

EURO 2000

(Robert Meolic, 2000, 2013)

The European football championship EURO 2000 held in Belgium and Netherlands serves us as an idea for a concurrent system. More precisely, only the matches played in group C will be observed. In each group, four teams played one match with each other. After each team had played all three matches, two teams with the most points continued to play in the quarterfinal of the championship, while the other two teams went home. If two or more teams had the same number of points, then other criteria were used to determine the final order of teams.

In group C, Slovenia, Yugoslavia, Spain, and Norway competed. There was a very interesting situation in this group and nobody really dared to forecast the two teams which would be the lucky ones. Slovenia and Norway are small countries in the football sense and they participated in the European football championship for the first time. Yugoslavia had a lot of good football players, but the quality of the team on the whole was unknown. The team from Spain was favourite, but football is a very unpredictable game.

Informally, the problem proposed as a benchmark study can be given as follows. The concurrent system consists of four football teams. In the first part of system execution, teams play a match with each other. Each match can end with a winner or in a tie. The winner of a match gets 3 points. If there is no winner, each team gets 1 point. In the second part of system execution, the points of all four teams are compared. Each team gets a label which reflects its place in the table. We take that if two teams have the same number of points, any of them can be the better one.

Properties of the described system that are interesting for us are:

- possible quadruples of points in the final table,
- the minimal number of points that can be enough to place in the quarterfinal,
- the minimal number of points and special situations which guarantee placing in the quarterfinal etc.

EST does not support CCS with data-passing, yet. Therefore, we annotated data in action names. We facilitated our work by introducing hierarchical process description, where each process can include references (gates) to other processes.

The first part of the EURO 2000 problem is represented by four processes, one for each team. The process represents sequential playing of three matches. After a process executes the first part of its task, it does not stop. With regard to the number of obtained points the process continues with execution of one of 9 possible processes SI(0), SI(1), ..., SI(7), SI(9). Actions win, tie, and lose has indices which are not random but they assure a fixed ordering of matches where only one game is possible in every system's state (we are not interested in examination of all possible different ordering because the system would have equal final states, just much more complex internal structure).

The second part of the EURO 2000 problem consists in sorting teams with regard to obtained points. Each process participates in comparisons which lead to the final

ordering. The teams are arranged into pairs A (Slovenia and Yugoslavia) and B (Spain and Norway). First, the points of the teams in a pair are compared. The team which is better becomes the winner (state W), while the other becomes the loser (state L). Because there is no data-passing in our process algebra, we need many transitions for one comparison. After the points are compared in pairs, the points of the winners and the points of the losers are compared. The teams which are both times the winner or the loser take the 1st place and the 4th place in the table, respectively. The points of the other two teams which were once a winner and once a loser are compared again to determine the 2nd and 3rd place.

Files **euro2000.sort**, **euro2000si.dat**, **euro2000yu.dat**, **euro2000es.dat**, and **euro2000no.dat** are (almost) original specification of the system. They are formed in such a way that the composition is minimal and thus the verification is efficient. The part of specification for Slovenia team is given here (please notice special character @ in the beginning of the state names @si0, ... @si9, it denotes gates, i.e. continuation of the specification in another process).

```

PROCESS si
SORT sortEuro
INITIAL STATE si
TRANSITIONS si = win1?.p0l + equal1?.p0e + lose1?.p0w
                p0l = silose!.p10
                p0e = siequal!.p11
                p0w = siwin!.p13
                p10 = win2?.p10l + equal2?.p10e + lose2?.p10w
                p11 = win2?.p11l + equal2?.p11e + lose2?.p11w
                p13 = win2?.p13l + equal2?.p13e + lose2?.p13w
                p10l = silose!.p20
                p10e = siequal!.p21
                p10w = siwin!.p23
                p11l = silose!.p21
                p11e = siequal!.p22
                p11w = siwin!.p24
                p13l = silose!.p23
                p13e = siequal!.p24
                p13w = siwin!.p26
                p20 = win3?.p20l + equal3?.p20e + lose3?.p20w
                p21 = win3?.p21l + equal3?.p21e + lose3?.p21w
                p22 = win3?.p22l + equal3?.p22e + lose3?.p22w
                p23 = win3?.p23l + equal3?.p23e + lose3?.p23w
                p24 = win3?.p24l + equal3?.p24e + lose3?.p24w
                p26 = win3?.p26l + equal3?.p26e + lose3?.p26w
                p20l = silose!.p30
                p20e = siequal!.p31
                p20w = siwin!.p33
                p21l = silose!.p31
                p21e = siequal!.p32
                p21w = siwin!.p34
                p22l = silose!.p32
                p22e = siequal!.p33
                p22w = siwin!.p35
                p23l = silose!.p33
                p23e = siequal!.p34
                p23w = siwin!.p36
                p24l = silose!.p34
                p24e = siequal!.p35

```

```

p24w = siwin!.p37
p26l = silose!.p36
p26e = siequal!.p37
p26w = siwin!.p39
p30 = si0points!.@si0
p31 = si1points!.@si1
p32 = si2points!.@si2
p33 = si3points!.@si3
p34 = si4points!.@si4
p35 = si5points!.@si5
p36 = si6points!.@si6
p37 = si7points!.@si7
p39 = si9points!.@si9

```

PROCESS si0

SORT sortEuro

INITIAL STATE si0

```

TRANSITIONS si0 = a0!.si0 + a0?.p2 + alose?.p4 + awin?.p5 +
                  a1?.p3 + a2?.p3 + a3?.p3 + a4?.p3 + a5?.p3 + a6?.p3 +
                  a7?.p3 + a8?.p3 + a9?.p3 + a10?.p3
p1 = awin!.p4
p2 = awin!.p4 + alose!.p5
p3 = alose!.p5

p4 = w0!.p4 + w0?.p7 + wlose?.p12 + wwin?.p13 +
      w1?.p8 + w2?.p8 + w3?.p8 + w4?.p8 + w5?.p8 + w6?.p8 +
      w7?.p8 + w8?.p8 + w9?.p8 + w10?.p8
p6 = wwin!.p12
p7 = wwin!.p12 + wlose!.p13
p8 = wlose!.p13

p5 = l0!.p5 + l0?.p10 + llose?.p13 + lwin?.p15 +
      l1?.p11 + l2?.p11 + l3?.p11 + l4?.p11 + l5?.p11 + l6?.p11 +
      l7?.p11 + l8?.p11 + l9?.p11 + l10?.p11
p9 = lwin!.p13
p10 = lwin!.p13 + llose!.p15
p11 = llose!.p15

p13 = lw0!.p13 + lw0?.p17 + lwlose?.p22 + lwwin?.p23 +
      lw1?.p18 + lw2?.p18 + lw3?.p18 + lw4?.p18 + lw5?.p18 +
      lw6?.p18 + lw7?.p18 + lw8?.p18 + lw9?.p18 + lw10?.p18
p16 = lwwin!.p22
p17 = lwwin!.p22 + lwlose!.p23
p18 = lwlose!.p23

p12 = si1!.stop
p22 = si2!.stop
p23 = si3!.stop
p15 = si4!.stop

```

Here is the log from executing euro2000-dat.tcl.

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Running on i686 (Linux, 3.2.0-38-generic-pae) with tcl 8.5.11 and tk 8.5.11.

Initialization of GUI package... OK
Initialization of BDD package... OK
Initialization of Process_Algebra package... OK

Initialization of Versis package... OK
Initialization of Model checking package... OK
Initialization of Strucval package... OK
Initialization of CCS package... OK
Ready.

>cd "/home/meolic/est/est-2ed/data/euro2000"; xsource "euro2000-dat.tcl"; cd "/home/meolic/est/est-2ed/data"

Reading file: euro2000.sort
Sort sortEuro ... OK

Reading file: euro2000si.dat
Process si ... OK
Process si0 ... OK
Process si1 ... OK
Process si2 ... OK
Process si3 ... OK
Process si4 ... OK
Process si5 ... OK
Process si6 ... OK
Process si7 ... OK
Process si8 ... OK
Process si9 ... OK
Process si10 ... OK

Reading file: euro2000yu.dat
Process yu ... OK
Process yu0 ... OK
Process yu1 ... OK
Process yu2 ... OK
Process yu3 ... OK
Process yu4 ... OK
Process yu5 ... OK
Process yu6 ... OK
Process yu7 ... OK
Process yu8 ... OK
Process yu9 ... OK
Process yu10 ... OK

Reading file: euro2000es.dat
Process es ... OK
Process es0 ... OK
Process es1 ... OK
Process es2 ... OK
Process es3 ... OK
Process es4 ... OK
Process es5 ... OK
Process es6 ... OK
Process es7 ... OK
Process es8 ... OK
Process es9 ... OK
Process es10 ... OK

Reading file: euro2000no.dat
Process no ... OK
Process no0 ... OK
Process no1 ... OK
Process no2 ... OK
Process no3 ... OK
Process no4 ... OK
Process no5 ... OK
Process no6 ... OK
Process no7 ... OK
Process no8 ... OK
Process no9 ... OK
Process no10 ... OK

