Clarification of Design Philosophy for Railway Crossing System Based on FRAM

13th June 2018

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Outline

- Motivation
- Basic railway crossing control
- Modelling
- Analysis result 1 (JRE)
- Analysis result 2 (JAMSS)
- Extracted design requirements
- Conclusion

Motivation

Number of railway crossings in JRE : 6897 (FY2015)

Characteristics and issues of control logic of railway crossing

- Complex and large
- implemented with electric relays (Hardware logic)

➡ **Necessity to improve maitenability and implementation with software control**

- Much implicit knowledge in standard logic

➡ **Necessity to make implicit knowledge explicit**

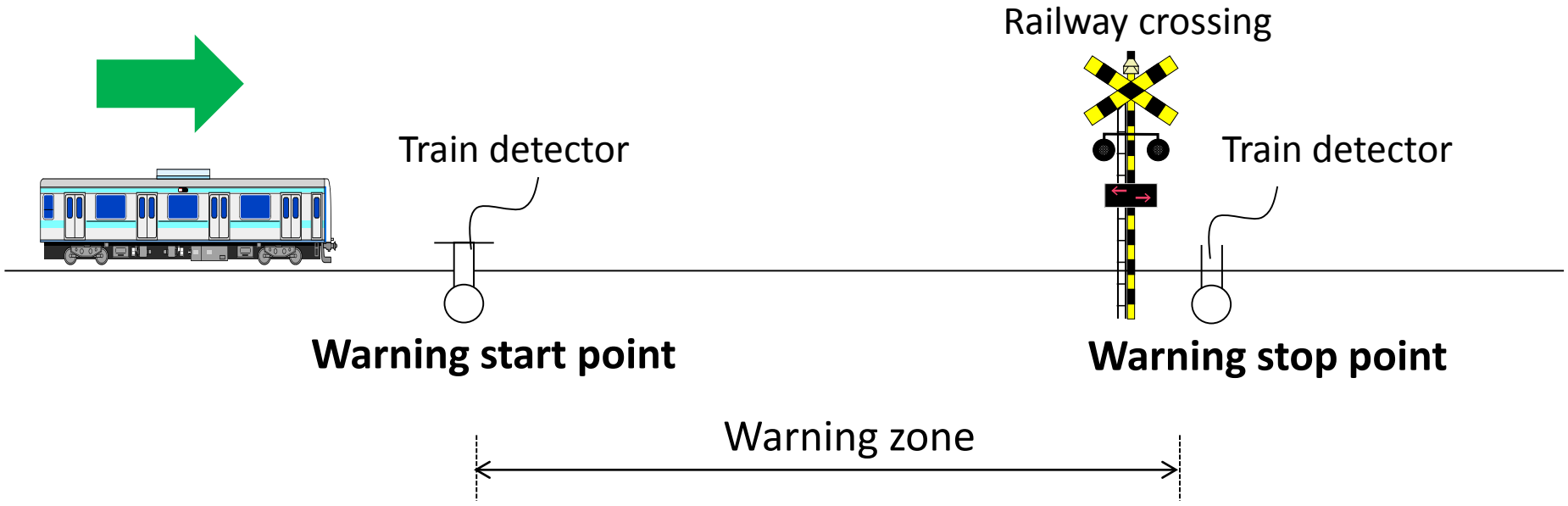
Current control logic achieve high safety.

⬇

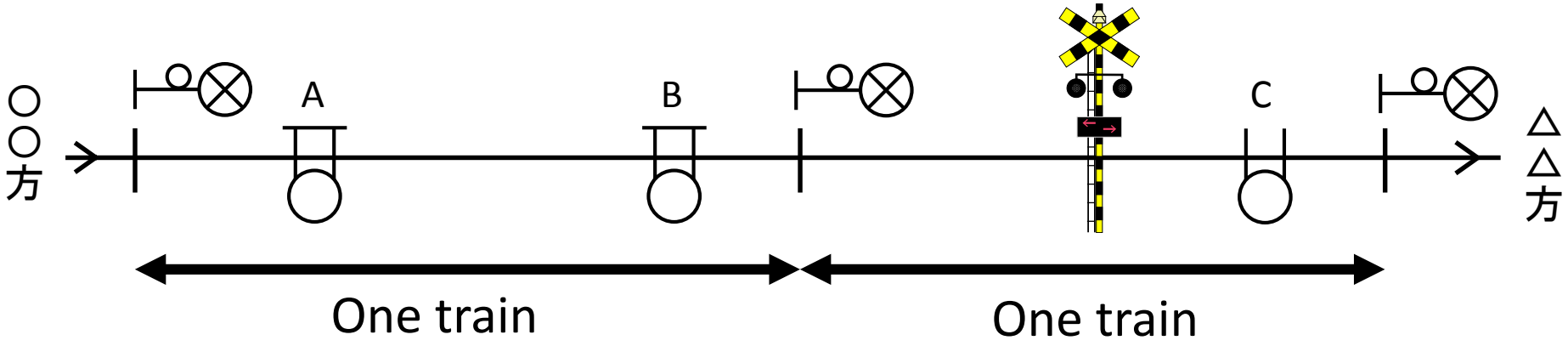
Extraction of hidden success-factors with FRAM and usage them to develop software logic

Basic railway crossing control logic

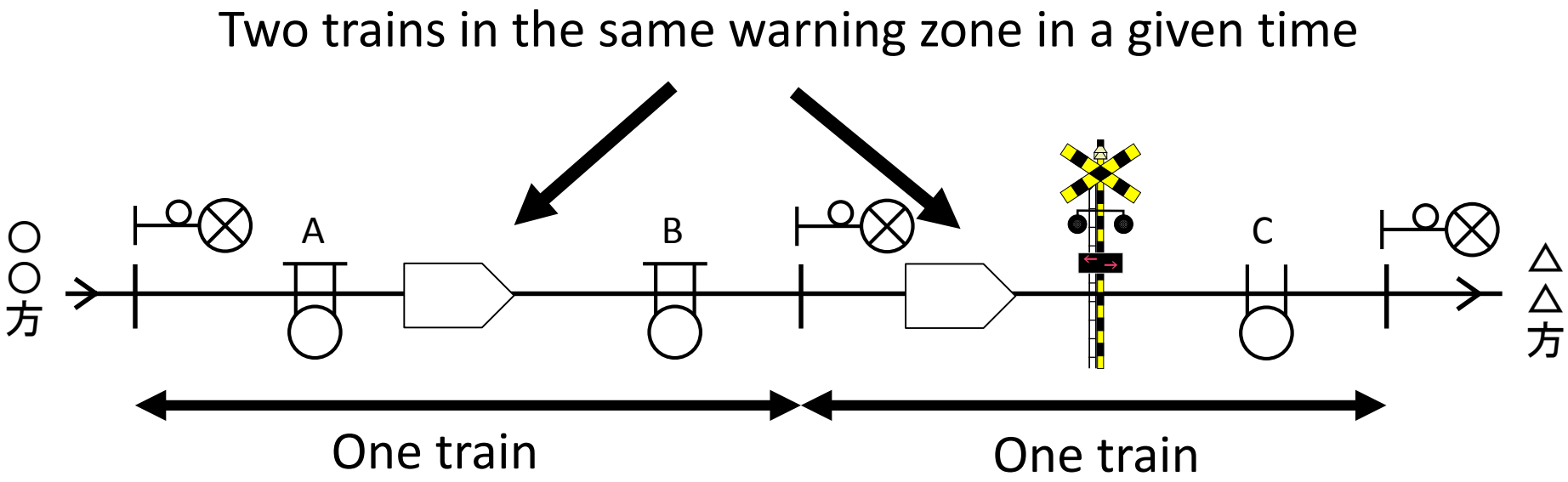
Warning starts when a train detected at the warning start point.
Warning stops when a train detected at the warning stop point.



