ETH
Eidgenössische Technische Hochschule Zürich
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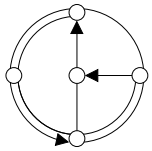
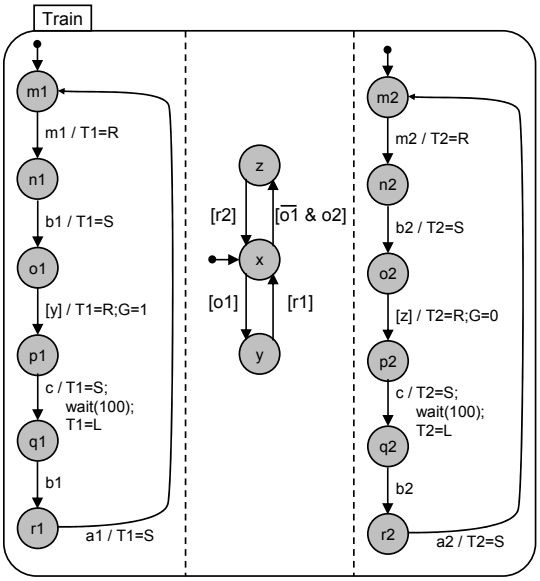


WS 2005/2006 Prof. R. Wattenhofer / Roland Flury / Thomas Moscibroda / Stefan Schmid

Discrete Event Systems
Exercise 5: Sample Solution

1 The Winter Train Problem

We can model each train individually and combine the corresponding sub-states using an AND-super-state, see the figure below. Additionally, in order to "synchronize" the trains, a third sub-state is needed (shown in the middle) which implements a mutual exclusion: For instance, if there is no train between Stans and Engelberg and if train 1 is in state c1, T1 can enter the critical section and train 2 has to wait. (Notice that if both trains are in states c1 and c2 respectively, T1 has priority.)



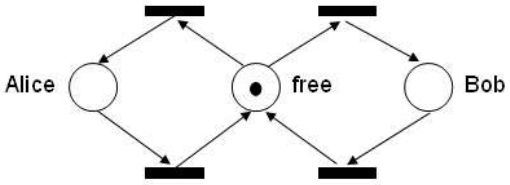
2 Token Game

a) In this example, it is easy to enumerate all possible markings in order to disprove the claim. As an alternative, note that the sum of tokens at the places a, e, d, and f is always at most 1: place e gets only a token if place a loses a token, place d gets only a token if place e loses a token, and similarly for places f and d and a and f.

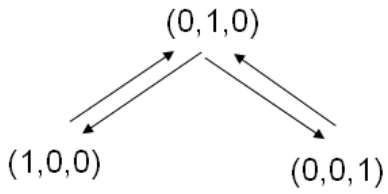
b) Starting with [a,c] and performing all possible transitions yields the following possible markings: {[a,c],[b,e,c],[d,b],[b,f,c]}. The number of markings is clearly finite.

3 A Candlelight Dinner

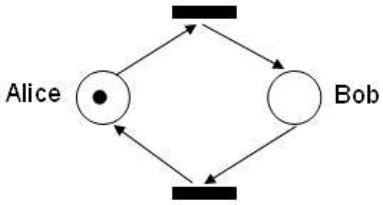
a) (i) The following figure shows a possible solution with three places: Either Alice has the spoon or Bob, or the spoon lies on the table.



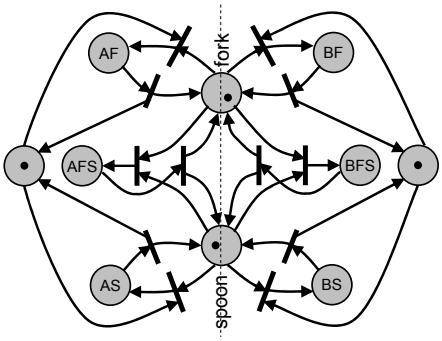
(ii) The claim follows directly from the finite state transition graph:



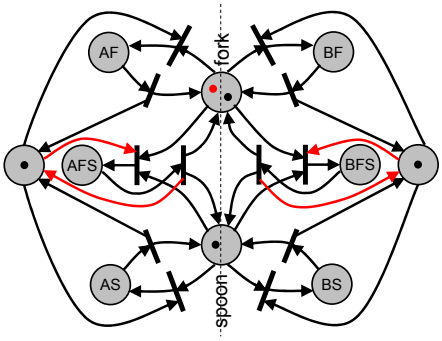
(iii) If Alice and Bob strictly alternate, the petri net looks as follows:



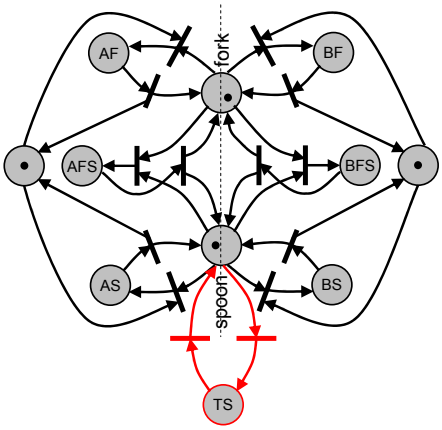
b) The situation could be modelled as shown in the following figure. Note that the petri net is symmetric, since Alice (petri net on the left) and Bob (petri net on the right) behave in the same way. Thereby, AF denotes that Alice has the fork and eats veggies, AS denotes that Alice has the spoon and eats veggies, and the place AFS denotes that Alice uses both fork and spoon to eat spaghetti. BF, BS, and BFS are the corresponding places of Bob. Finally, the place "fork" (or "spoon") means that the fork (or spoon) is free.



c) The additional fork can be taken into account by adding a token to the place "fork free." However, we have to make sure that neither Alice nor Bob has two forks at the same time. This requires two additional transitions as shown in the figure.



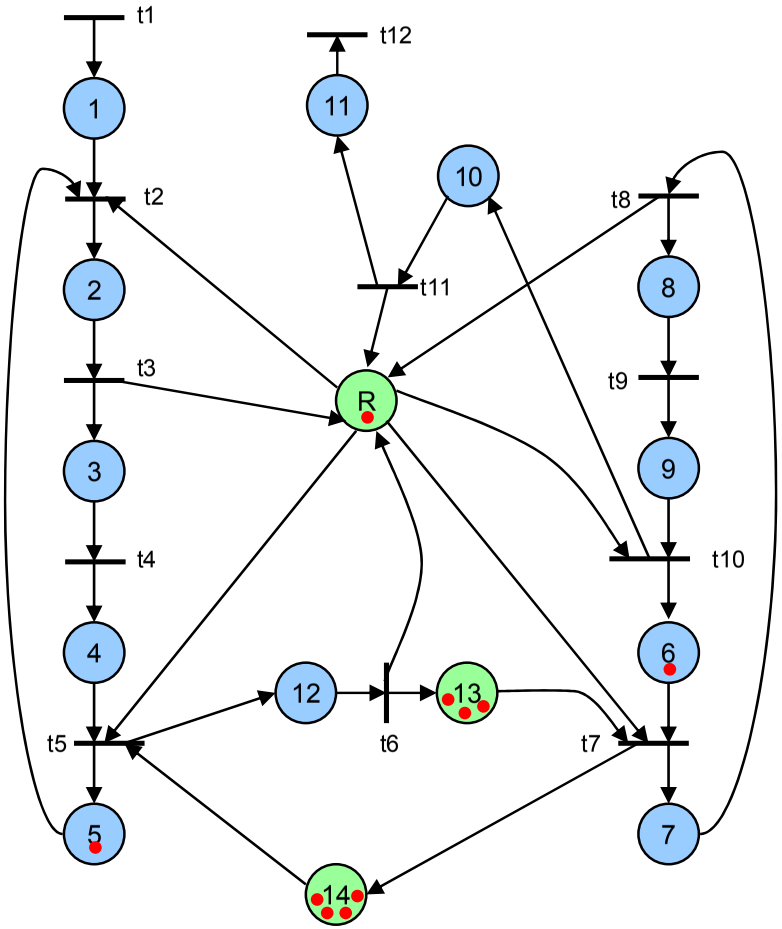
d) The petri net now looks as follows:



4 Producer-Consumer System under Mutual Exclusion

The petri nets are attached at the end of this document. Please note the tables indicating the places and transitions of the nets.