WARNING: unreachable state p1<si0>
WARNING: unreachable state p6<si0>
WARNING: unreachable state p9<si0>
WARNING: unreachable state p16<si0>
WARNING: unreachable state p1<yu0>
WARNING: unreachable state p6<yu0>
WARNING: unreachable state p9<yu0>
WARNING: unreachable state p16<yu0>

WARNING: unreachable state p1<es0>
WARNING: unreachable state p6<es0>
WARNING: unreachable state p9<es0>
WARNING: unreachable state p16<es0>
WARNING: unreachable state p1<no0>
WARNING: unreachable state p6<no0>
WARNING: unreachable state p9<no0>
WARNING: unreachable state p16<no0>
Parallel composition (1): EURODAT...

composition EURODAT
pa_comp_state_number: 143292
pa_comp_transition_number: 378378
pa_comp_transition_visible: 260012

ACTL/ACTLW model checking on composition EURODAT
EEF {si0points!} ==> TRUE
Witness: (TAU)(silose!)(TAU)(silose!)(TAU)(silose!)(si0points!)
Spin trail generated and saved into file wc.out
MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURODAT
EEF {si1points!} ==> TRUE
Witness: (TAU)(siequal!)(TAU)(silose!)(TAU)(silose!)(si1points!)
Spin trail generated and saved into file wc.out
MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURODAT
EEF {si2points!} ==> TRUE
Witness: (TAU)(siequal!)(TAU)(silose!)(TAU)(siequal!)(si2points!)
Spin trail generated and saved into file wc.out
MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURODAT
EEF {si3points!} ==> TRUE
Witness: (TAU)(siequal!)(TAU)(siequal!)(TAU)(siequal!)(si3points!)
Spin trail generated and saved into file wc.out
MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURODAT
EEF {si4points!} ==> TRUE
Witness: (TAU)(siequal!)(TAU)(siwin!)(TAU)(silose!)(si4points!)
Spin trail generated and saved into file wc.out
MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURODAT
EEF {si5points!} ==> TRUE
Witness: (TAU)(siequal!)(TAU)(siwin!)(TAU)(siequal!)(si5points!)
Spin trail generated and saved into file wc.out
MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURODAT
EEF {si6points!} ==> TRUE
Witness: (TAU)(silose!)(TAU)(siwin!)(TAU)(siwin!)(si6points!)
Spin trail generated and saved into file wc.out
MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURODAT
EEF {si7points!} ==> TRUE
Witness: (TAU)(siequal!)(TAU)(siwin!)(TAU)(siwin!)(si7points!)
Spin trail generated and saved into file wc.out
MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURODAT
EEF {si9points!} ==> TRUE
Witness: (TAU)(siwin!)(TAU)(siwin!)(TAU)(siwin!)(si9points!)
Spin trail generated and saved into file wc.out
MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURODAT
AAF {si0points! OR si1points! OR si2points! OR si3points! OR si4points! OR si5points! OR si6points!
OR si7points! OR si9points!} ==> TRUE
Witness not generated.

ACTL/ACTLW model checking on composition EURODAT

EEF {si1!} ==> TRUE
Witness: (TAU)(yuequal!)(siequal!)(TAU)(siwin!)(TAU)(siwin!)(eslose!)(si7points!)(nolose!)(TAU)
(yuwin!)(TAU)(yuequal!)(yu5points!)(TAU)(TAU)(esequal!)(nolose!)(TAU)(eswin!)(es4points!)(nolose!)
(no0points!)(TAU)(TAU)(TAU)(TAU)(si1!)
Spin trail generated and saved into file wc.out
MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURODAT
EEF {si2!} ==> TRUE
Witness: (TAU)(yuequal!)(siequal!)(TAU)(siwin!)(TAU)(siwin!)(eslose!)(si7points!)(nolose!)(TAU)
(yuwin!)(TAU)(eslose!)(yuwin!)(yu7points!)(TAU)(TAU)(nolose!)(TAU)(noequal!)(no1points!)(esequal!)
(es1points!)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(si2!)
Spin trail generated and saved into file wc.out
MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURODAT
EEF {si3!} ==> TRUE
Witness: (TAU)(yuequal!)(siequal!)(TAU)(siwin!)(TAU)(eslose!)(silose!)(si4points!)(nowin!)(TAU)
(yuwin!)(TAU)(yuequal!)(yu5points!)(TAU)(TAU)(esequal!)(nolose!)(TAU)(eswin!)(es4points!)(nolose!)
(no3points!)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(si3!)
Spin trail generated and saved into file wc.out
MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURODAT
EEF {si4!} ==> TRUE
Witness: (TAU)(yuequal!)(siequal!)(TAU)(siwin!)(TAU)(eslose!)(silose!)(si4points!)(nowin!)(TAU)
(yuwin!)(TAU)(eswin!)(yulose!)(yu4points!)(TAU)(TAU)(nolose!)(TAU)(noequal!)(esequal!)(es4points!)
(no4points!)(TAU)(TAU)(TAU)(TAU)(si4!)
Spin trail generated and saved into file wc.out
MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURODAT
AAF {si1! OR si2! OR si3! OR si4!} ==> TRUE
Witness not generated.

ACTL/ACTLW model checking on composition EURODAT
AAG [si1!] NOT EEF {yu1! OR es1! OR no1!} ==> TRUE
Witness not generated.

ACTL/ACTLW model checking on composition EURODAT
AAG [si2!] NOT EEF {yu2! OR es2! OR no2!} ==> TRUE
Witness not generated.

ACTL/ACTLW model checking on composition EURODAT
AAG [si3!] NOT EEF {yu3! OR es3! OR no3!} ==> TRUE
Witness not generated.

ACTL/ACTLW model checking on composition EURODAT
AAG [si4!] NOT EEF {yu4! OR es4! OR no4!} ==> TRUE
Witness not generated.

ACTL/ACTLW model checking on composition EURODAT
EEF <si2points!> <yu4points!> <es6points!> <no4points!> true ==> TRUE
Witness: (TAU)(yuequal!)(siequal!)(TAU)(eswin!)(silose!)(TAU)(noequal!)(TAU)(siequal!)(yuwin!)(TAU)
(eswin!)(yulose!)(nolose!)(TAU)(eslose!)(nowin!)(si2points!)(yu4points!)(es6points!)(no4points!)
Spin trail generated and saved into file wc.out
MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURODAT
EEF {si2points!} EEF {si1! OR si2!} ==> TRUE
Witness: (TAU)(siequal!)(TAU)(silose!)(TAU)(siequal!)(si2points!)(yuequal!)(eswin!)(noequal!)(TAU)
(yuequal!)(TAU)(eswin!)(noequal!)(TAU)(eswin!)(es9points!)(yulose!)(yu2points!)(TAU)(TAU)(nolose!)
(no2points!)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(si2!)
Spin trail generated and saved into file wc.out
MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURODAT
AAG [si7points!] AAF {si1! OR si2!} ==> TRUE
Witness not generated.

ACTL/ACTLW model checking on composition EURODAT
AAG [es7points! OR es9points!] AAG [si5points!] AAF {si1! OR si2!} ==> TRUE
Witness not generated.

ACTL/ACTLW model checking on composition EURODAT

```

AAG [siwin!] AAG [siequal!] AAG [siequal!] AAG [yu1points! OR yu2points! OR yu3points! OR yu4points!
OR yu5points! OR yu6points!] AAF {si1! OR si2!} ==> TRUE
Witness not generated.

```

Here are some data about timing on Intel Atom D525 with 2GB RAM:

```

[CPU]pa_read_process euro2000.sort[CPU: 19ms]
[CPU]pa_read_process euro2000si.dat[CPU: 68ms]
[CPU]pa_read_process euro2000yu.dat[CPU: 69ms]
[CPU]pa_read_process euro2000es.dat[CPU: 79ms]
[CPU]pa_read_process euro2000no.dat[CPU: 64ms]
[CPU]pa_encode_process {si yu es no}[CPU: 171ms]
[CPU]versis_compose 1 EURODAT {si yu es no} {si1 si2 si3 si4 yu1 yu2 yu3 yu4 es1
es2 es3 es4 no1 no2 no3 no4 siwin siequal silose yuwin yuequal yulose eswin
esequal eslose nowin noequal nolose si0points si1points si2points si3points
si4points si5points si6points si7points si9points yu0points yu1points
yu2points yu3points yu4points yu5points yu6points yu7points yu9points
es0points es1points es2points es3points es4points es5points es6points es7points
es9points no0points no1points no2points no3points no4points no5points
no6points no7points no9points}[CPU: 9013ms]
[CPU]mc_read_actl_file euro2000.actl[CPU: 1ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F1 16[CPU: 129ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F2 16[CPU: 234ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F3 16[CPU: 201ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F4 16[CPU: 252ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F5 16[CPU: 303ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F6 16[CPU: 171ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F7 16[CPU: 159ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F8 16[CPU: 164ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F9 16[CPU: 84ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F10 16[CPU: 33539ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F11 16[CPU: 8801ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F12 16[CPU: 12951ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F13 16[CPU: 13209ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F14 16[CPU: 5640ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F15 16[CPU: 41289ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F16 16[CPU: 18403ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F17 16[CPU: 19620ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F18 16[CPU: 20359ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F19 16[CPU: 18649ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F20 16[CPU: 255ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F21 16[CPU: 17703ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F22 16[CPU: 25645ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F23 16[CPU: 28496ms]
[CPU]mc_check_actl 1 EURODAT euro2000.actl_F24 16[CPU: 39016ms]