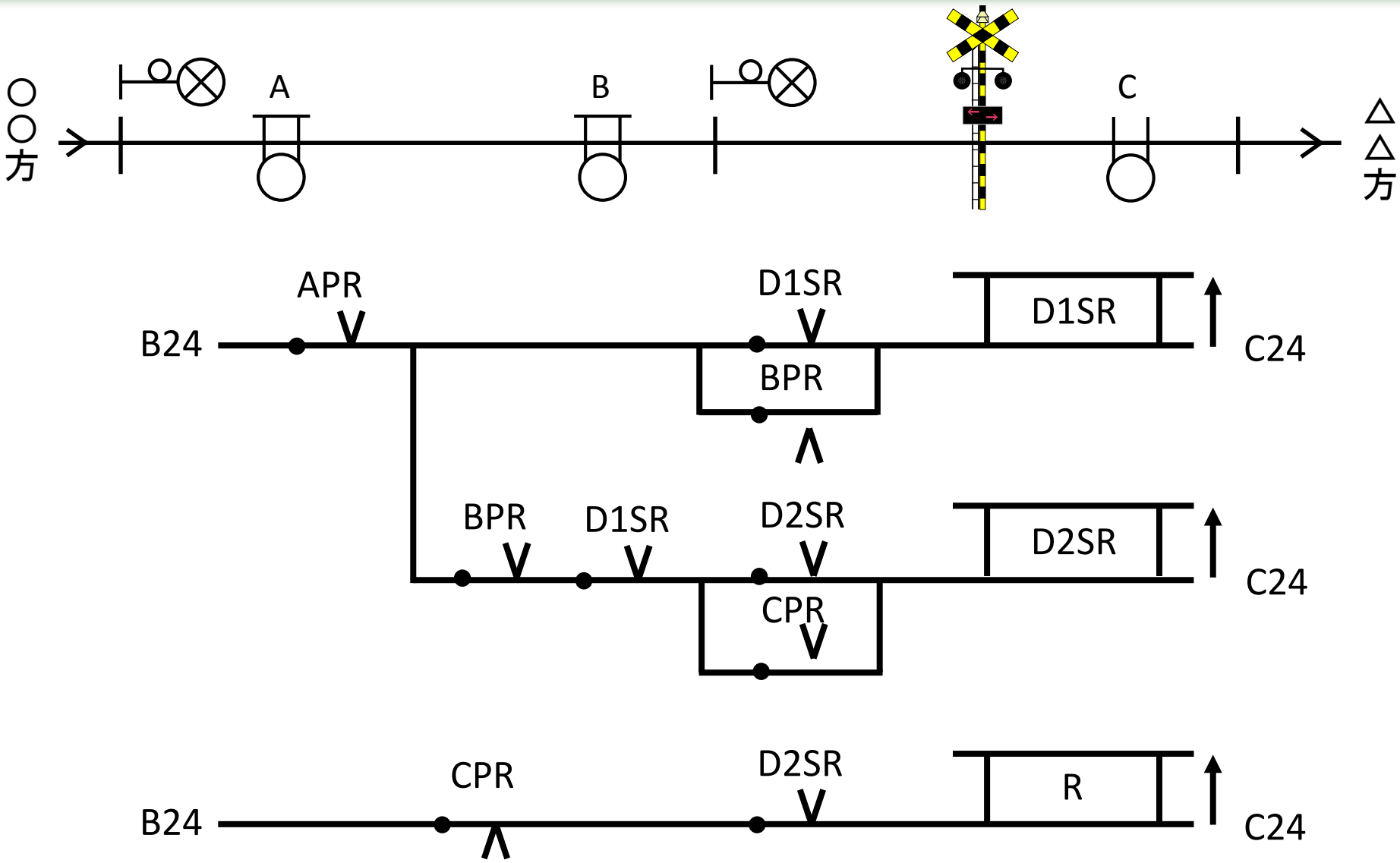
Control logic focused on



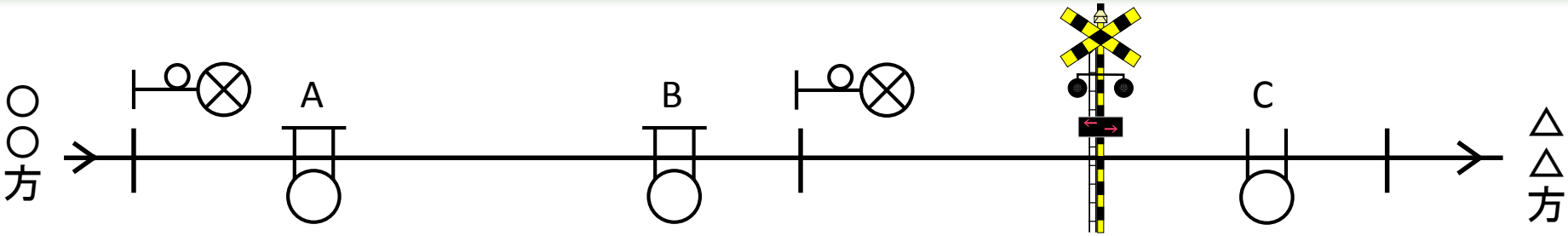
Control logic focused on

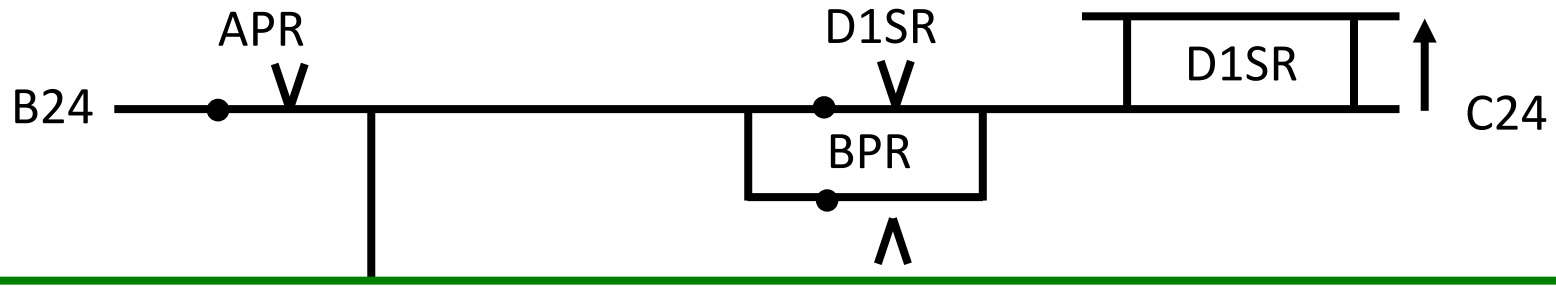


Specify functions

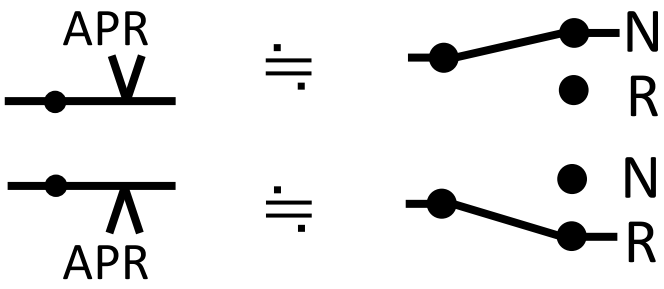


Specify functions



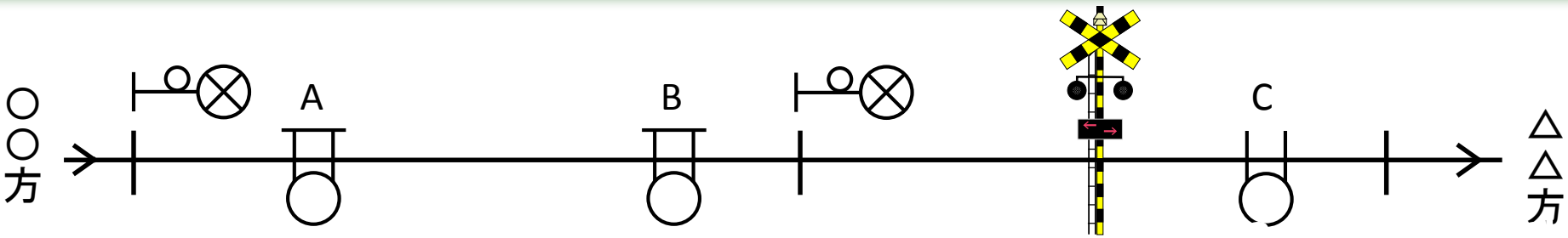


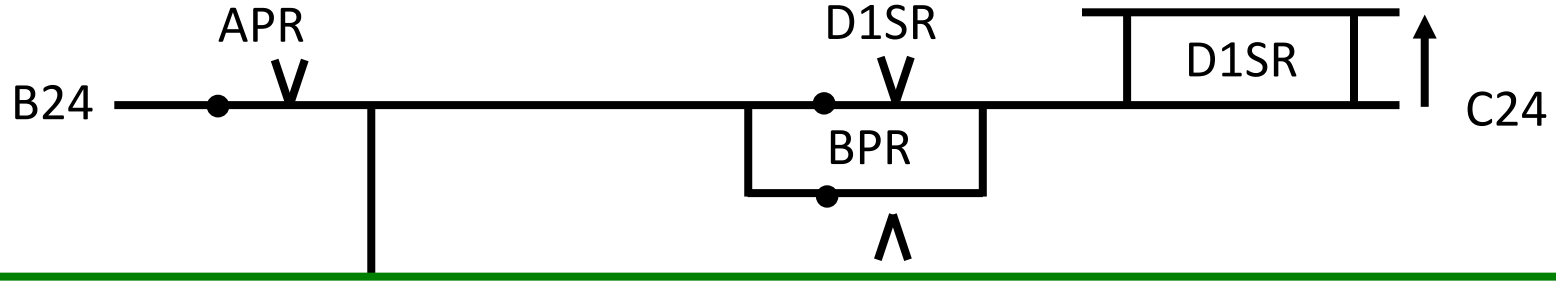
→ Driven relay with a circuit. Two states, picked or dropped



→ a connection point, a kind of a switch

Specify functions



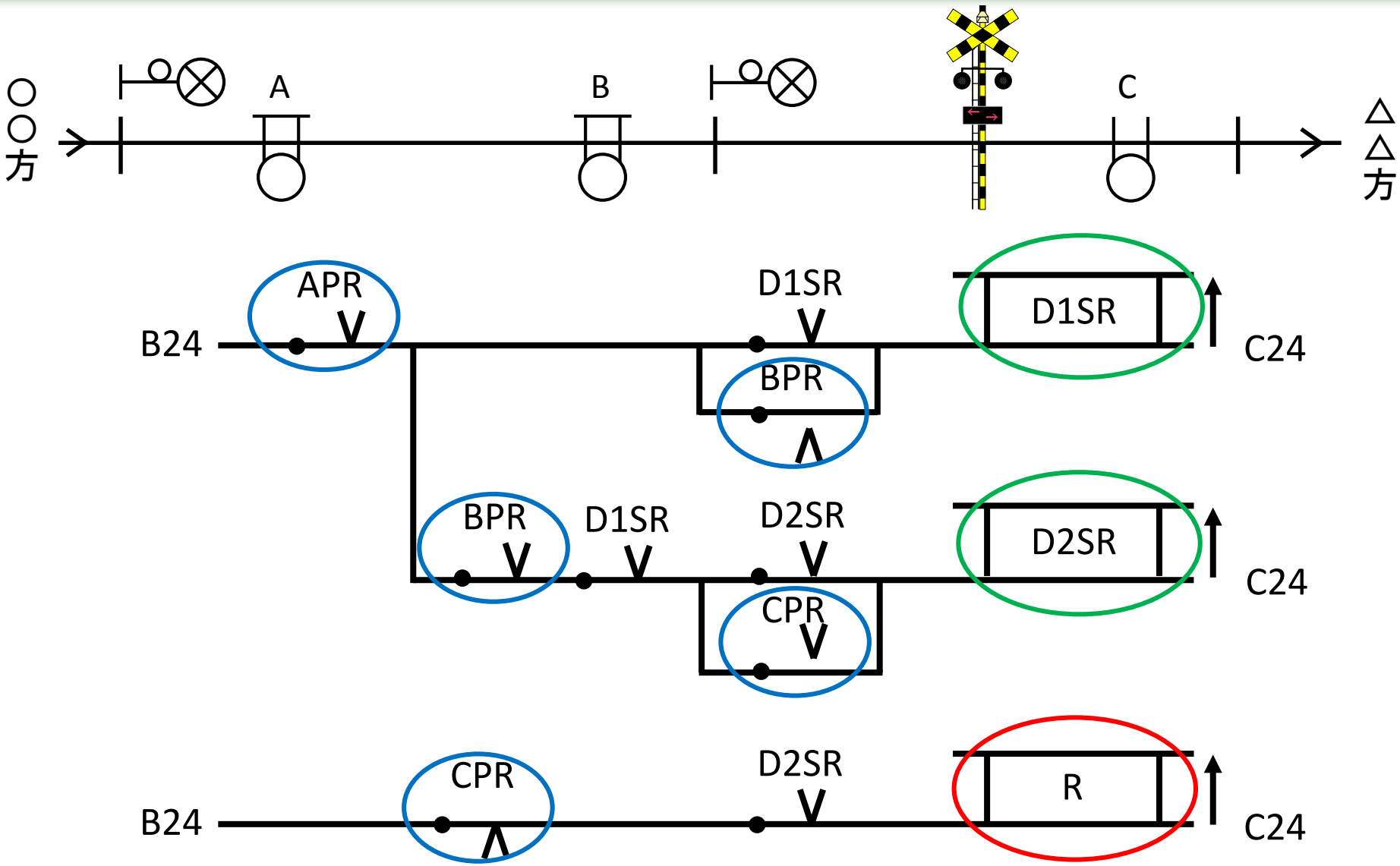


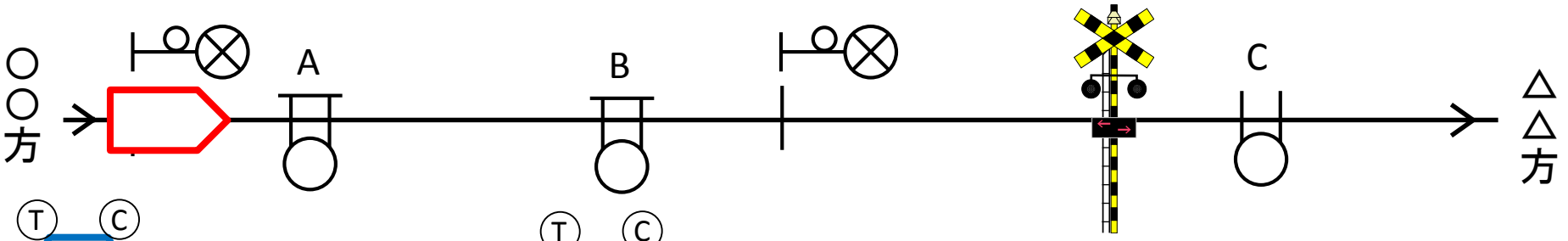
→ Driven relay with a circuit. Two states, picked or dropped