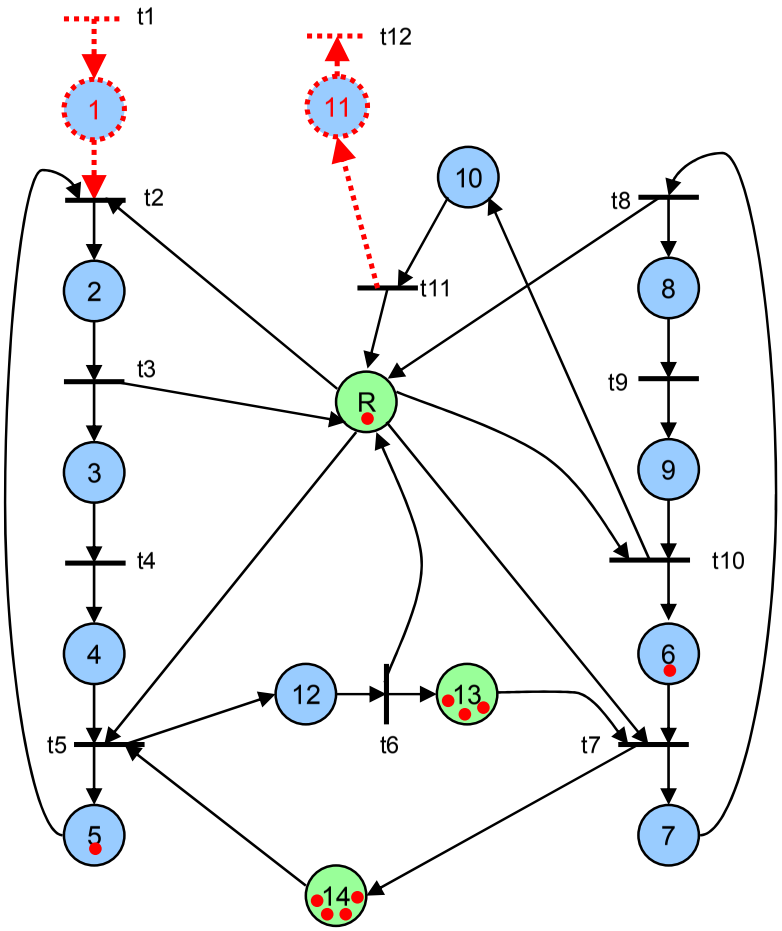
a) Draw the Petri net

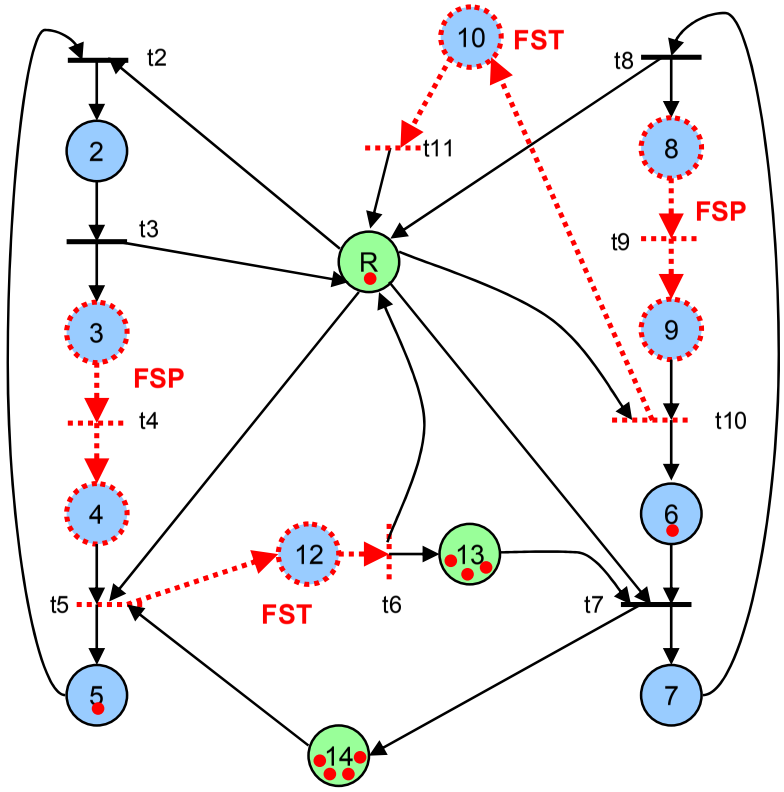


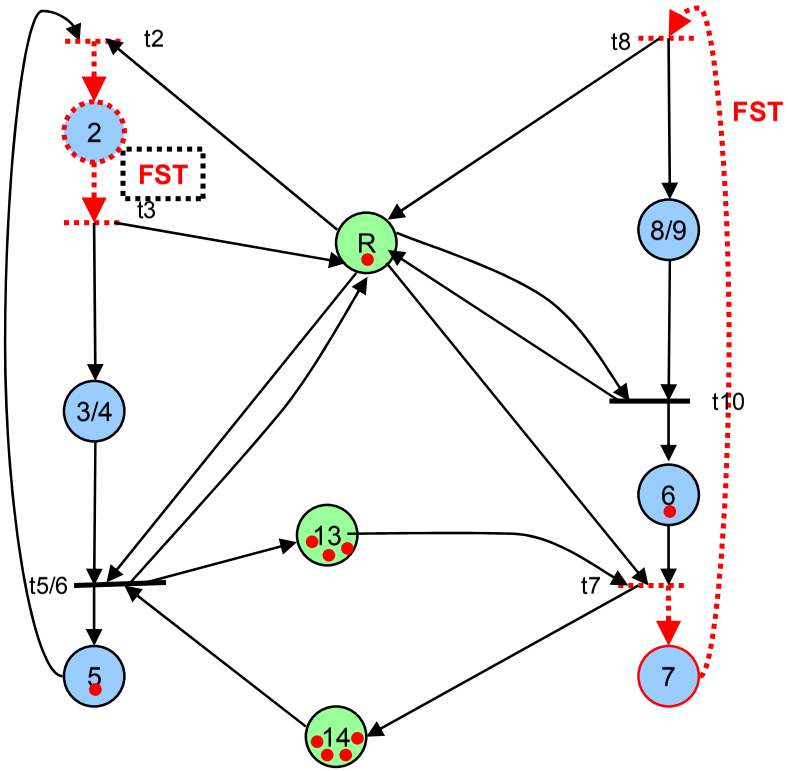
t1	Raw parts arrive
t2	Robot picks up raw parts
t3	… and delivers them to M1
t4	M1 preprocesses raw parts
t5	Robot picks up preproc. product from M1
t6	… and puts it into the buffer
t7	Robot picks preproc. product from the buffer
t8	… and delivers it to M2
t9	M2 finishes the product
t10	Robot picks finished product from M2
t11	… and puts it to output line
t12	Output line consumes product

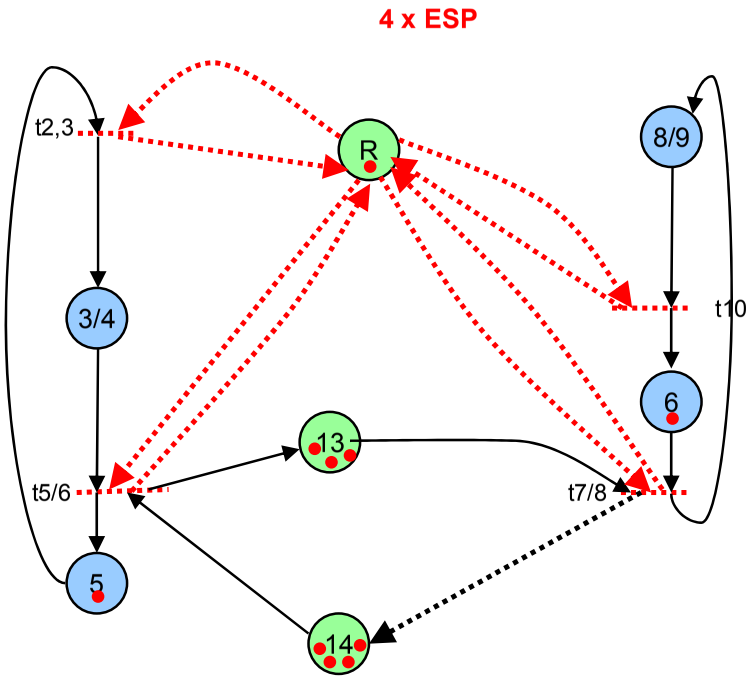
1	Models input line, each token represents the raw parts for one item
2	The robot holds the raw parts or one item and moves them to M1
3	M1 has the raw parts
4	M1 has finished preprocessing the raw parts
5	M1 is waiting for new raw parts
6	M2 is waiting for preprocessed parts from the buffer
7	The robot holds a preprocessed item retrieved from the buffer
8	M2 has a preprocessed item
9	M2 has finished producing the item
10	The robot holds the finished item and moves it to the output line
11	The output line holds the finished products until they're consumed (sink)
12	The robot holds a preprocessed item and moves it from M1 to the buffer
13	The buffer, holding the preprocessed items
14	The counter part to the buffer, ensuring its capacity constraints
R	The robot, under mutual exclusion for all tasks