```

Files **euro2000.ccs** and **euro2000-net.ccs** are alternative specification using CCS. They are more elegant but much less efficient. Here is the complete description of processes.

```
/* PART ONE: PLAY MATCHES */
```

```

TEAM   = play1?.(win1?.win!.TEAM13 + lose1?.lose!.TEAM10 +
equal1?.equal!.TEAM11)
TEAM10 = play2?.(win2?.win!.TEAM23 + lose2?.lose!.TEAM20 +
equal2?.equal!.TEAM21)
TEAM11 = play2?.(win2?.win!.TEAM24 + lose2?.lose!.TEAM21 +
equal2?.equal!.TEAM22)
TEAM13 = play2?.(win2?.win!.TEAM26 + lose2?.lose!.TEAM23 +

```

```

equal2?.equal!.TEAM24)
TEAM20 = play3?.(win3?.win!.TEAM33 + lose3?.lose!.TEAM30 +
equal3?.equal!.TEAM31)
TEAM21 = play3?.(win3?.win!.TEAM34 + lose3?.lose!.TEAM31 +
equal3?.equal!.TEAM32)
TEAM22 = play3?.(win3?.win!.TEAM35 + lose3?.lose!.TEAM32 +
equal3?.equal!.TEAM33)
TEAM23 = play3?.(win3?.win!.TEAM36 + lose3?.lose!.TEAM33 +
equal3?.equal!.TEAM34)
TEAM24 = play3?.(win3?.win!.TEAM37 + lose3?.lose!.TEAM34 +
equal3?.equal!.TEAM35)
TEAM26 = play3?.(win3?.win!.TEAM39 + lose3?.lose!.TEAM36 +
equal3?.equal!.TEAM37)
TEAM30 = points0!.team0!.STOP
TEAM31 = points1!.team1!.STOP
TEAM32 = points2!.team2!.STOP
TEAM33 = points3!.team3!.STOP
TEAM34 = points4!.team4!.STOP
TEAM35 = points5!.team5!.STOP
TEAM36 = points6!.team6!.STOP
TEAM37 = points7!.team7!.STOP
TEAM39 = points9!.team9!.STOP

MATCH = go?.play!.play!.(win!.lose! + equal!.equal!).next!.STOP

/* PART TWO: FIND ORDERING */
/* THE STRUCTURE OF PROCESSES IS REPEATED */
/* ALTHOUGH NOT ALL CHOICES ARE POSSIBLE */
/* (E.G. YOU CAN NOT WIN WITH 0 POINTS) */
/* abcd = first comparison */
/* w = already better than another one */
/* l = already worst than another one */
/* x = better and then worst */
/* y = worst and then better */

ORDER = team0?.TEAM0 + team1?.TEAM1 + team2?.TEAM2 + team3?.TEAM3 +
team4?.TEAM4 + team5?.TEAM5 + team6?.TEAM6 + team7?.TEAM7 + team9?.TEAM9

/* TEAM HAS 0 POINTS */

TEAM0 = abcd0!.(abcdwin?.TEAM0WIN + abcdlose?.TEAM0LOSE)
TEAM0WIN = w0!.(wwin?.TEAM0WINWIN + wlose?.TEAM0X)
TEAM0LOSE = l0!.(lwin?.TEAM0Y + llose?.TEAM0LOSELOSE)
TEAM0X = x0!.(xwin?.TEAM0XYWIN + xlose?.TEAM0XYLOSE)
TEAM0Y = y0!.(ywin?.TEAM0XYWIN + ylose?.TEAM0XYLOSE)

/* TEAM HAS 1 POINT */

TEAM1 = abcd1!.(abcdwin?.TEAM1WIN + abcdlose?.TEAM1LOSE)
TEAM1WIN = w1!.(wwin?.TEAM1WINWIN + wlose?.TEAM1X)
TEAM1LOSE = l1!.(lwin?.TEAM1Y + llose?.TEAM1LOSELOSE)
TEAM1X = x1!.(xwin?.TEAM1XYWIN + xlose?.TEAM1XYLOSE)
TEAM1Y = y1!.(ywin?.TEAM1XYWIN + ylose?.TEAM1XYLOSE)

/* TEAM HAS 2 POINTS */

TEAM2 = abcd2!.(abcdwin?.TEAM2WIN + abcdlose?.TEAM2LOSE)
TEAM2WIN = w2!.(wwin?.TEAM2WINWIN + wlose?.TEAM2X)
TEAM2LOSE = l2!.(lwin?.TEAM2Y + llose?.TEAM2LOSELOSE)
TEAM2X = x2!.(xwin?.TEAM2XYWIN + xlose?.TEAM2XYLOSE)

```



```

TEAM2Y = y2!.(ywin?.TEAMXYWIN + ylose?.TEAMXYLOSE)

/* TEAM HAS 3 POINTS */

TEAM3 = abcd3!.(abcdwin?.TEAM3WIN + abcdlose?.TEAM3LOSE)
TEAM3WIN = w3!.(wwin?.TEAMWINWIN + wlose?.TEAM3X)
TEAM3LOSE = l3!.(lwin?.TEAM3Y + llose?.TEAMLOSELOSE)
TEAM3X = x3!.(xwin?.TEAMXYWIN + xlose?.TEAMXYLOSE)
TEAM3Y = y3!.(ywin?.TEAMXYWIN + ylose?.TEAMXYLOSE)

/* TEAM HAS 4 POINTS */

TEAM4 = abcd4!.(abcdwin?.TEAM4WIN + abcdlose?.TEAM4LOSE)
TEAM4WIN = w4!.(wwin?.TEAMWINWIN + wlose?.TEAM4X)
TEAM4LOSE = l4!.(lwin?.TEAM4Y + llose?.TEAMLOSELOSE)
TEAM4X = x4!.(xwin?.TEAMXYWIN + xlose?.TEAMXYLOSE)
TEAM4Y = y4!.(ywin?.TEAMXYWIN + ylose?.TEAMXYLOSE)

/* TEAM HAS 5 POINTS */

TEAM5 = abcd5!.(abcdwin?.TEAM5WIN + abcdlose?.TEAM5LOSE)
TEAM5WIN = w5!.(wwin?.TEAMWINWIN + wlose?.TEAM5X)
TEAM5LOSE = l5!.(lwin?.TEAM5Y + llose?.TEAMLOSELOSE)
TEAM5X = x5!.(xwin?.TEAMXYWIN + xlose?.TEAMXYLOSE)
TEAM5Y = y5!.(ywin?.TEAMXYWIN + ylose?.TEAMXYLOSE)

/* TEAM HAS 6 POINTS */

TEAM6 = abcd6!.(abcdwin?.TEAM6WIN + abcdlose?.TEAM6LOSE)
TEAM6WIN = w6!.(wwin?.TEAMWINWIN + wlose?.TEAM6X)
TEAM6LOSE = l6!.(lwin?.TEAM6Y + llose?.TEAMLOSELOSE)
TEAM6X = x6!.(xwin?.TEAMXYWIN + xlose?.TEAMXYLOSE)
TEAM6Y = y6!.(ywin?.TEAMXYWIN + ylose?.TEAMXYLOSE)

/* TEAM HAS 7 POINTS */

TEAM7 = abcd7!.(abcdwin?.TEAM7WIN + abcdlose?.TEAM7LOSE)
TEAM7WIN = w7!.(wwin?.TEAMWINWIN + wlose?.TEAM7X)
TEAM7LOSE = l7!.(lwin?.TEAM7Y + llose?.TEAMLOSELOSE)
TEAM7X = x7!.(xwin?.TEAMXYWIN + xlose?.TEAMXYLOSE)
TEAM7Y = y7!.(ywin?.TEAMXYWIN + ylose?.TEAMXYLOSE)

/* TEAM CANNOT HAVE 8 POINTS */

/* TEAM HAS 9 POINTS */

TEAM9 = abcd9!.(abcdwin?.TEAM9WIN + abcdlose?.TEAM9LOSE)
TEAM9WIN = w9!.(wwin?.TEAMWINWIN + wlose?.TEAM9X)
TEAM9LOSE = l9!.(lwin?.TEAM9Y + llose?.TEAMLOSELOSE)
TEAM9X = x9!.(xwin?.TEAMXYWIN + xlose?.TEAMXYLOSE)
TEAM9Y = y9!.(ywin?.TEAMXYWIN + ylose?.TEAMXYLOSE)

/* FINAL PLACE */

TEAMWINWIN = place1!.STOP
TEAMXYWIN = place2!.STOP
TEAMXYLOSE = place3!.STOP
TEAMLOSELOSE = place4!.STOP

/* COMPARE POINTS OF TWO TEAMS */