Each state (picked and dropped) of a relay is one function

→ a connection point, a kind of a switch

Specify functions




○○方
A
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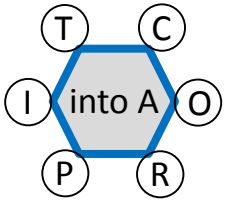
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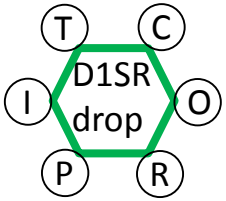
T
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D1SR
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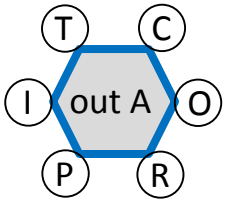
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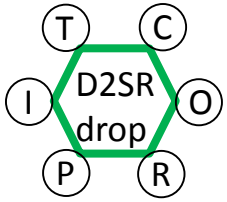
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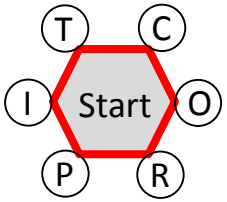
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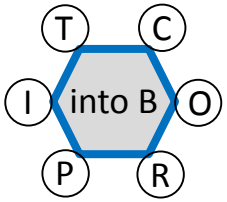
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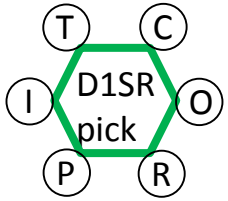
T
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D1SR
pick
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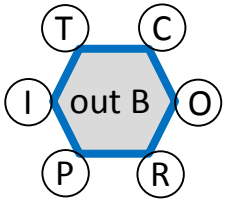
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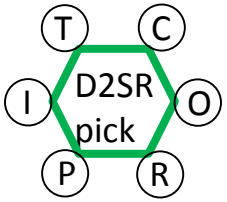
T
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D2SR
pick
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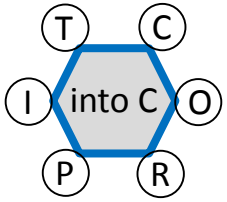
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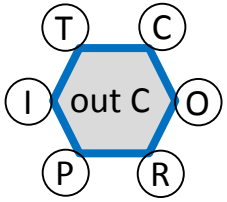
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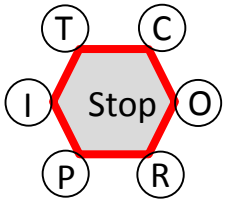
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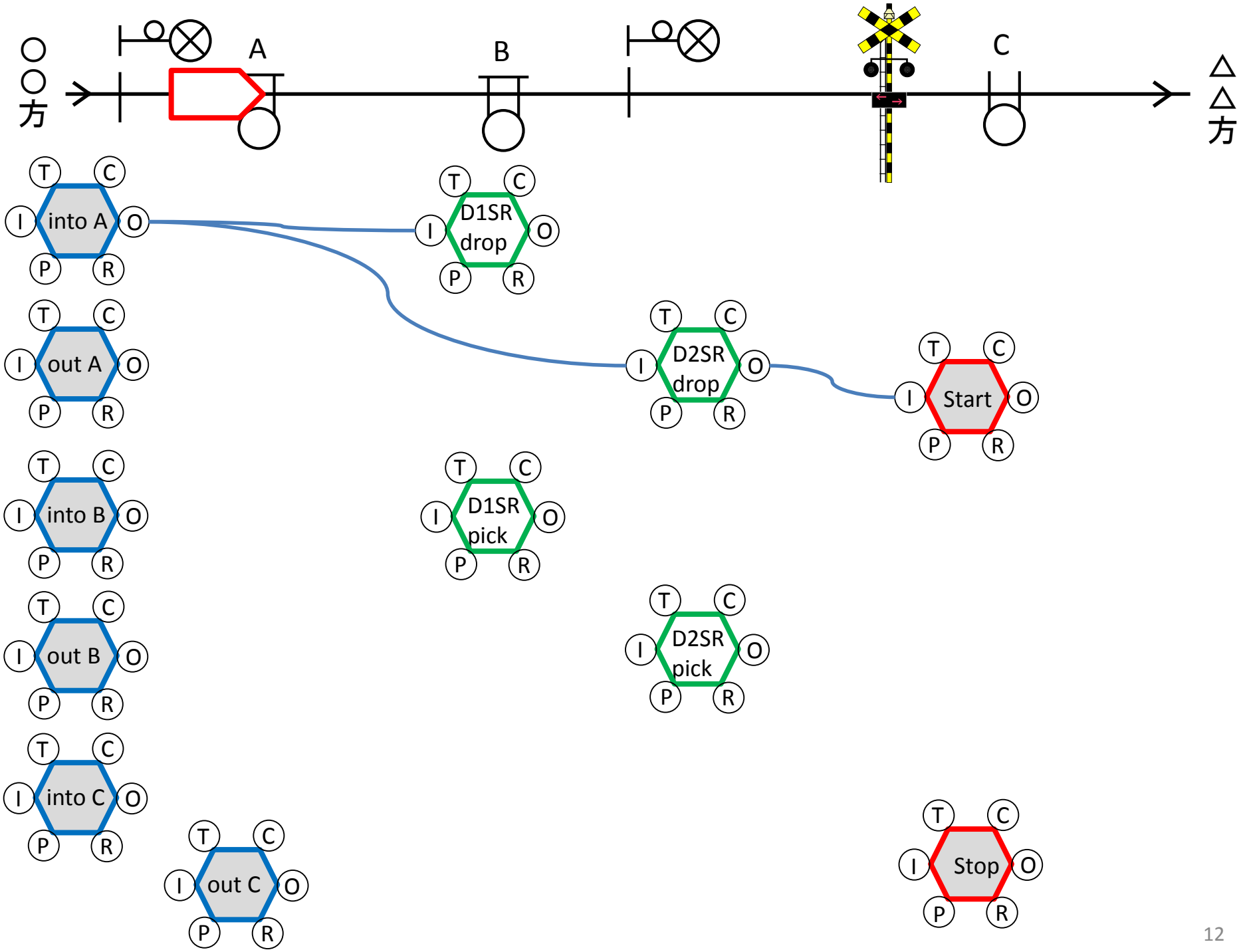
○○方
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D1SR
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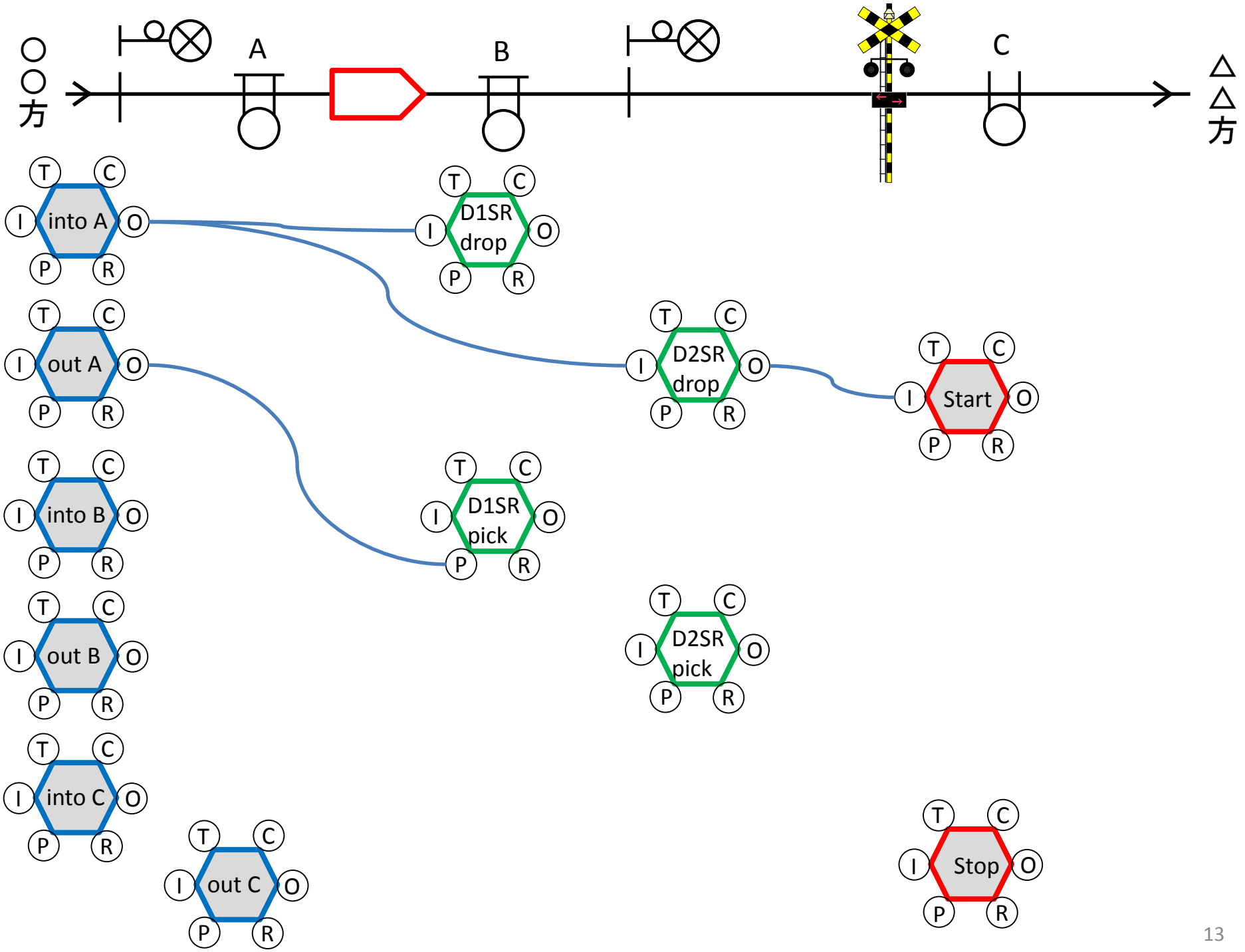
out A
D2SR
drop
Start
into B
D1SR
pick
out B
D2SR
pick
into C
out C
Stop


