex1.txt  
./DSPN-Tool-Release -load /Users.../Model/casoTcp/tcp -dta-path  
../DTA/ -cslta PROB_TA > 0.10 until_0B (3 || #SYN_SENT>0,  
#S_ESTABLISHED>0) -wrsat tcp_server_ex1.txt  
./DSPN-Tool-Release -load /Users.../Model/casoTcp/tcp -dta-path  
../DTA/ -cslta PROB_TA > 0.10 until_0B (3 ||  
#AC_FIN_WAIT_1>0, #AC_TIME_WAIT>0) -wrsat tcp_ex2.txt
```