```

COMPARE = x0?.CMPX0 + x1?.CMPX1 + x2?.CMPX2 + x3?.CMPX3 + x4?.CMPX4 +
x5?.CMPX5 + x6?.CMPX6 + x7?.CMPX7 + x9?.CMPX9

CMPX0 = y0?.CMPEQU + (y1? + y2? + y3? + y4? + y5? + y6? + y7? + y9?).CMPY
 CMPX1 = y0?.CMPX + y1?.CMPEQU + (y2? + y3? + y4? + y5? + y6? + y7? + y9?).CMPY
 CMPX2 = (y0? + y1?).CMPX + y2?.CMPEQU + (y3? + y4? + y5? + y6? + y7? + y9?).CMPY
 CMPX3 = (y0? + y1? + y2?).CMPX + y3?.CMPEQU + (y4? + y5? + y6? + y7? + y9?).CMPY
 CMPX4 = (y0? + y1? + y2? + y3?).CMPX + y4?.CMPEQU + (y5? + y6? + y7? + y9?).CMPY
 CMPX5 = (y0? + y1? + y2? + y3? + y4?).CMPX + y5?.CMPEQU + (y6? + y7? + y9?).CMPY
 CMPX6 = (y0? + y1? + y2? + y3? + y4? + y5?).CMPX + y6?.CMPEQU + (y7? + y9?).CMPY
 CMPX7 = (y0? + y1? + y2? + y3? + y4? + y5? + y6?).CMPX + y7?.CMPEQU + y9?.CMPY
 CMPX7 = (y0? + y1? + y2? + y3? + y4? + y5? + y6? + y7?).CMPX + y9?.CMPEQU
 CMPEQU = (xwin!.ylose! + xlose!.ywin!).STOP
 CMPX = xwin!.ylose!.STOP
 CMPY = xlose!.ywin!.STOP

The system is obtained by composition of many instances of the given processes:

START = next1!.STOP

raw net EURO = //(START,

trace MATCH [next1/go][next2/next][match1/play][match1win/win][match1lose/lose]
[match1equal/equal],
 trace MATCH [next2/go][next3/next][match2/play][match2win/win][match2lose/lose]
[match2equal/equal],
 trace MATCH [next3/go][next4/next][match3/play][match3win/win][match3lose/lose]
[match3equal/equal],
 trace MATCH [next4/go][next5/next][match4/play][match4win/win][match4lose/lose]
[match4equal/equal],
 trace MATCH [next5/go][next6/next][match5/play][match5win/win][match5lose/lose]
[match5equal/equal],
 trace MATCH [next6/go][TAU/next][match6/play][match6win/win][match6lose/lose]
[match6equal/equal],

trace TEAM
[siwin/win][silose/lose][siequal/equal]
[match1/play1][match1win/win1][match1lose/lose1][match1equal/equal1]
[match2/play2][match2win/win2][match2lose/lose2][match2equal/equal2]
[match3/play3][match3win/win3][match3lose/lose3][match3equal/equal3]
[si0points/points0][si1points/points1][si2points/points2]
[si3points/points3][si4points/points4]
[si5points/points5][si6points/points6][si7points/points7]
[si9points/points9]
[si0p/team0][si1p/team1][si2p/team2][si3p/team3][si4p/team4][si5p/team5]
[si6p/team6][si7p/team7][si9p/team9],

trace TEAM
[yuwin/win][yulose/lose][yuequal/equal]
[match1/play1][match1win/win1][match1lose/lose1][match1equal/equal1]
[match4/play2][match4win/win2][match4lose/lose2][match4equal/equal2]
[match5/play3][match5win/win3][match5lose/lose3][match5equal/equal3]
[yu0points/points0][yu1points/points1][yu2points/points2]
[yu3points/points3][yu4points/points4]
[yu5points/points5][yu6points/points6][yu7points/points7]
[yu9points/points9]
[yu0p/team0][yu1p/team1][yu2p/team2][yu3p/team3][yu4p/team4][yu5p/team5]
[yu6p/team6][yu7p/team7][yu9p/team9],

```

trace TEAM
[eswin/win][eslose/lose][esequal/equal]
[match2/play1][match2win/win1][match2lose/lose1][match2equal/equal1]
[match5/play2][match5win/win2][match5lose/lose2][match5equal/equal2]
[match6/play3][match6win/win3][match6lose/lose3][match6equal/equal3]
[es0points/points0][es1points/points1][es2points/points2]
[es3points/points3][es4points/points4]
[es5points/points5][es6points/points6][es7points/points7]
[es9points/points9]
[es0p/team0][es1p/team1][es2p/team2][es3p/team3][es4p/team4][es5p/team5]
[es6p/team6][es7p/team7][es9p/team9],

trace TEAM
[nowin/win][nolose/lose][noequal/equal]
[match3/play1][match3win/win1][match3lose/lose1][match3equal/equal1]
[match4/play2][match4win/win2][match4lose/lose2][match4equal/equal2]
[match6/play3][match6win/win3][match6lose/lose3][match6equal/equal3]
[no0points/points0][no1points/points1][no2points/points2]
[no3points/points3][no4points/points4]
[no5points/points5][no6points/points6][no7points/points7]
[no9points/points9]
[no0p/team0][no1p/team1][no2p/team2][no3p/team3][no4p/team4][no5p/team5]
[no6p/team6][no7p/team7][no9p/team9],

/* e is the winner of the first pair (si,yu), g is the loser */
/* f is the winner of the second pair (es,no), h is the loser */

trace ORDER [si0p/team0][si1p/team1][si2p/team2][si3p/team3][si4p/team4]
[si5p/team5][si6p/team6][si7p/team7][si9p/team9]
[a0/abcd0][a1/abcd1][a2/abcd2][a3/abcd3][a4/abcd4][a5/abcd5][a6/abcd6]
[a7/abcd7][a9/abcd9][awin/abcdwin][alose/abcdlose]
[e0/w0][e1/w1][e2/w2][e3/w3][e4/w4][e5/w5][e6/w6][e7/w7][e9/w9][ewin/wwin]
[elose/wlose]
[g0/l0][g1/l1][g2/l2][g3/l3][g4/l4][g5/l5][g6/l6][g7/l7][g9/l9][gwin/lwin]
[glose/llose]
[si1/place1][si2/place2][si3/place3][si4/place4],

trace ORDER [yu0p/team0][yu1p/team1][yu2p/team2][yu3p/team3][yu4p/team4]
[yu5p/team5][yu6p/team6][yu7p/team7][yu9p/team9]
[b0/abcd0][b1/abcd1][b2/abcd2][b3/abcd3][b4/abcd4][b5/abcd5][b6/abcd6]
[b7/abcd7][b9/abcd9][bwin/abcdwin][blose/abcdlose]
[e0/w0][e1/w1][e2/w2][e3/w3][e4/w4][e5/w5][e6/w6][e7/w7][e9/w9][ewin/wwin]
[elose/wlose]
[g0/l0][g1/l1][g2/l2][g3/l3][g4/l4][g5/l5][g6/l6][g7/l7][g9/l9][gwin/lwin]
[glose/llose]
[yu1/place1][yu2/place2][yu3/place3][yu4/place4],

trace ORDER [es0p/team0][es1p/team1][es2p/team2][es3p/team3][es4p/team4]
[es5p/team5][es6p/team6][es7p/team7][es9p/team9]
[c0/abcd0][c1/abcd1][c2/abcd2][c3/abcd3][c4/abcd4][c5/abcd5][c6/abcd6]
[c7/abcd7][c9/abcd9][cwin/abcdwin][close/abcdlose]
[f0/w0][f1/w1][f2/w2][f3/w3][f4/w4][f5/w5][f6/w6][f7/w7][f9/w9][fwin/wwin]
[flose/wlose]
[h0/l0][h1/l1][h2/l2][h3/l3][h4/l4][h5/l5][h6/l6][h7/l7][h9/l9][hwin/lwin]
[hlose/llose]
[es1/place1][es2/place2][es3/place3][es4/place4],

trace ORDER [no0p/team0][no1p/team1][no2p/team2][no3p/team3][no4p/team4]
[no5p/team5][no6p/team6][no7p/team7][no9p/team9]

```

```

[d0/abcd0][d1/abcd1][d2/abcd2][d3/abcd3][d4/abcd4][d5/abcd5][d6/abcd6]
[d7/abcd7][d9/abcd9][dwin/abcdwin][dlose/abcdlose]
[f0/w0][f1/w1][f2/w2][f3/w3][f4/w4][f5/w5][f6/w6][f7/w7][f9/w9][fwin/wwin]
[flose/wlose]
[h0/l0][h1/l1][h2/l2][h3/l3][h4/l4][h5/l5][h6/l6][h7/l7][h9/l9][hwin/lwin]
[hlose/llose]
[no1/place1][no2/place2][no3/place3][no4/place4],

```

trace COMPARE

```

[a0/x0][a1/x1][a2/x2][a3/x3][a4/x4][a5/x5][a6/x6][a7/x7][a9/x9][awin/xwin]
[alose/xlose]
[b0/y0][b1/y1][b2/y2][b3/y3][b4/y4][b5/y5][b6/y6][b7/y7][b9/y9][bwin/ywin]
[blose/ylose],