○○方
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△△方
into A
D1SR drop
out A
D2SR drop
Start
into B
D1SR pick
out B
D2SR pick
into C
out C
Stop
T
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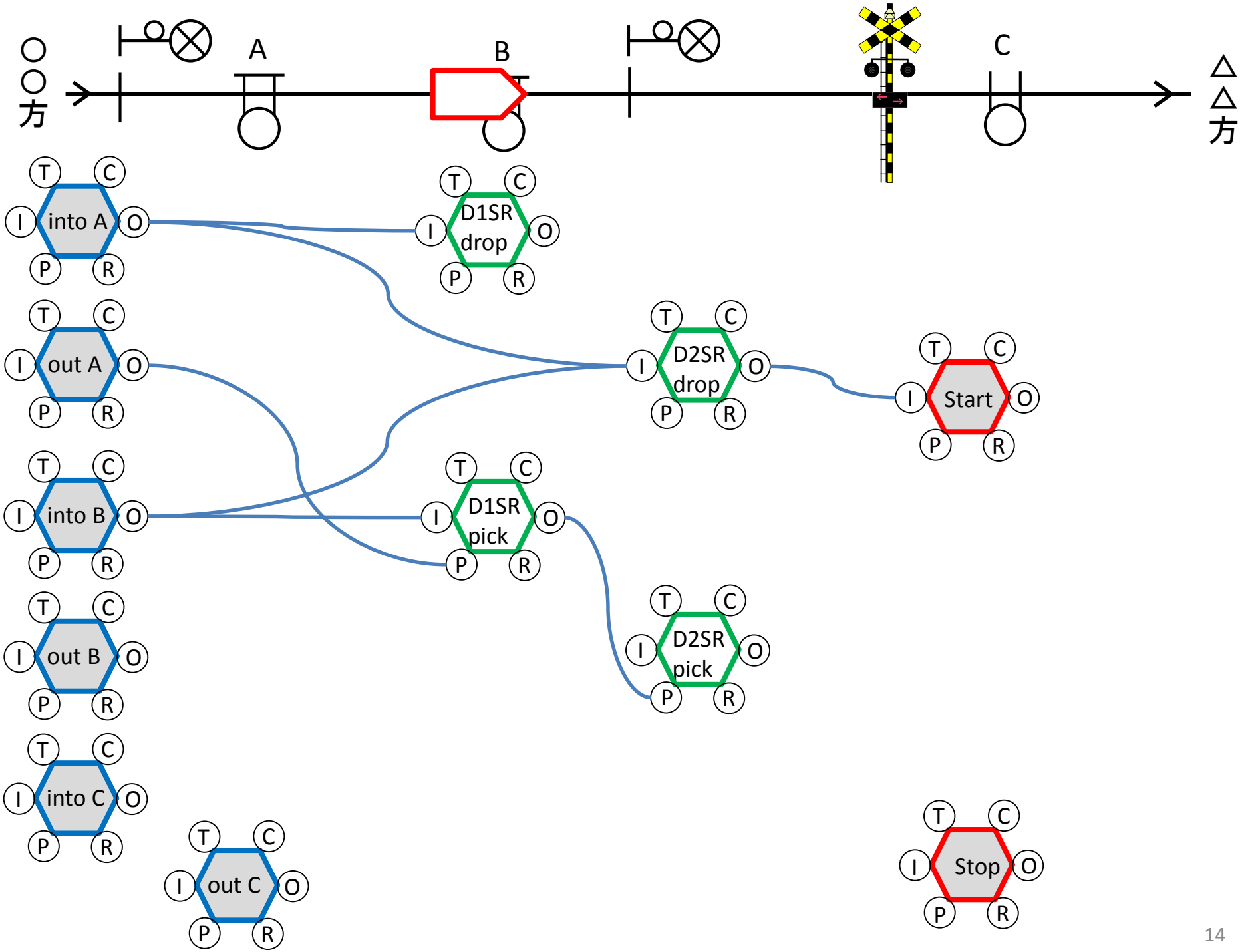
R


○○方
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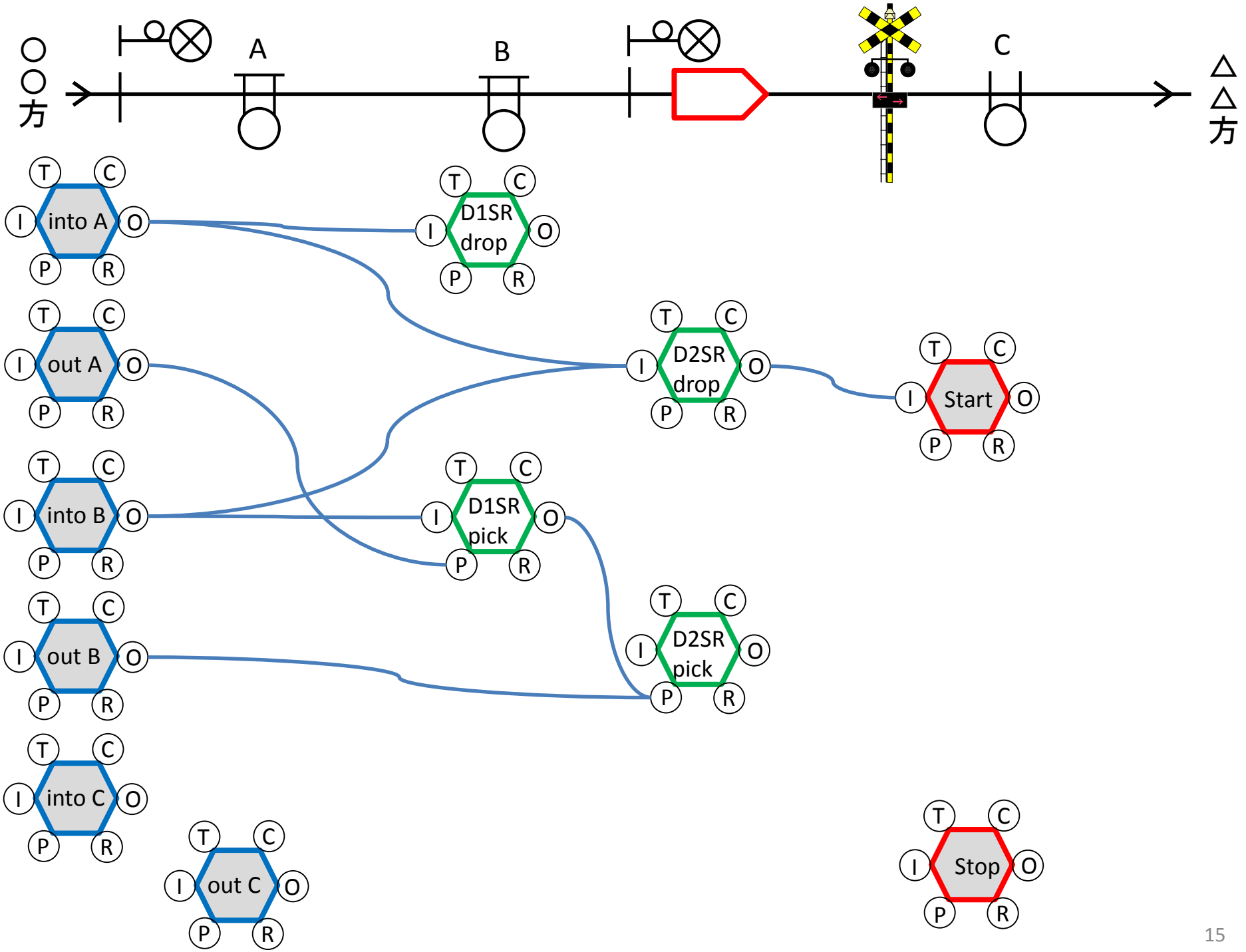
D1SR
drop
out A
D2SR
drop
Start
into B
D1SR
pick
out B
D2SR
pick
into C
out C
Stop


○○方
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drop
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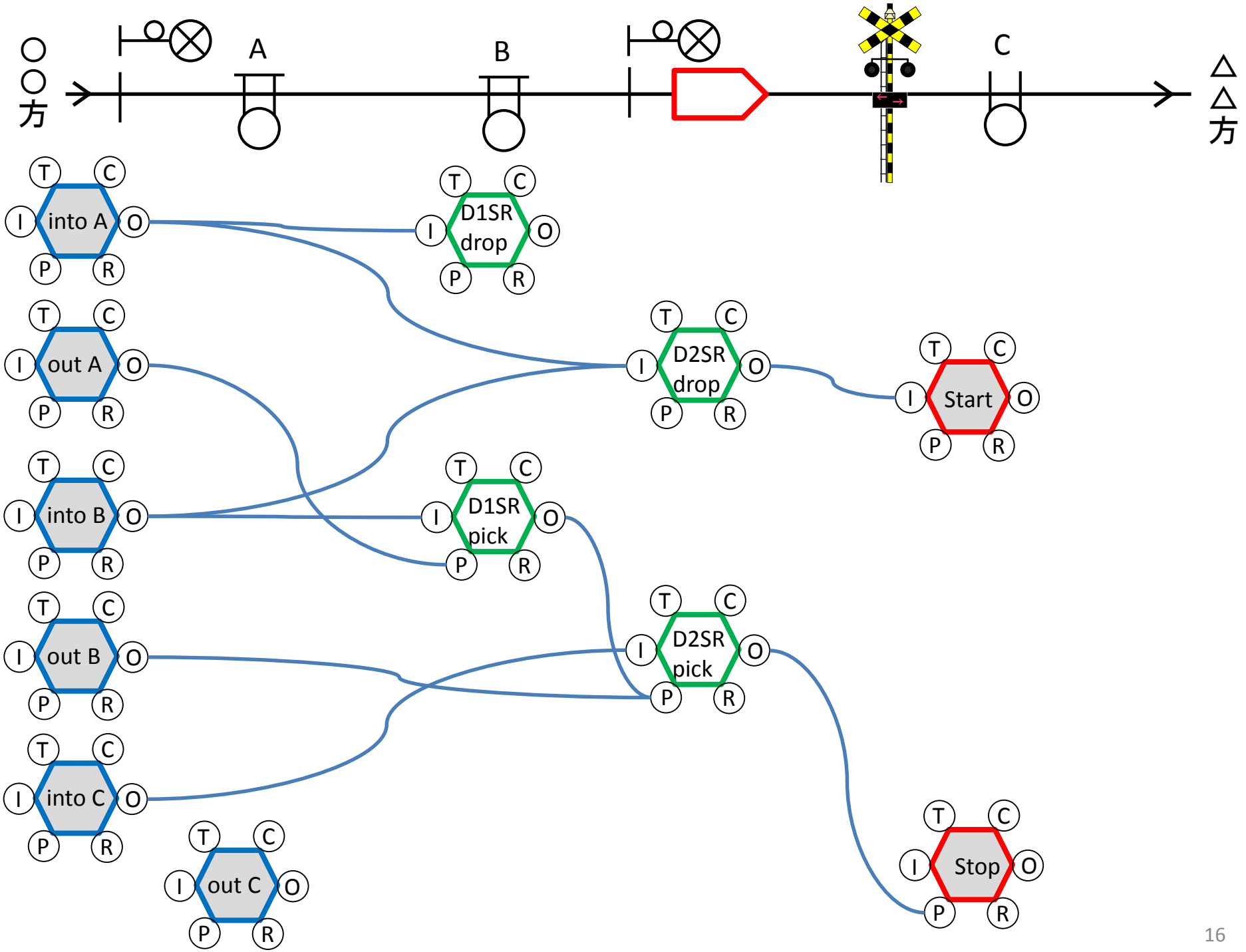
into B
D1SR
pick
out B
D2SR
pick
into C
out C
Stop