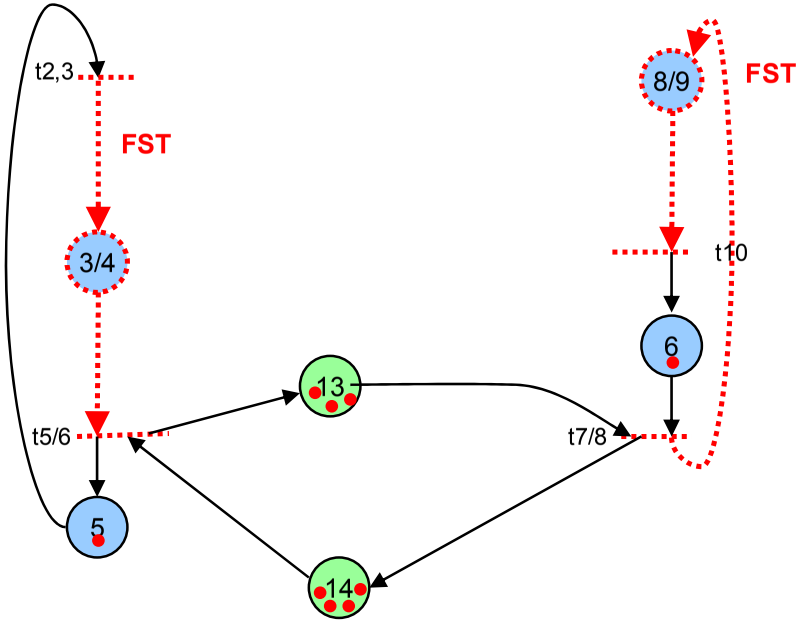
b) Show that the obtained net is life and bounded