```

trace COMPARE

```

[c0/x0][c1/x1][c2/x2][c3/x3][c4/x4][c5/x5][c6/x6][c7/x7][c9/x9][cwin/xwin]
[close/xlose]
[d0/y0][d1/y1][d2/y2][d3/y3][d4/y4][d5/y5][d6/y6][d7/y7][d9/y9][dwin/ywin]
[dlose/ylose],

```

trace COMPARE

```

[e0/x0][e1/x1][e2/x2][e3/x3][e4/x4][e5/x5][e6/x6][e7/x7][e9/x9][ewin/xwin]
[elose/xlose]
[f0/y0][f1/y1][f2/y2][f3/y3][f4/y4][f5/y5][f6/y6][f7/y7][f9/y9][fwin/ywin]
[flose/ylose],

```

trace COMPARE

```

[g0/x0][g1/x1][g2/x2][g3/x3][g4/x4][g5/x5][g6/x6][g7/x7][g9/x9][gwin/xwin]
[glose/xlose]
[h0/y0][h1/y1][h2/y2][h3/y3][h4/y4][h5/y5][h6/y6][h7/y7][h9/y9][hwin/ywin]
[hlose/ylose],

```

trace COMPARE

```

)\next1\next2\next3\next4\next5\next6
\match1\match1win\match1lose\match1equal
\match2\match2win\match2lose\match2equal
\match3\match3win\match3lose\match3equal
\match4\match4win\match4lose\match4equal
\match5\match5win\match5lose\match5equal
\match6\match6win\match6lose\match6equal
\si0p\si1p\si2p\si3p\si4p\si5p\si6p\si7p\si9p
\yu0p\yu1p\yu2p\yu3p\yu4p\yu5p\yu6p\yu7p\yu9p
\es0p\es1p\es2p\es3p\es4p\es5p\es6p\es7p\es9p
\no0p\no1p\no2p\no3p\no4p\no5p\no6p\no7p\no9p
\ao\ai\aa\aa3\aa4\aa5\aa6\aa7\aa9\awin\alose
\b0\b1\b2\b3\b4\b5\b6\b7\b9\bwin\blose
\c0\c1\c2\c3\c4\c5\c6\c7\c9\cwin\close
\d0\d1\d2\d3\d4\d5\d6\d7\d9\dwin\dlose
\e0\e1\e2\e3\e4\e5\e6\e7\ewin\elose
\f0\f1\f2\f3\f4\f5\f6\f7\f9\fwin\flose
\g0\g1\g2\g3\g4\g5\g6\g7\g9\gwin\glose
\h0\h1\h2\h3\h4\h5\h6\h7\h9\hwin\hlose
\x0\x1\x2\x3\x4\x5\x6\x7\x9\xwin\xlose
\y0\y1\y2\y3\y4\y5\y6\y7\y9\ywin\ylose

```

Here is the log from executing euro2000.tcl.

This is free software, and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute EST; type "license" for details.

Running on i686 (Linux, 3.2.0-38-generic-pae) with tcl 8.5.11 and tk 8.5.11.

Initialization of GUI package... OK
Initialization of BDD package... OK
Initialization of Process_Algebra package... OK
Initialization of Versis package... OK
Initialization of Model checking package... OK
Initialization of Strucval package... OK
Initialization of CCS package... OK
Ready.

```
>cd "/home/meolic/est/est-2ed/data/euro2000"; xsource "euro2000.tcl"; cd "/home/meolic/est/est-2ed/data"
```

Reading file: euro2000.ccs

Process TEAM ... OK
Process TEAM10 ... OK
Process TEAM11 ... OK
Process TEAM13 ... OK
Process TEAM20 ... OK
Process TEAM21 ... OK
Process TEAM22 ... OK
Process TEAM23 ... OK
Process TEAM24 ... OK
Process TEAM26 ... OK
Process TEAM30 ... OK
Process TEAM31 ... OK
Process TEAM32 ... OK
Process TEAM33 ... OK
Process TEAM34 ... OK
Process TEAM35 ... OK
Process TEAM36 ... OK
Process TEAM37 ... OK
Process TEAM39 ... OK
Process MATCH ... OK
Process ORDER ... OK
Process TEAM0 ... OK
Process TEAM0WIN ... OK
Process TEAM0LOSE ... OK
Process TEAM0X ... OK
Process TEAM0Y ... OK
Process TEAM1 ... OK
Process TEAM1WIN ... OK
Process TEAM1LOSE ... OK
Process TEAM1X ... OK
Process TEAM1Y ... OK
Process TEAM2 ... OK
Process TEAM2WIN ... OK
Process TEAM2LOSE ... OK
Process TEAM2X ... OK
Process TEAM2Y ... OK
Process TEAM3 ... OK
Process TEAM3WIN ... OK
Process TEAM3LOSE ... OK
Process TEAM3X ... OK
Process TEAM3Y ... OK
Process TEAM4 ... OK
Process TEAM4WIN ... OK
Process TEAM4LOSE ... OK
Process TEAM4X ... OK
Process TEAM4Y ... OK
Process TEAM5 ... OK
Process TEAM5WIN ... OK
Process TEAM5LOSE ... OK
Process TEAM5X ... OK
Process TEAM5Y ... OK
Process TEAM6 ... OK
Process TEAM6WIN ... OK
Process TEAM6LOSE ... OK
Process TEAM6X ... OK
Process TEAM6Y ... OK
Process TEAM7 ... OK
Process TEAM7WIN ... OK

```

Process TEAM7LOSE ... OK
Process TEAM7X ... OK
Process TEAM7Y ... OK
Process TEAM9 ... OK
Process TEAM9WIN ... OK
Process TEAM9LOSE ... OK
Process TEAM9X ... OK
Process TEAM9Y ... OK
Process TEAMWINWIN ... OK
Process TEAMXYWIN ... OK
Process TEAMXYLOSE ... OK
Process TEAMLOSELOSE ... OK
Process COMPARE ... OK
Process CMPX0 ... OK
Process CMPX1 ... OK
Process CMPX2 ... OK
Process CMPX3 ... OK
Process CMPX4 ... OK
Process CMPX5 ... OK
Process CMPX6 ... OK
Process CMPX7 ... OK
Process CMPX7 ... OK
Process CMPEQU ... OK
Process CMPX ... OK
Process CMPY ... OK

```

Reading file: euro2000-net.ccs

```

Process START ... OK
Parallel composition EURO ...
  minimization of process MATCH#1 ... (8s, 8t, 8v) -> (8s, 8t, 8v) OK
  minimization of process MATCH#2 ... (8s, 8t, 8v) -> (8s, 8t, 8v) OK
  minimization of process MATCH#3 ... (8s, 8t, 8v) -> (8s, 8t, 8v) OK
  minimization of process MATCH#4 ... (8s, 8t, 8v) -> (8s, 8t, 8v) OK
  minimization of process MATCH#5 ... (8s, 8t, 8v) -> (8s, 8t, 8v) OK
  minimization of process MATCH#6 ... (8s, 8t, 7v) -> (7s, 7t, 7v) OK
  minimization of process TEAM#1 ... (69s, 88t, 88v) -> (69s, 88t, 88v) OK
  minimization of process TEAM#2 ... (69s, 88t, 88v) -> (69s, 88t, 88v) OK
  minimization of process TEAM#3 ... (69s, 88t, 88v) -> (69s, 88t, 88v) OK
  minimization of process TEAM#4 ... (69s, 88t, 88v) -> (69s, 88t, 88v) OK
  minimization of process ORDER#1 ... (97s, 148t, 148v) -> (80s, 116t, 116v) OK
  minimization of process ORDER#2 ... (97s, 148t, 148v) -> (80s, 116t, 116v) OK
  minimization of process ORDER#3 ... (97s, 148t, 148v) -> (80s, 116t, 116v) OK
  minimization of process ORDER#4 ... (97s, 148t, 148v) -> (80s, 116t, 116v) OK
  minimization of process COMPARE#1 ... (18s, 89t, 89v) -> (15s, 87t, 87v) OK
  minimization of process COMPARE#2 ... (18s, 89t, 89v) -> (15s, 87t, 87v) OK
  minimization of process COMPARE#3 ... (18s, 89t, 89v) -> (15s, 87t, 87v) OK
  minimization of process COMPARE#4 ... (18s, 89t, 89v) -> (15s, 87t, 87v) OK
  minimization of process COMPARE#5 ... (18s, 89t, 89v) -> (15s, 87t, 87v) OK
  calculating composition ... OK

```

composition EURO

```

pa_comp_state_number: 644675
pa_comp_transition_number: 1961726
pa_comp_transition_visible: 881616

```

ACTL/ACTLW model checking on composition EURO

```

EEF {si0points!} ==> TRUE
Witness: (TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(silose!)(TAU)(TAU)(TAU)(TAU)(TAU)(silose!)(TAU)(TAU)
(TAU)(silose!)(si0points!)
Spin trail generated and saved into file wc.out
MSC generated and saved into file wc.msc

```

ACTL/ACTLW model checking on composition EURO

```

EEF {si1points!} ==> TRUE
Witness: (TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(silose!)(TAU)(TAU)(TAU)(TAU)(TAU)(silose!)(TAU)(TAU)
(siequal!)(si1points!)
Spin trail generated and saved into file wc.out
MSC generated and saved into file wc.msc

```

ACTL/ACTLW model checking on composition EURO

```

EEF {si2points!} ==> TRUE
Witness: (TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(silose!)(TAU)(TAU)(TAU)(TAU)(TAU)(siequal!)(TAU)(TAU)
(siequal!)(si2points!)
Spin trail generated and saved into file wc.out
MSC generated and saved into file wc.msc

```

ACTL/ACTLW model checking on composition EURO

EEF {si3points!} ==> TRUE

Witness: (TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(silose!)(TAU)(TAU)(TAU)(TAU)(TAU)(silose!)(TAU)(TAU)(siwin!)(si3points!)