○○方
A
B
C
△△方
into A
D1SR drop
out A
D2SR drop
Start
into B
D1SR pick
out B
D2SR pick
into C
out C
Stop
T
C
I
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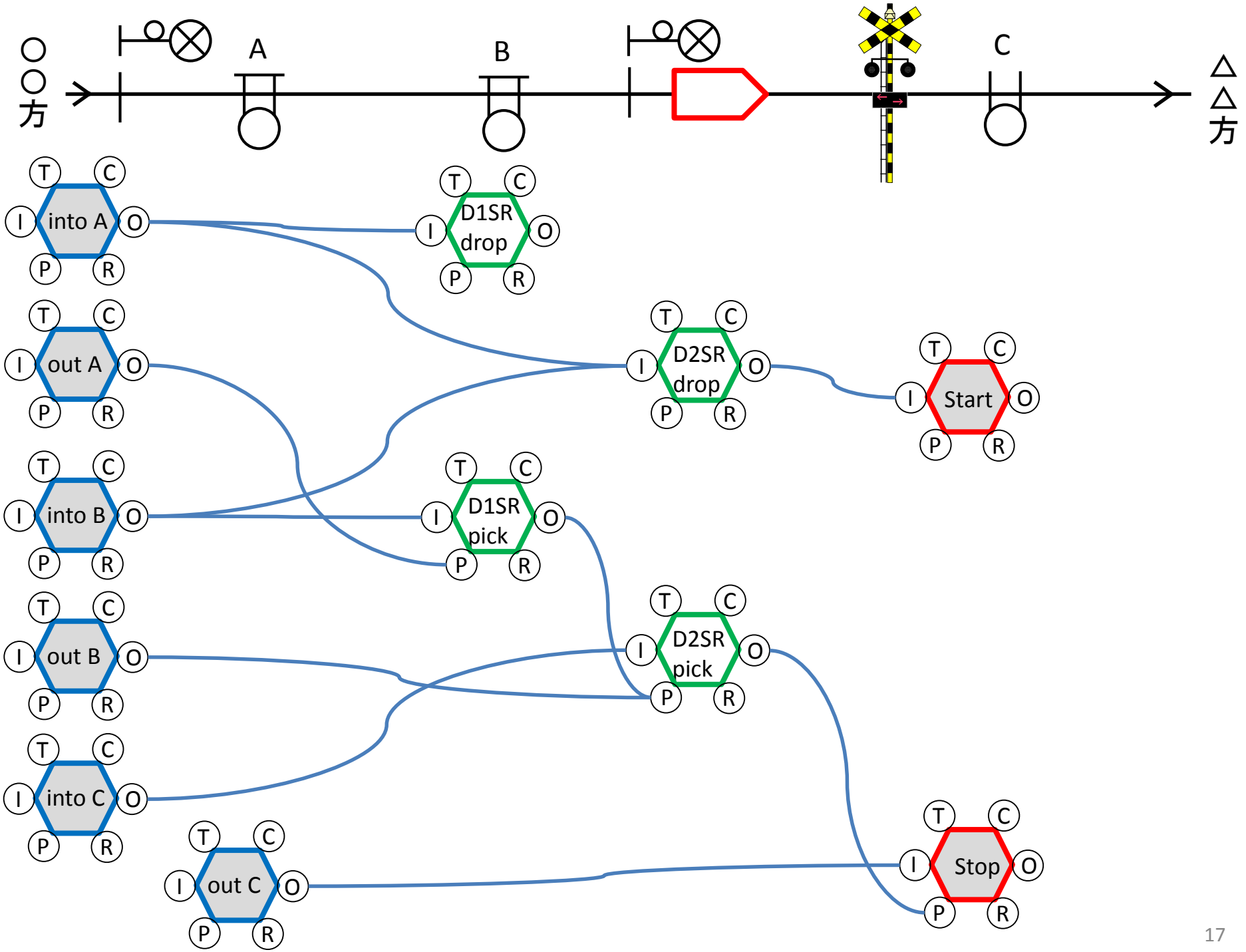
R


○○方
A
B
C
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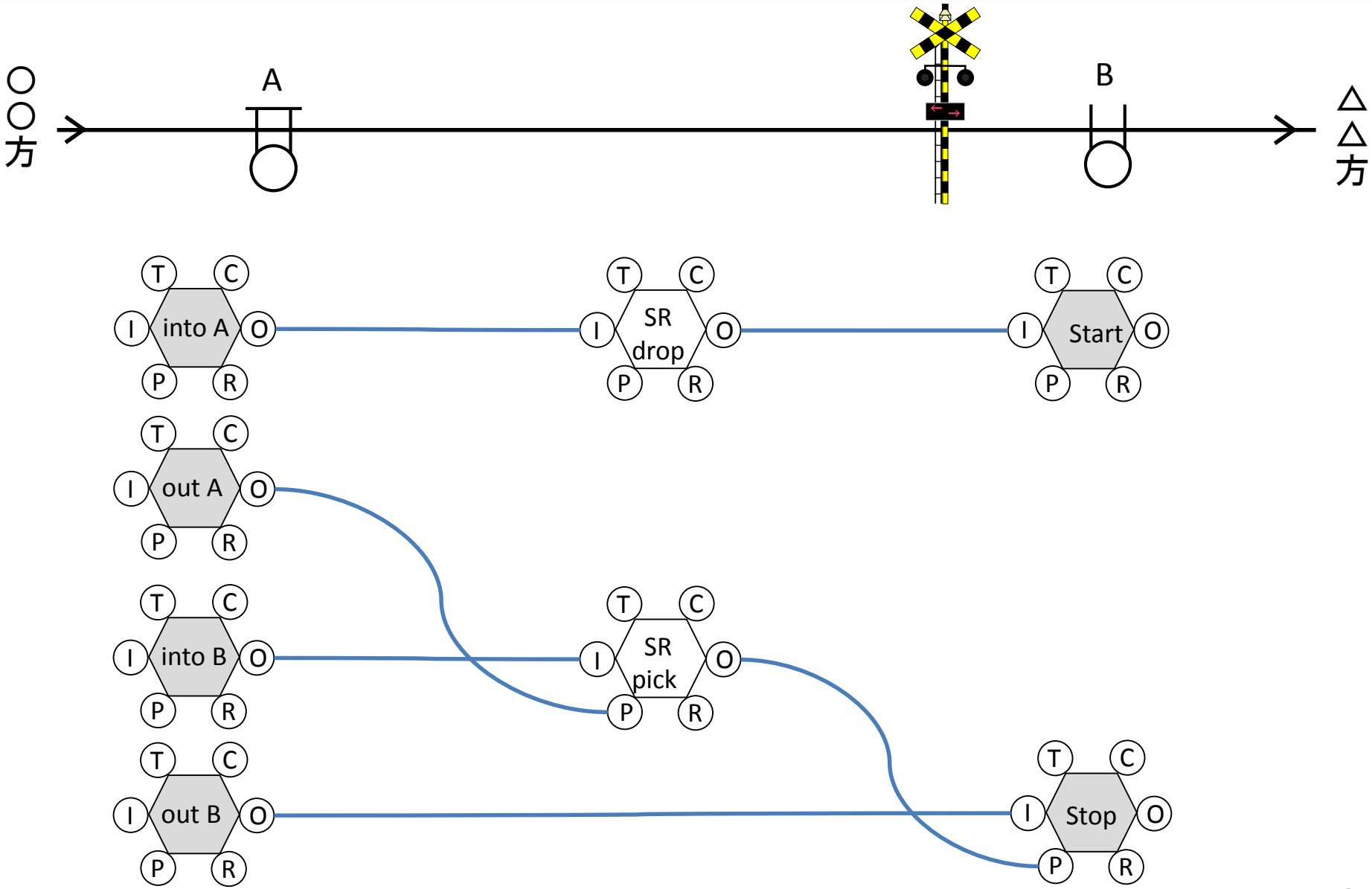
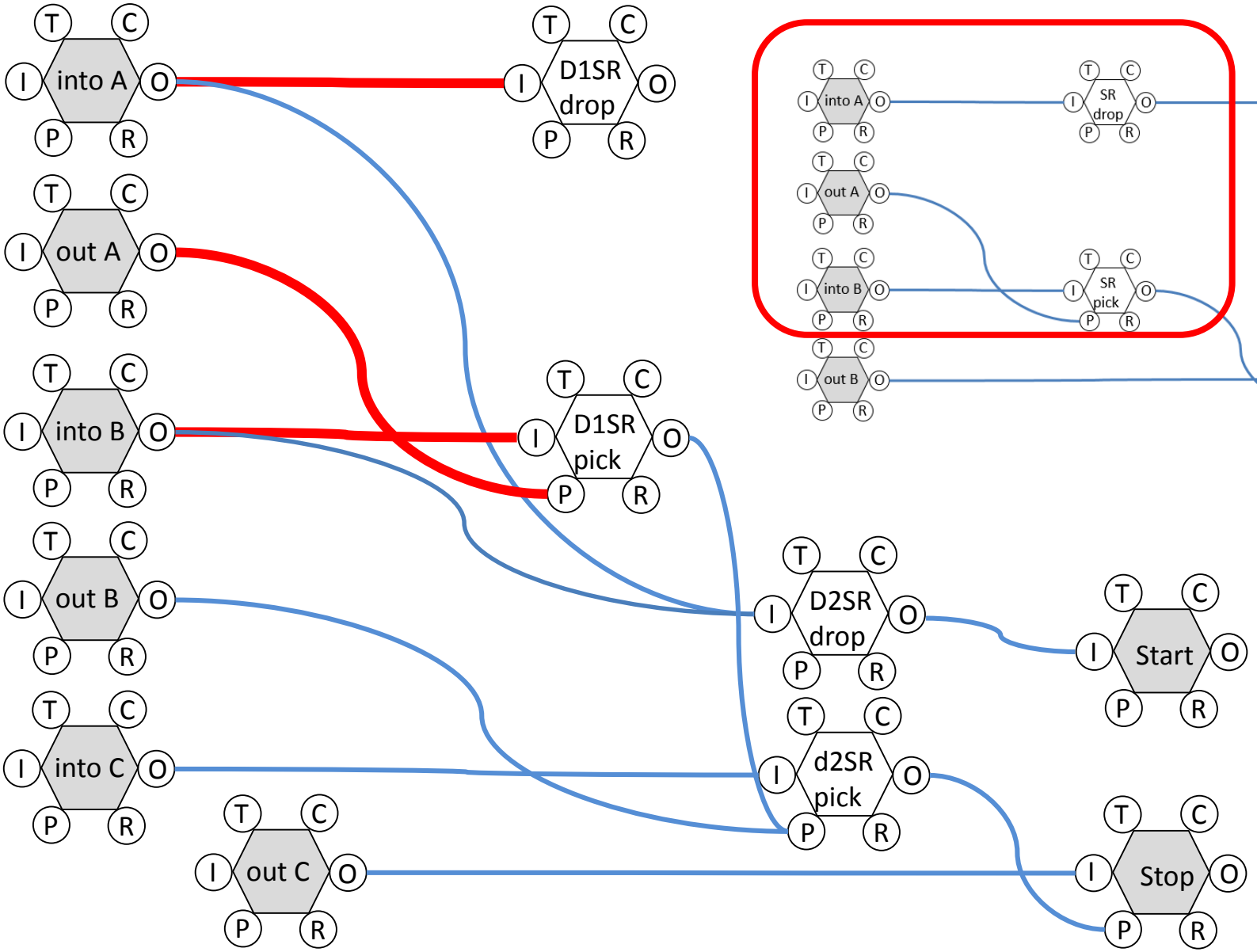
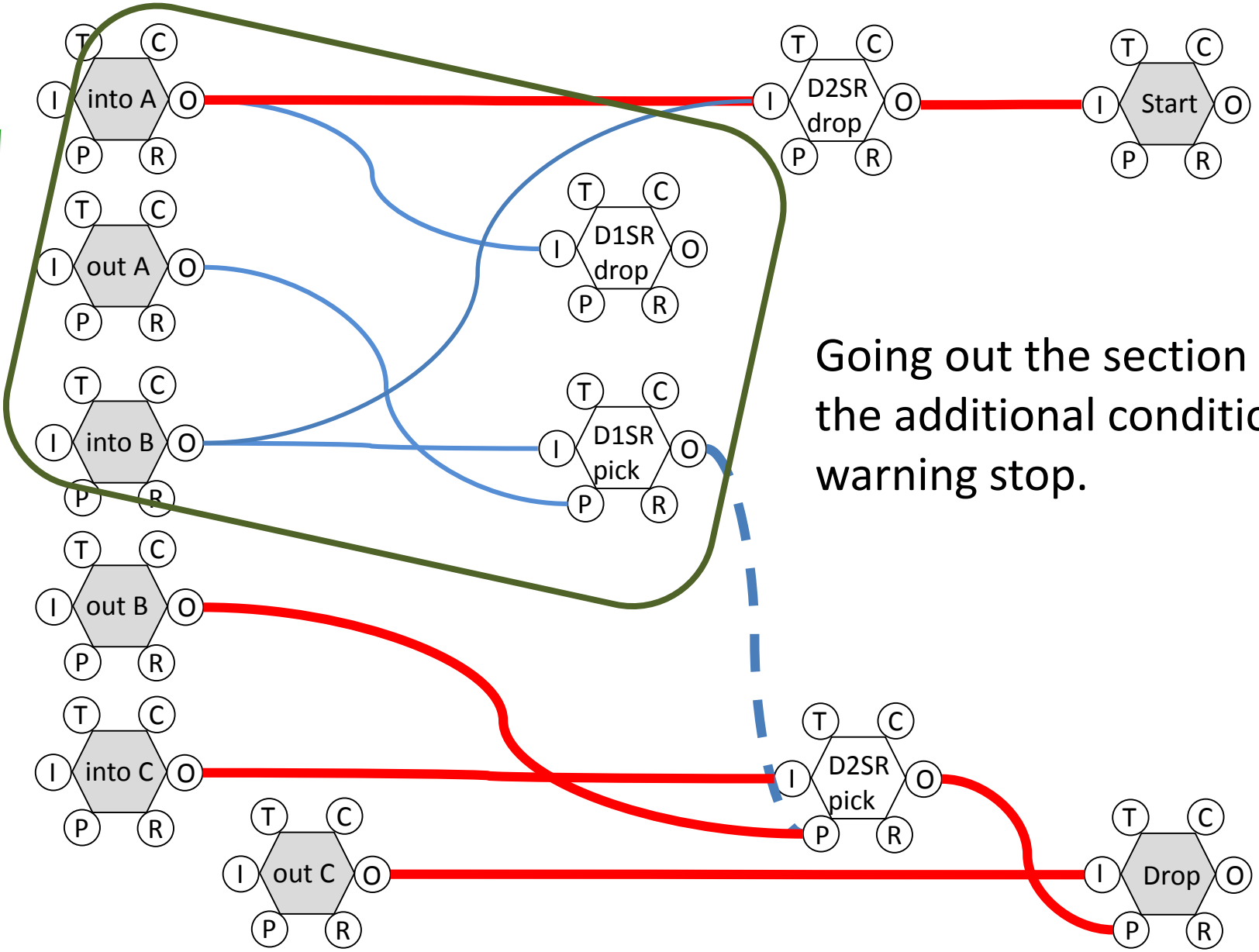
into A
D1SR drop
out A
D2SR drop
Start
into B
D1SR pick
out B
D2SR pick
into C
out C
Stop
T
C
I
O
P
R