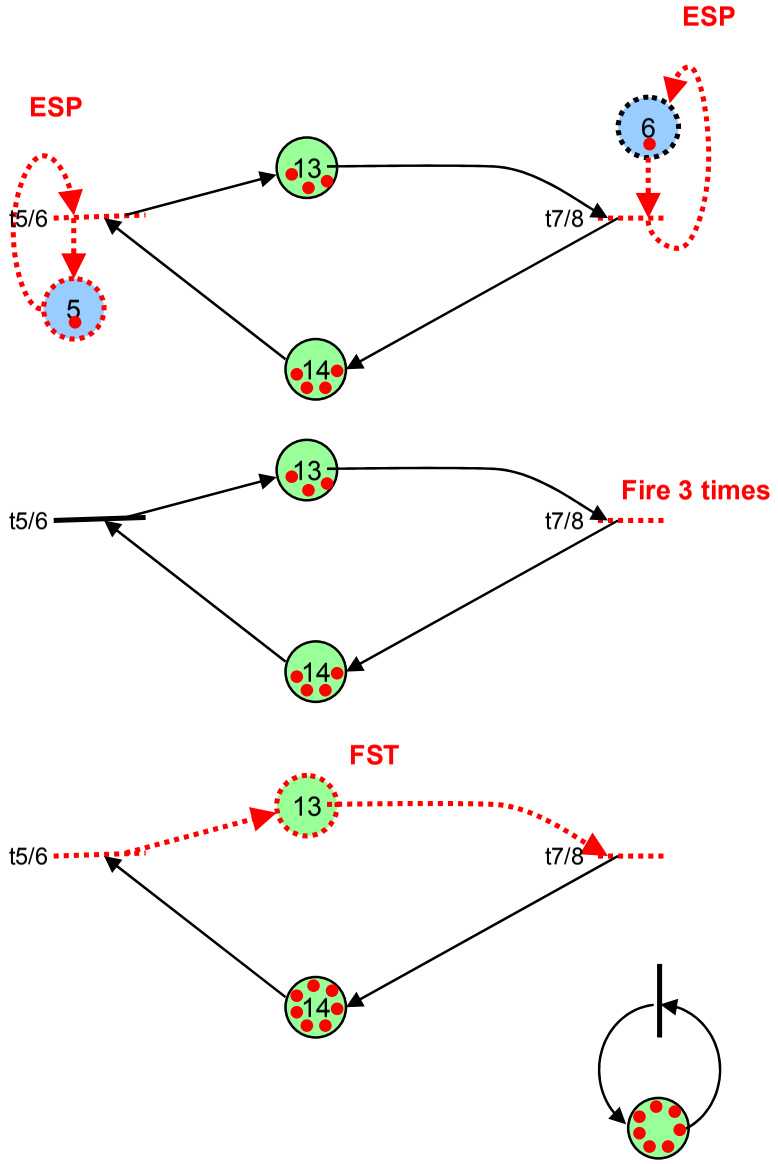
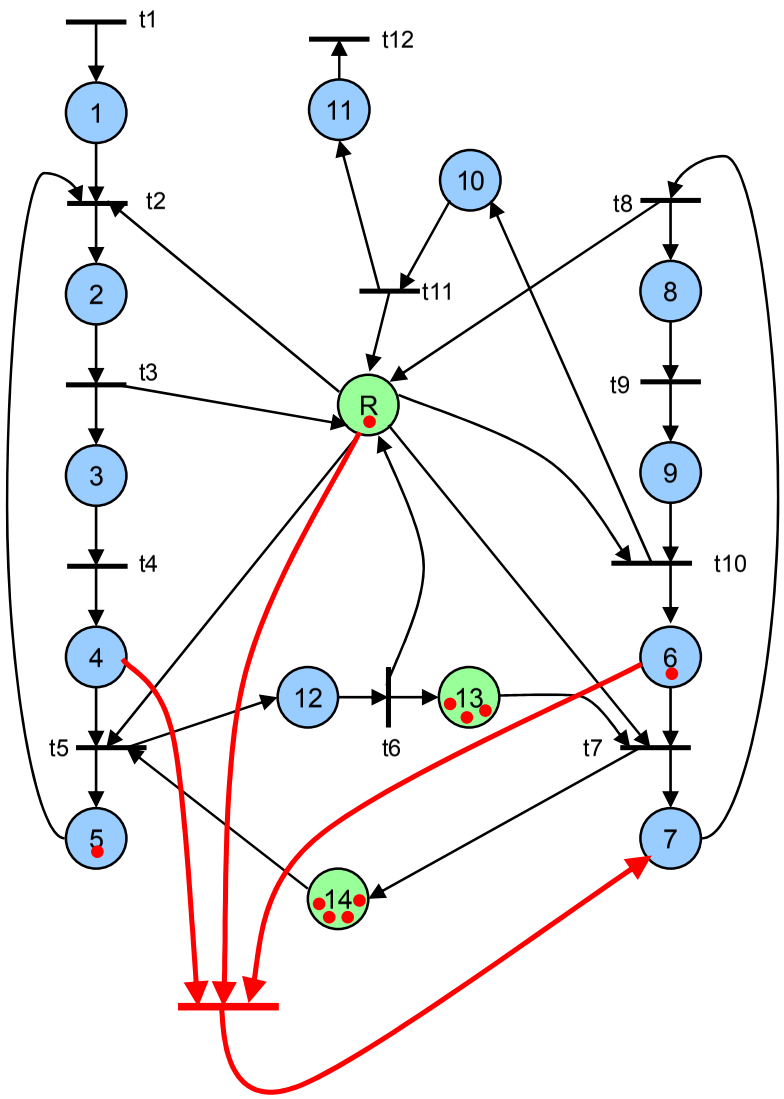





t2
t8
FST
2
FST
t3
R
8/9
3/4
t10
6
13
t5/6
t7
5
7
14


4 x ESP
t2,3
R
8/9
3/4
t10
6
13
t5/6
t7/8
5
14


t2,3
FST
3/4
t5/6
5
13
14
8/9
FST
t10
6
t7/8


ESP
ESP
6
13
t5/6
t7/8
5
14
13
Fire 3 times
t5/6
t7/8
14
FST
13
t5/6
t7/8
14

c) Bypassing the buffer