Spin trail generated and saved into file wc.out

MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURO

EEF {si4points!} ==> TRUE

Witness: (TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(siwin!)(TAU)(TAU)(TAU)(TAU)(TAU)(silose!)(TAU)(TAU)(siequal!)(si4points!)

Spin trail generated and saved into file wc.out

MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURO

EEF {si5points!} ==> TRUE

Witness: (TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(siwin!)(TAU)(TAU)(TAU)(TAU)(TAU)(siequal!)(TAU)(TAU)(siequal!)(si5points!)

Spin trail generated and saved into file wc.out

MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURO

EEF {si6points!} ==> TRUE

Witness: (TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(siwin!)(TAU)(TAU)(TAU)(TAU)(TAU)(silose!)(TAU)(TAU)(siwin!)(si6points!)

Spin trail generated and saved into file wc.out

MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURO

EEF {si7points!} ==> TRUE

Witness: (TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(siwin!)(TAU)(TAU)(TAU)(TAU)(TAU)(siwin!)(TAU)(TAU)(siequal!)(si7points!)

Spin trail generated and saved into file wc.out

MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURO

EEF {si9points!} ==> TRUE

Witness: (TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(siwin!)(TAU)(TAU)(TAU)(TAU)(TAU)(siwin!)(TAU)(TAU)(siwin!)(si9points!)

Spin trail generated and saved into file wc.out

MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURO

AAF {si0points! OR si1points! OR si2points! OR si3points! OR si4points! OR si5points! OR si6points! OR si7points! OR si9points!} ==> TRUE

Witness not generated.

ACTL/ACTLW model checking on composition EURO

EEF {si1!} ==> TRUE

Witness: (TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(siwin!)(TAU)(TAU)(TAU)(TAU)(TAU)(eswin!)(yulose!)(silose!)(TAU)(TAU)(TAU)(TAU)(TAU)(siwin!)(si6points!)(TAU)(TAU)(nolose!)(TAU)(TAU)(TAU)(TAU)(TAU)(yuwin!)(TAU)(TAU)(TAU)(TAU)(yuwin!)(eslose!)(TAU)(yu6points!)(TAU)(TAU)(TAU)(TAU)(nolose!)(TAU)(TAU)(eswin!)(es6points!)(TAU)(TAU)(nolose!)(no0points!)(TAU)(TAU)(TAU)(TAU)(TAU)(si1!)

Spin trail generated and saved into file wc.out

MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURO

EEF {si2!} ==> TRUE

Witness: (TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(siwin!)(TAU)(TAU)(TAU)(TAU)(TAU)(eswin!)(yulose!)(silose!)(TAU)(TAU)(TAU)(TAU)(TAU)(siwin!)(si6points!)(TAU)(TAU)(nolose!)(TAU)(TAU)(TAU)(TAU)(TAU)(yuwin!)(TAU)(TAU)(TAU)(TAU)(yuwin!)(eslose!)(TAU)(yu6points!)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(nolose!)(TAU)(TAU)(TAU)(eswin!)(es6points!)(TAU)(TAU)(nolose!)(no0points!)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(si2!)

Spin trail generated and saved into file wc.out

MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURO

EEF {si3!} ==> TRUE

Witness: (TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(siwin!)(TAU)(TAU)(TAU)(TAU)(TAU)(eswin!)(yulose!)(silose!)(TAU)(TAU)(TAU)(TAU)(TAU)(siwin!)(si6points!)(TAU)(TAU)(nolose!)(TAU)(TAU)(TAU)(TAU)(TAU)(yuwin!)(TAU)(TAU)(TAU)(TAU)(yuwin!)(eslose!)(TAU)(yu6points!)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(nolose!)(TAU)(TAU)(TAU)(eswin!)(es6points!)(TAU)(TAU)(nolose!)(no0points!)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(si3!)

Spin trail generated and saved into file wc.out

MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURO

EEF {si4!} ==> TRUE

Witness: (TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(siwin!)(TAU)(TAU)(TAU)(TAU)(TAU)(eswin!)(yulose!)(silose!)(TAU)(TAU)(TAU)(TAU)(TAU)(nowin!)(TAU)(TAU)(TAU)(TAU)(TAU)(yuwin!)(TAU)(TAU)(TAU)(TAU)(TAU)(yuwin!)(eslose!)(TAU)(yu6points!)(TAU)(silose!)(si3points!)(TAU)(TAU)(TAU)(TAU)(TAU)(no!lose!)(TAU)(TAU)(TAU)(eslose!)(nowin!)(no6points!)(TAU)(es3points!)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(si4!)

Spin trail generated and saved into file wc.out

MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURO

AAF {si1! OR si2! OR si3! OR si4!} ==> FALSE

Counterexample: (TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(siwin!)(TAU)(TAU)(TAU)(TAU)(TAU)(eswin!)(yulose!)(silose!)(TAU)(TAU)(TAU)(TAU)(TAU)(siwin!)(si6points!)(TAU)(TAU)(no!lose!)(TAU)(TAU)(TAU)(TAU)(TAU)(yuwin!)(TAU)(TAU)(TAU)(TAU)(eswin!)(TAU)(yulose!)(yu3points!)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(no!lose!)(TAU)(TAU)(TAU)(TAU)(eswin!)(es9points!)(TAU)(TAU)(no!lose!)(no0points!)(TAU)

Spin trail generated and saved into file wc.out

MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURO

AAG [si1!] NOT EEF {yu1! OR es1! OR no1!} ==> TRUE

Witness not generated.

ACTL/ACTLW model checking on composition EURO

AAG [si2!] NOT EEF {yu2! OR es2! OR no2!} ==> TRUE

Witness not generated.

ACTL/ACTLW model checking on composition EURO

AAG [si3!] NOT EEF {yu3! OR es3! OR no3!} ==> TRUE

Witness not generated.

ACTL/ACTLW model checking on composition EURO

AAG [si4!] NOT EEF {yu4! OR es4! OR no4!} ==> TRUE

Witness not generated.

ACTL/ACTLW model checking on composition EURO

EEF <si2points!> <yu4points!> <es6points!> <no4points!> true ==> TRUE

Witness: (TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(siequal!)(TAU)(TAU)(TAU)(TAU)(TAU)(yuequal!)(eswin!)(silose!)(TAU)(TAU)(TAU)(TAU)(TAU)(noequal!)(TAU)(TAU)(TAU)(TAU)(TAU)(siequal!)(nowin!)(yulose!)(TAU)(TAU)(TAU)(TAU)(TAU)(yuwin!)(eslose!)(TAU)(TAU)(TAU)(eswin!)(no!lose!)(si2points!)(yu4points!)(es6points!)(no4points!)

Spin trail generated and saved into file wc.out

MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURO

EEF {si2points!} EEF {si1! OR si2!} ==> TRUE

Witness: (TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(siequal!)(TAU)(TAU)(TAU)(TAU)(TAU)(siequal!)(TAU)(TAU)(TAU)(silose!)(si2points!)(TAU)(TAU)(TAU)(yuequal!)(TAU)(nowin!)(TAU)(TAU)(TAU)(TAU)(nowin!)(yulose!)(TAU)(esequal!)(TAU)(TAU)(TAU)(TAU)(TAU)(yuequal!)(yu2points!)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(esequal!)(TAU)(TAU)(TAU)(eslose!)(es2points!)(TAU)(TAU)(nowin!)(no9points!)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(TAU)(si2!)

Spin trail generated and saved into file wc.out

MSC generated and saved into file wc.msc

ACTL/ACTLW model checking on composition EURO

AAG [si7points!] AAF {si1! OR si2!} ==> TRUE

Witness not generated.

ACTL/ACTLW model checking on composition EURO

AAG [es7points! OR es9points!] AAG [si5points!] AAF {si1! OR si2!} ==> TRUE

Witness not generated.

ACTL/ACTLW model checking on composition EURO

AAG [siwin!] AAG [siequal!] AAG [siequal!] AAG [yu1points! OR yu2points! OR yu3points! OR yu4points! OR yu5points! OR yu6points!] AAF {si1! OR si2!} ==> TRUE

Witness not generated.