FRAM model in the case of the basic logic

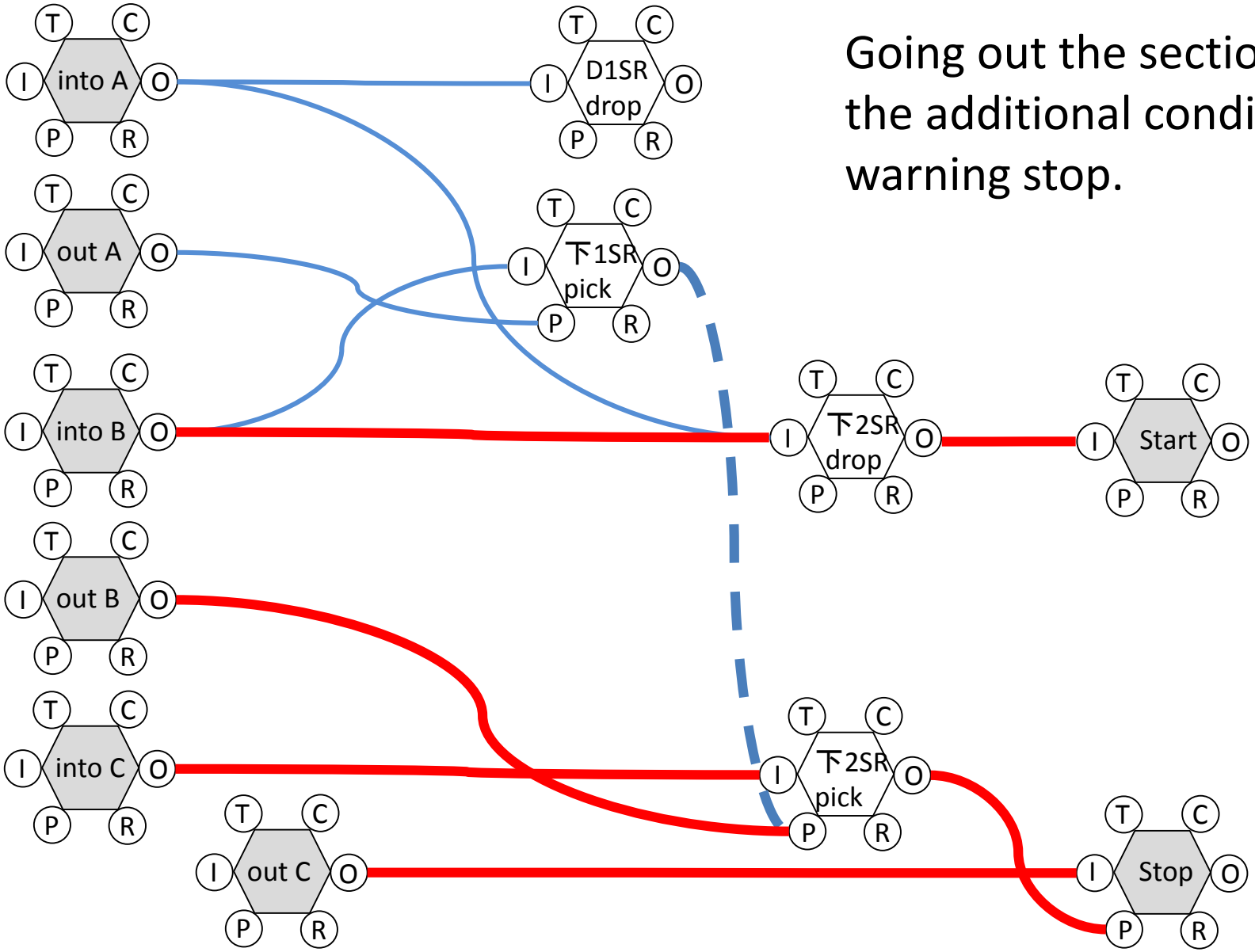




Detection a train running between A and B



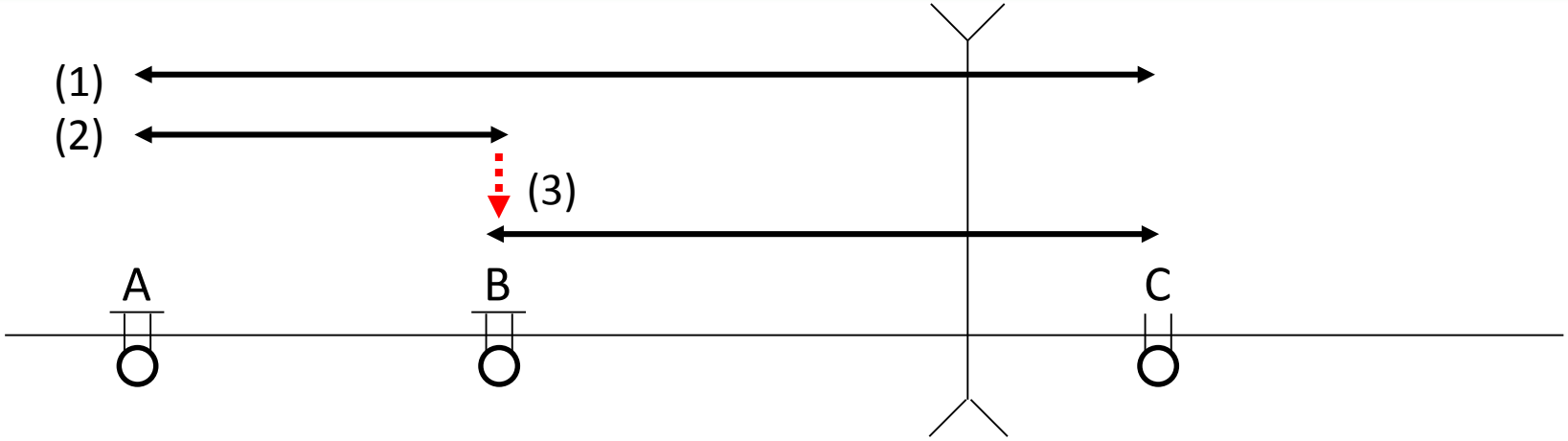
Warning control along overall warning zone



Going out the section A-B is the additional condition for warning stop.

Warning control between B and C

Extraction of success factors



(1) Logic covering the overall warning zone
(2) Train detection between A and B, B and C
(3) Train tracking

Clarification of Design Philosophy for Railway Crossing System Based on FRAM

2018.6.13 FRAMily 2018

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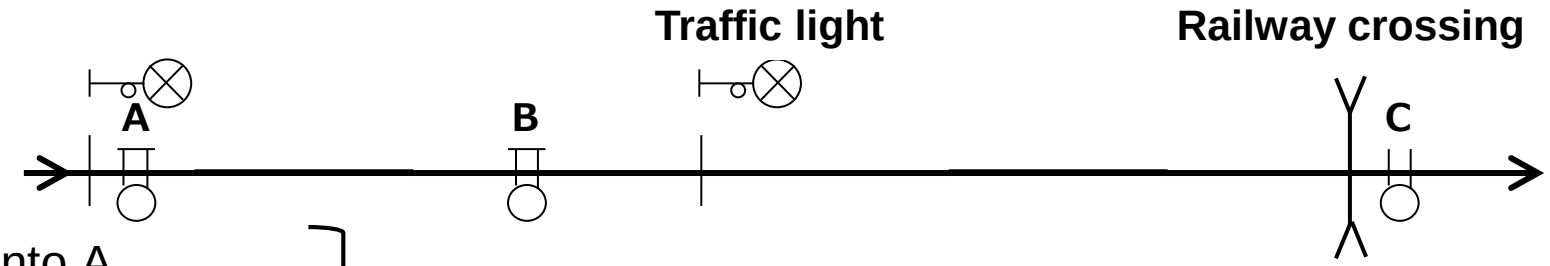
Analysis result 2 (JAMSS)

Functions



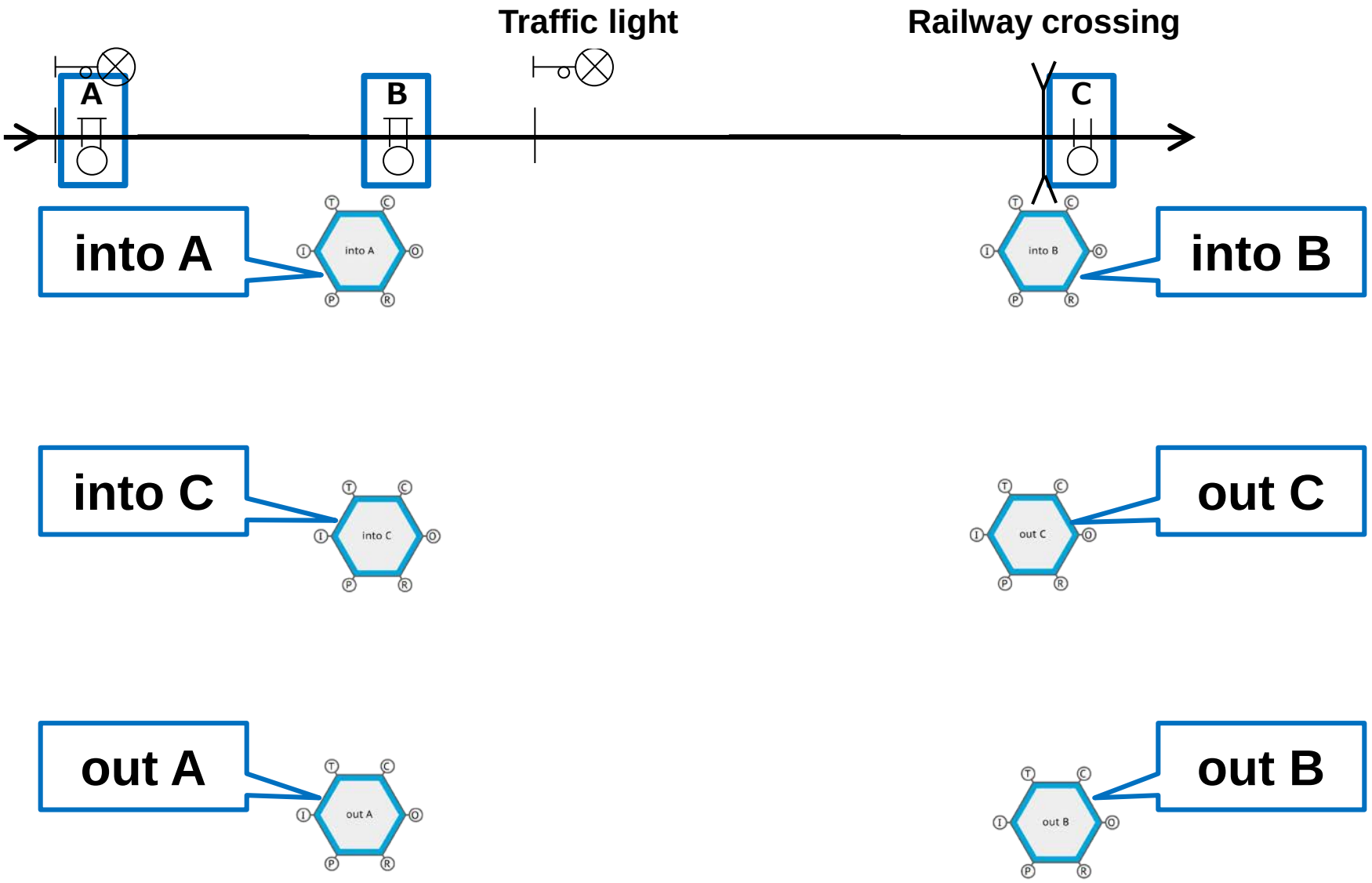
- into A
- out A
- into B
- out B
- into C
- out C
- D1SR drop
- D1SR pick
- D2SR drop
- D2SR pick
- Start
- Stop