Here are some data about timing on Intel Atom D525 with 2GB RAM:

[CPU]ccs_read euro2000.ccs[CPU: 405ms]

[CPU]ccs_read euro2000-net.ccs[CPU: 92801ms]


```

[CPU]mc_read_act1_file euro2000.act1[CPU: 1ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F1 16[CPU: 727ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F2 16[CPU: 1327ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F3 16[CPU: 1192ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F4 16[CPU: 1467ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F5 16[CPU: 1757ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F6 16[CPU: 2102ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F7 16[CPU: 1122ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F8 16[CPU: 1098ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F9 16[CPU: 475ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F10 16[CPU: 1441887ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F11 16[CPU: 84459ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F12 16[CPU: 149195ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F13 16[CPU: 167226ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F14 16[CPU: 88290ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F15 16[CPU: 1013449ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F16 16[CPU: 341770ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F17 16[CPU: 439713ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F18 16[CPU: 450515ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F19 16[CPU: 358894ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F20 16[CPU: 1619ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F21 16[CPU: 384582ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F22 16[CPU: 1002896ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F23 16[CPU: 1134202ms]
[CPU]mc_check_act1 1 EURO euro2000.act1_F24 16[CPU: 1335021ms]

```

File **euro2000-test.ccs** is used to compose system from two parts specified in **euro2000-net2.ccs**.

```

raw net EURO2 = //(MATCHES,ORDERING)
\si0p\si1p\si2p\si3p\si4p\si5p\si6p\si7p\si9p
\yu0p\yu1p\yu2p\yu3p\yu4p\yu5p\yu6p\yu7p\yu9p
\es0p\es1p\es2p\es3p\es4p\es5p\es6p\es7p\es9p
\no0p\no1p\no2p\no3p\no4p\no5p\no6p\no7p\no9p

```

We have tried to compare different solutions. Unfortunately, we are not able to check equivalence relations (the processes are huge). Here is the log from the part of **euro2000-test.tcl** (equivalence checking was commented out) .

```

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```

```

Running on x86_64 (Linux, 2.6.18-6-amd64) with tcl 8.4.12 and tk 8.4.12.

```

```

Initialization of GUI package... OK
Initialization of BDD package... OK
Initialization of Process_Algebra package... OK
Initialization of Versis package... OK
Initialization of Model checking package... OK
Initialization of Strucval package... OK
Initialization of CCS package... OK
Ready.

```

```

>cd "/home/meolic/est/est-2ed/data/euro2000"; source "euro2000-test.tcl"; cd "/home/meolic/est/est-2ed/data"

```

Reading file: euro2000.sort
Sort sortEuro ... OK

Reading file: euro2000si.dat
Process si ... OK
Process si0 ... OK
Process si1 ... OK
Process si2 ... OK
Process si3 ... OK
Process si4 ... OK
Process si5 ... OK
Process si6 ... OK
Process si7 ... OK
Process si8 ... OK
Process si9 ... OK
Process si10 ... OK

Reading file: euro2000yu.dat
Process yu ... OK
Process yu0 ... OK
Process yu1 ... OK
Process yu2 ... OK
Process yu3 ... OK
Process yu4 ... OK
Process yu5 ... OK
Process yu6 ... OK
Process yu7 ... OK
Process yu8 ... OK
Process yu9 ... OK
Process yu10 ... OK

Reading file: euro2000es.dat
Process es ... OK
Process es0 ... OK
Process es1 ... OK
Process es2 ... OK
Process es3 ... OK
Process es4 ... OK
Process es5 ... OK
Process es6 ... OK
Process es7 ... OK
Process es8 ... OK
Process es9 ... OK
Process es10 ... OK

Reading file: euro2000no.dat
Process no ... OK
Process no0 ... OK
Process no1 ... OK
Process no2 ... OK
Process no3 ... OK
Process no4 ... OK
Process no5 ... OK
Process no6 ... OK
Process no7 ... OK
Process no8 ... OK
Process no9 ... OK
Process no10 ... OK

WARNING: unreachable state p1<si0>
WARNING: unreachable state p6<si0>
WARNING: unreachable state p9<si0>
WARNING: unreachable state p16<si0>
WARNING: unreachable state p1<yu0>
WARNING: unreachable state p6<yu0>
WARNING: unreachable state p9<yu0>
WARNING: unreachable state p16<yu0>
WARNING: unreachable state p1<es0>
WARNING: unreachable state p6<es0>
WARNING: unreachable state p9<es0>
WARNING: unreachable state p16<es0>
WARNING: unreachable state p1<no0>
WARNING: unreachable state p6<no0>
WARNING: unreachable state p9<no0>
WARNING: unreachable state p16<no0>

Parallel composition (1): EURODAT...

composition EURODAT

pa_comp_state_number: 143292

pa_comp_transition_number: 378378

pa_comp_transition_visible: 260012

Reading file: euro2000.ccs

Process TEAM ... OK
Process TEAM10 ... OK
Process TEAM11 ... OK
Process TEAM13 ... OK
Process TEAM20 ... OK
Process TEAM21 ... OK
Process TEAM22 ... OK
Process TEAM23 ... OK
Process TEAM24 ... OK
Process TEAM26 ... OK
Process TEAM30 ... OK
Process TEAM31 ... OK
Process TEAM32 ... OK
Process TEAM33 ... OK
Process TEAM34 ... OK
Process TEAM35 ... OK
Process TEAM36 ... OK
Process TEAM37 ... OK
Process TEAM39 ... OK
Process MATCH ... OK
Process ORDER ... OK
Process TEAM0 ... OK
Process TEAM0WIN ... OK
Process TEAM0LOSE ... OK
Process TEAM0X ... OK
Process TEAM0Y ... OK
Process TEAM1 ... OK
Process TEAM1WIN ... OK
Process TEAM1LOSE ... OK
Process TEAM1X ... OK
Process TEAM1Y ... OK
Process TEAM2 ... OK
Process TEAM2WIN ... OK
Process TEAM2LOSE ... OK
Process TEAM2X ... OK
Process TEAM2Y ... OK
Process TEAM3 ... OK
Process TEAM3WIN ... OK
Process TEAM3LOSE ... OK
Process TEAM3X ... OK
Process TEAM3Y ... OK
Process TEAM4 ... OK
Process TEAM4WIN ... OK
Process TEAM4LOSE ... OK
Process TEAM4X ... OK
Process TEAM4Y ... OK
Process TEAM5 ... OK
Process TEAM5WIN ... OK
Process TEAM5LOSE ... OK
Process TEAM5X ... OK
Process TEAM5Y ... OK
Process TEAM6 ... OK
Process TEAM6WIN ... OK
Process TEAM6LOSE ... OK
Process TEAM6X ... OK
Process TEAM6Y ... OK
Process TEAM7 ... OK
Process TEAM7WIN ... OK
Process TEAM7LOSE ... OK
Process TEAM7X ... OK
Process TEAM7Y ... OK
Process TEAM9 ... OK
Process TEAM9WIN ... OK
Process TEAM9LOSE ... OK
Process TEAM9X ... OK
Process TEAM9Y ... OK
Process TEAMWINWIN ... OK

Process TEAMXYWIN ... OK
Process TEAMXYLOSE ... OK
Process TEAMLOSELOSE ... OK
Process COMPARE ... OK
Process CMPX0 ... OK
Process CMPX1 ... OK
Process CMPX2 ... OK
Process CMPX3 ... OK
Process CMPX4 ... OK
Process CMPX5 ... OK
Process CMPX6 ... OK
Process CMPX7 ... OK
Process CMPX7 ... OK
Process CMPEQU ... OK
Process CMPX ... OK
Process CMPY ... OK

Reading file: euro2000-net.ccs

Process START ... OK

Parallel composition EURO ...

minimization of process MATCH#1 ... (8s, 8t, 8v) -> (8s, 8t, 8v) OK
minimization of process MATCH#2 ... (8s, 8t, 8v) -> (8s, 8t, 8v) OK
minimization of process MATCH#3 ... (8s, 8t, 8v) -> (8s, 8t, 8v) OK
minimization of process MATCH#4 ... (8s, 8t, 8v) -> (8s, 8t, 8v) OK
minimization of process MATCH#5 ... (8s, 8t, 8v) -> (8s, 8t, 8v) OK
minimization of process MATCH#6 ... (8s, 8t, 7v) -> (7s, 7t, 7v) OK
minimization of process TEAM#1 ... (69s, 88t, 88v) -> (69s, 88t, 88v) OK
minimization of process TEAM#2 ... (69s, 88t, 88v) -> (69s, 88t, 88v) OK
minimization of process TEAM#3 ... (69s, 88t, 88v) -> (69s, 88t, 88v) OK
minimization of process TEAM#4 ... (69s, 88t, 88v) -> (69s, 88t, 88v) OK
minimization of process ORDER#1 ... (97s, 148t, 148v) -> (80s, 116t, 116v) OK
minimization of process ORDER#2 ... (97s, 148t, 148v) -> (80s, 116t, 116v) OK
minimization of process ORDER#3 ... (97s, 148t, 148v) -> (80s, 116t, 116v) OK
minimization of process ORDER#4 ... (97s, 148t, 148v) -> (80s, 116t, 116v) OK
minimization of process COMPARE#1 ... (18s, 89t, 89v) -> (15s, 87t, 87v) OK
minimization of process COMPARE#2 ... (18s, 89t, 89v) -> (15s, 87t, 87v) OK
minimization of process COMPARE#3 ... (18s, 89t, 89v) -> (15s, 87t, 87v) OK
minimization of process COMPARE#4 ... (18s, 89t, 89v) -> (15s, 87t, 87v) OK
minimization of process COMPARE#5 ... (18s, 89t, 89v) -> (15s, 87t, 87v) OK
calculating composition ... OK

composition EURO

pa_comp_state_number: 644675

pa_comp_transition_number: 1961726

pa_comp_transition_visible: 881616

Reading file: euro2000-net2.ccs

Parallel composition SORT ...

WARNING: Added empty process STOP ...OK

Process START ... OK

Net MATCHES

Composition ...

WARNING: two nets with the same sort!

minimization of process MATCH#7 ... (8s, 8t, 8v) -> (8s, 8t, 8v) OK
minimization of process MATCH#8 ... (8s, 8t, 8v) -> (8s, 8t, 8v) OK
minimization of process MATCH#9 ... (8s, 8t, 8v) -> (8s, 8t, 8v) OK
minimization of process MATCH#10 ... (8s, 8t, 8v) -> (8s, 8t, 8v) OK
minimization of process MATCH#11 ... (8s, 8t, 8v) -> (8s, 8t, 8v) OK
minimization of process MATCH#12 ... (8s, 8t, 7v) -> (7s, 7t, 7v) OK
minimization of process TEAM#5 ... (69s, 88t, 88v) -> (69s, 88t, 88v) OK
minimization of process TEAM#6 ... (69s, 88t, 88v) -> (69s, 88t, 88v) OK
minimization of process TEAM#7 ... (69s, 88t, 88v) -> (69s, 88t, 88v) OK
minimization of process TEAM#8 ... (69s, 88t, 88v) -> (69s, 88t, 88v) OK
calculating composition ... OK

Creating process MATCHES ... OK

Net ORDERING

Composition ...

WARNING: two nets with the same sort!

minimization of process ORDER#5 ... (97s, 148t, 148v) -> (80s, 116t, 116v) OK
minimization of process ORDER#6 ... (97s, 148t, 148v) -> (80s, 116t, 116v) OK
minimization of process ORDER#7 ... (97s, 148t, 148v) -> (80s, 116t, 116v) OK
minimization of process ORDER#8 ... (97s, 148t, 148v) -> (80s, 116t, 116v) OK
minimization of process COMPARE#6 ... (18s, 89t, 89v) -> (15s, 87t, 87v) OK

```

minimization of process COMPARE#7 ... (18s, 89t, 89v) -> (15s, 87t, 87v) OK
minimization of process COMPARE#8 ... (18s, 89t, 89v) -> (15s, 87t, 87v) OK
minimization of process COMPARE#9 ... (18s, 89t, 89v) -> (15s, 87t, 87v) OK
minimization of process COMPARE#10 ... (18s, 89t, 89v) -> (15s, 87t, 87v) OK
calculating composition ... OK
Creating process ORDERING ... OK

```

```

process MATCHES
pa_state_number: 229524
pa_transition_number: 778614
pa_transition_visible: 662039

```

```

process ORDERING
pa_state_number: 542262
pa_transition_number: 1460824
pa_transition_visible: 376611

```

```

Reading file: euro2000-test.ccs
Parallel composition EURO2 ...OK

```

```

composition EURO2
pa_comp_state_number: 644675
pa_comp_transition_number: 1961726
pa_comp_transition_visible: 881616

```

Here are statistics about BDD nodes after executing the whole **euro2000-test.tcl** (without equivalence relations). About 10 GB of RAM was used to perform all this operations (using Biddy 1.1 on 64-bit architecture).

```

Statistic about BDD package:
bdd_table_number: 44965354
bdd_table_max: 210000630
bdd_table_generated: 210000630
bdd_table_foa: 1494013899
bdd_table_add: 284973527
bdd_table_compare: 12670216116
bdd_block_number: 210
bdd_garbage_number: 24

```

File **euro2000-product.ccs** is for studying the usability of witness and counterexample automata.

```

property F1OUT == EEF {si0p!};
property F1IN == EEF {si0p?};

```

```

automaton MATCHES_F1 = F1OUT @ MATCHES
automaton ORDERING_F1 = F1IN @ ORDERING

```

```

product EURO_A1 = (MATCHES * ORDERING_F1)
\si0p\si1p\si2p\si3p\si4p\si5p\si6p\si7p\si9p
\yu0p\yu1p\yu2p\yu3p\yu4p\yu5p\yu6p\yu7p\yu9p
\es0p\es1p\es2p\es3p\es4p\es5p\es6p\es7p\es9p
\no0p\no1p\no2p\no3p\no4p\no5p\no6p\no7p\no9p

```

```

product EURO_A2 = (ORDERING_F1 * MATCHES)
\si0p\si1p\si2p\si3p\si4p\si5p\si6p\si7p\si9p
\yu0p\yu1p\yu2p\yu3p\yu4p\yu5p\yu6p\yu7p\yu9p
\es0p\es1p\es2p\es3p\es4p\es5p\es6p\es7p\es9p
\no0p\no1p\no2p\no3p\no4p\no5p\no6p\no7p\no9p

```

```

product EURO_B1 = (MATCHES_F1 * ORDERING)
\si0p\si1p\si2p\si3p\si4p\si5p\si6p\si7p\si9p
\yu0p\yu1p\yu2p\yu3p\yu4p\yu5p\yu6p\yu7p\yu9p

```

\es0p\es1p\es2p\es3p\es4p\es5p\es6p\es7p\es9p
\no0p\no1p\no2p\no3p\no4p\no5p\no6p\no7p\no9p

product EURO_B2 = (ORDERING * MATCHES_F1)
\si0p\si1p\si2p\si3p\si4p\si5p\si6p\si7p\si9p
\yu0p\yu1p\yu2p\yu3p\yu4p\yu5p\yu6p\yu7p\yu9p
\es0p\es1p\es2p\es3p\es4p\es5p\es6p\es7p\es9p
\no0p\no1p\no2p\no3p\no4p\no5p\no6p\no7p\no9p

product EURO_C1 = (MATCHES_F1 * ORDERING_F1)
\si0p\si1p\si2p\si3p\si4p\si5p\si6p\si7p\si9p
\yu0p\yu1p\yu2p\yu3p\yu4p\yu5p\yu6p\yu7p\yu9p
\es0p\es1p\es2p\es3p\es4p\es5p\es6p\es7p\es9p
\no0p\no1p\no2p\no3p\no4p\no5p\no6p\no7p\no9p

product EURO_C2 = (ORDERING_F1 * MATCHES_F1)
\si0p\si1p\si2p\si3p\si4p\si5p\si6p\si7p\si9p
\yu0p\yu1p\yu2p\yu3p\yu4p\yu5p\yu6p\yu7p\yu9p
\es0p\es1p\es2p\es3p\es4p\es5p\es6p\es7p\es9p
\no0p\no1p\no2p\no3p\no4p\no5p\no6p\no7p\no9p

Here are the obtained results (using Biddy 1.1 on 64-bit architecture, about 5 GB of RAM was used to perform all this operations):

process MATCHES
pa_state_number: 229524
pa_transition_number: 778614
pa_transition_visible: 662039

PROCESS MATCHES
Number of states: 229524
Number of transitions: 778614

process ORDERING
pa_state_number: 542262
pa_transition_number: 1460824
pa_transition_visible: 376611

PROCESS ORDERING
Number of states: 542262
Number of transitions: 1460824

automaton MATCHES_F1
pa_state_number: 10827
pa_transition_number: 28238
pa_transition_visible: 24402

PROCESS MATCHES_F1
Number of states: 10827
Number of final states: 2690
Number of transitions: 28238

automaton ORDERING_F1
pa_state_number: 8440
pa_transition_number: 13848
pa_transition_visible: 10628

PROCESS ORDERING_F1
Number of states: 8440

Number of final states: 4220
Number of transitions: 13848

product EURO_A1 = MATCHES * ORDERING_F1
pa_state_number: 15015
pa_transition_number: 37493
pa_transition_visible: 21265

PROCESS EURO_A1
Number of states: 15015
Number of final states: 3737
Number of transitions: 37493

product EURO_A2 = ORDERING_F1 * MATCHES
pa_state_number: 1
pa_transition_number: 0
pa_transition_visible: 0

PROCESS EURO_A2
Number of states: 1
Number of transitions: 0

product EURO_B1 = MATCHES_F1 * ORDERING
pa_state_number: 1
pa_transition_number: 0
pa_transition_visible: 0

PROCESS EURO_B1
Number of states: 1
Number of transitions: 0

product EURO_B2 = ORDERING * MATCHES_F1
pa_state_number: 15015
pa_transition_number: 37493
pa_transition_visible: 21265

PROCESS EURO_B2
Number of states: 15015
Number of final states: 3737
Number of transitions: 37493

product EURO_C1 = MATCHES_F1 * ORDERING_F1
pa_state_number: 15015
pa_transition_number: 37493
pa_transition_visible: 21265

PROCESS EURO_C1
Number of states: 15015
Number of final states: 3737
Number of transitions: 37493

product EURO_C2 = ORDERING_F1 * MATCHES_F1
pa_state_number: 15015
pa_transition_number: 37493
pa_transition_visible: 21265

PROCESS EURO_C2
Number of states: 15015
Number of final states: 3737
Number of transitions: 37493