Railway crossing control

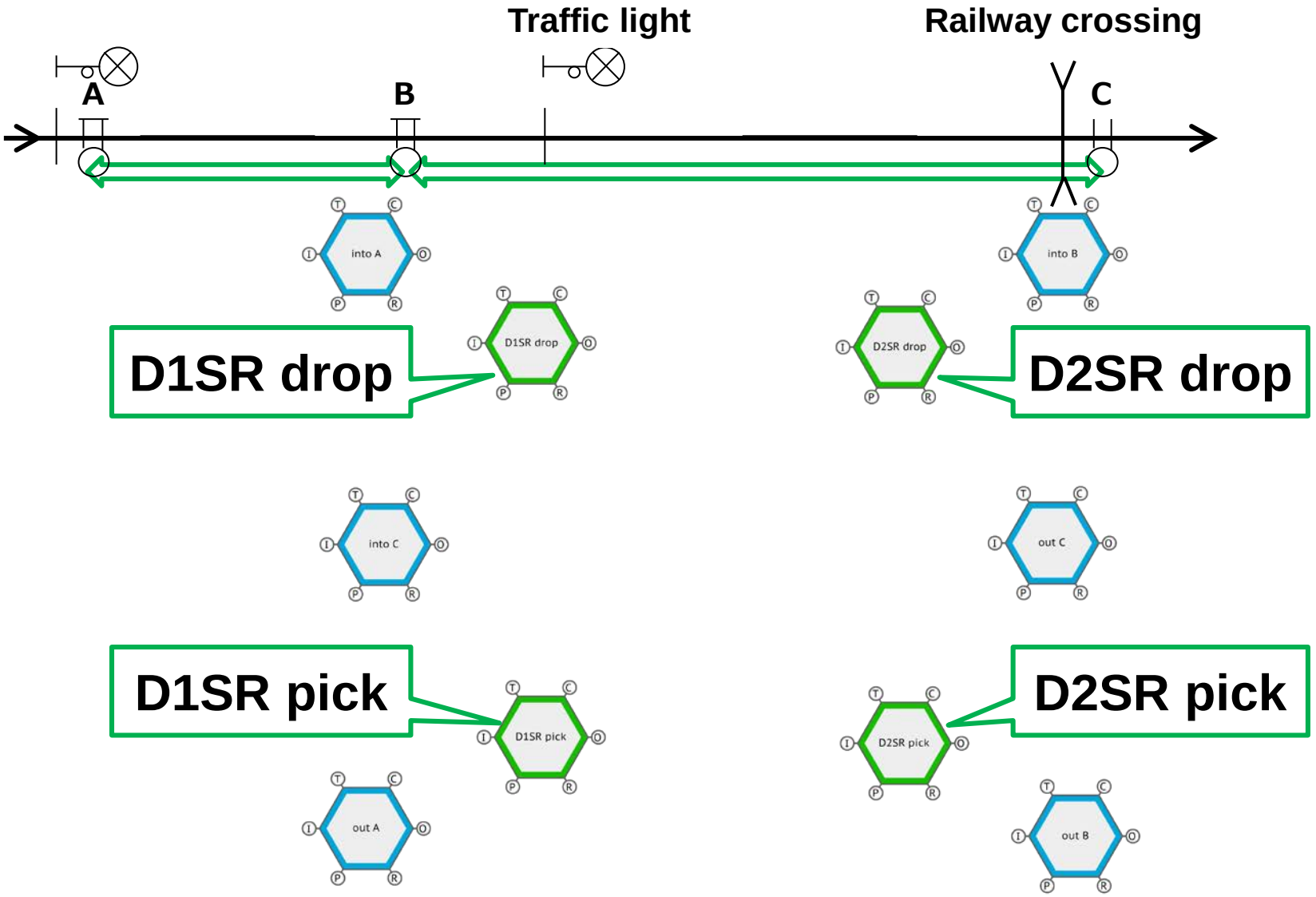
- Traffic light : Go

→Traffic light control

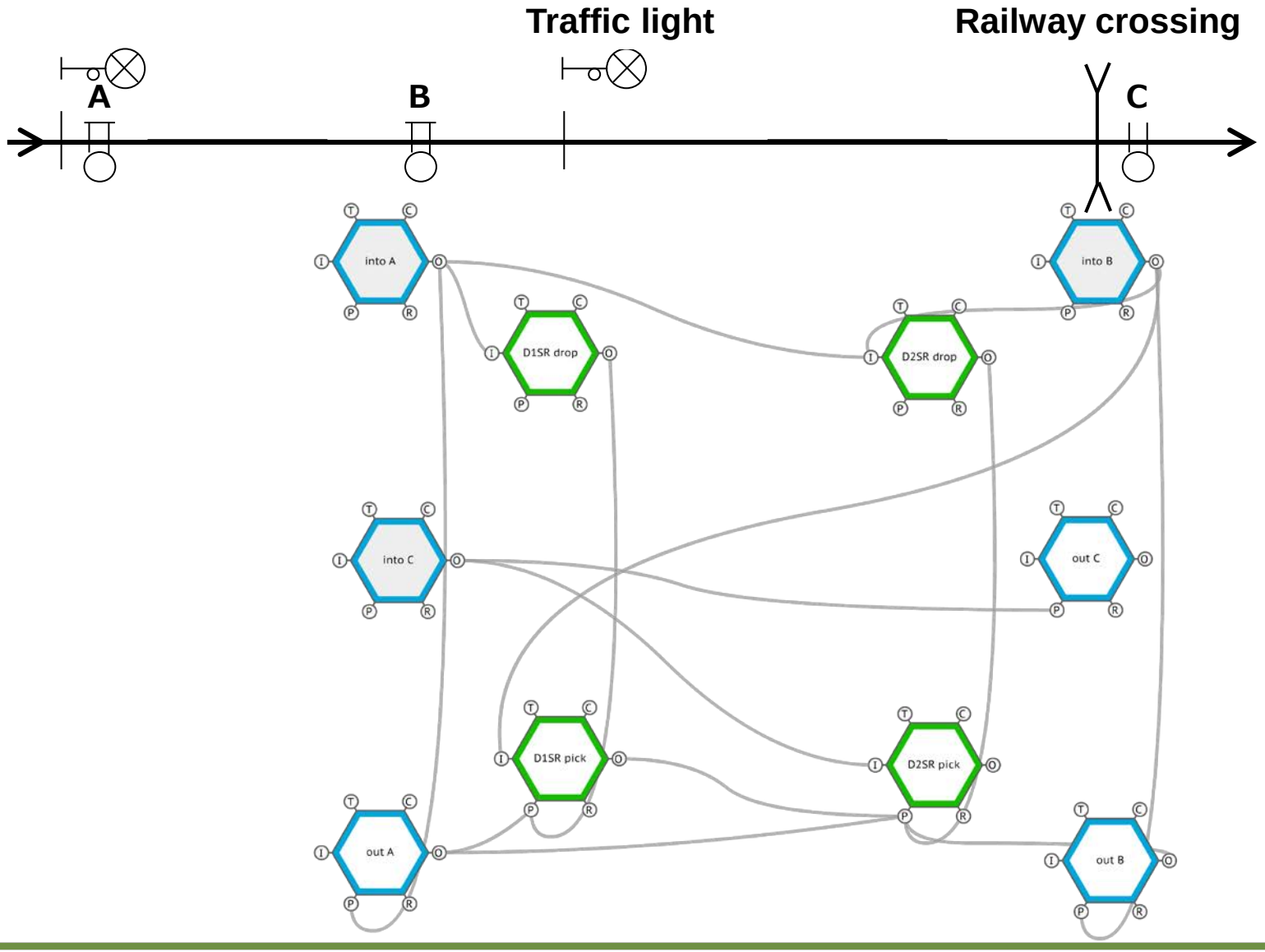
FRAM Model



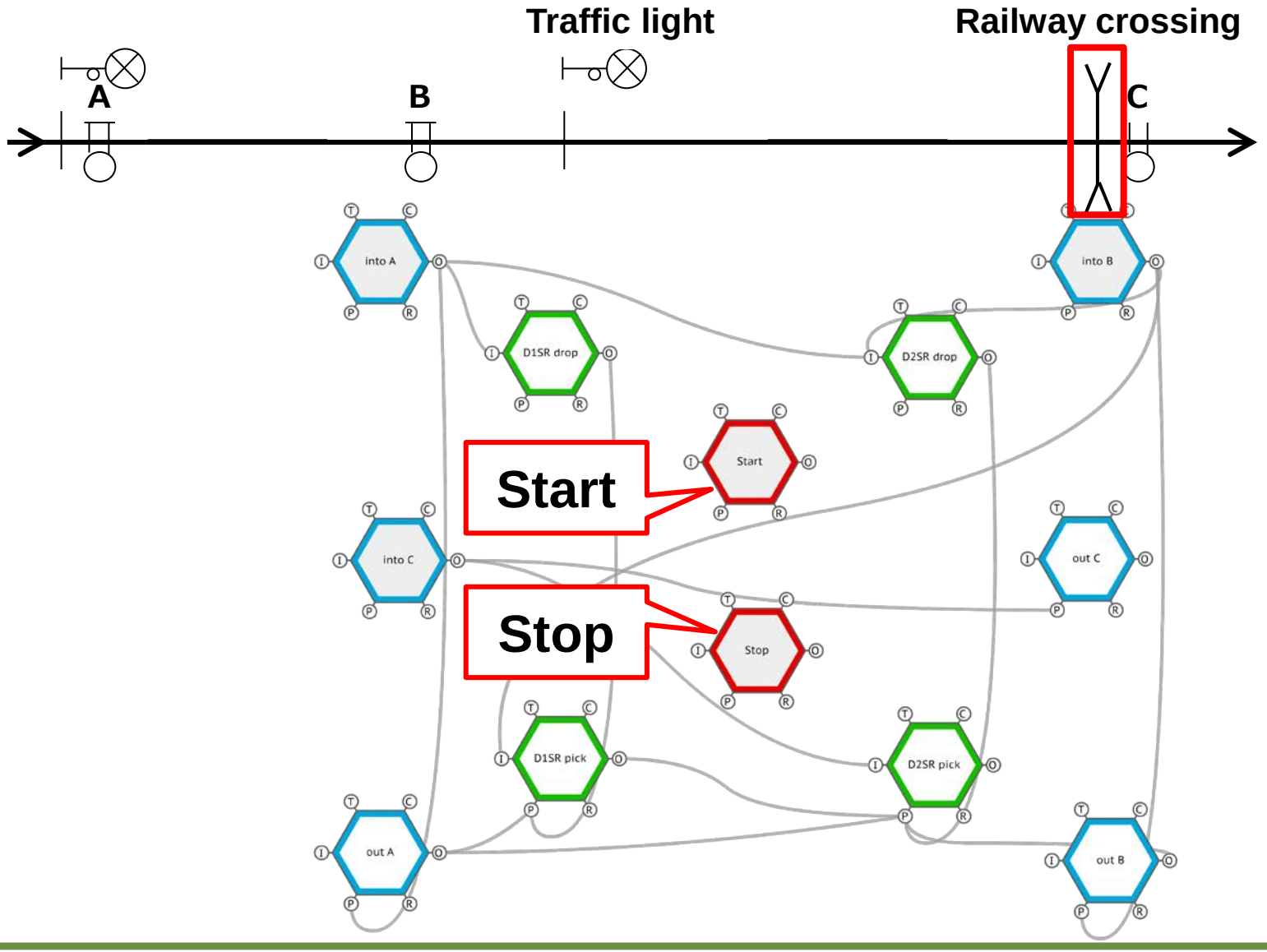
FRAM Model



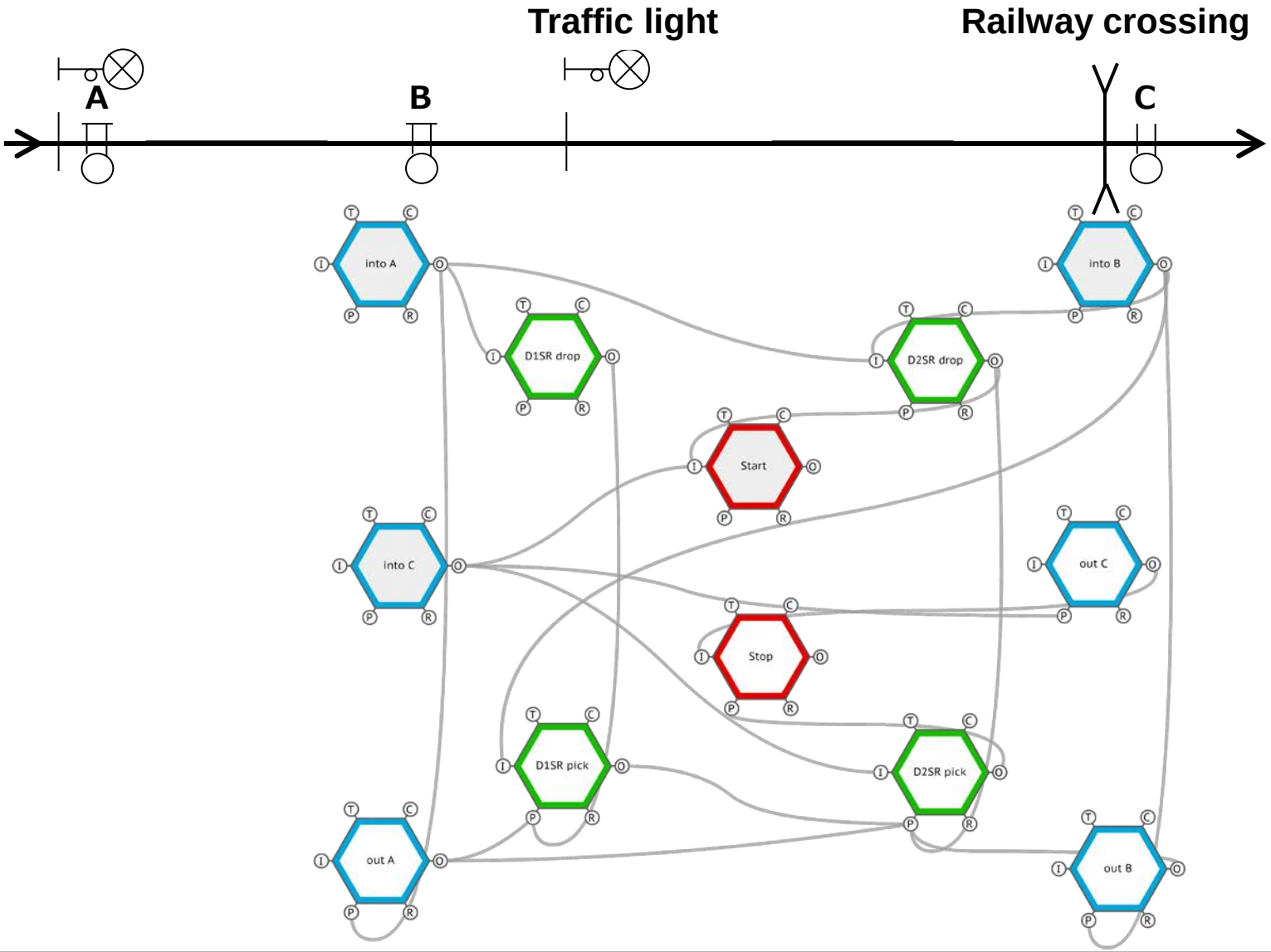
FRAM Model



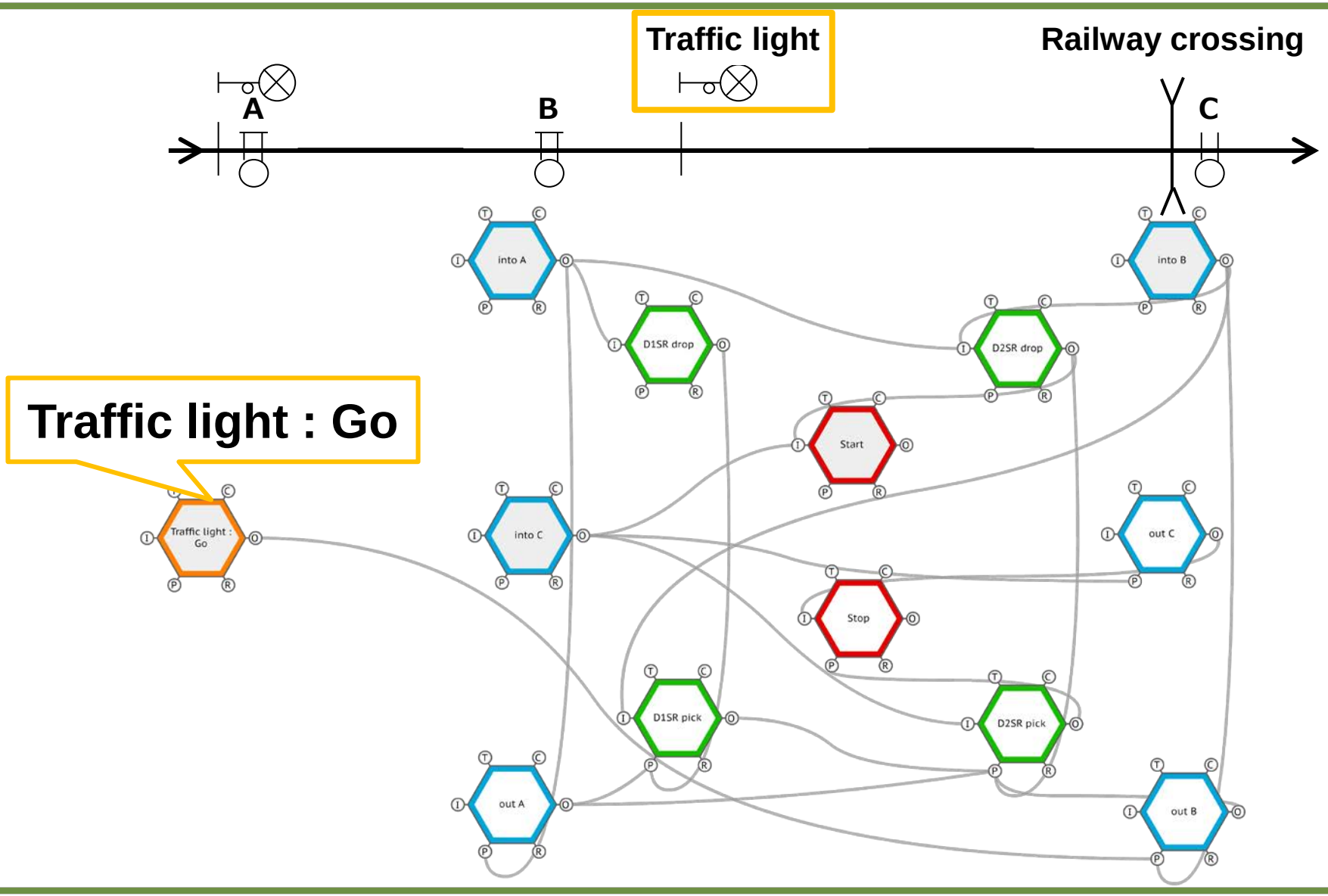
FRAM Model



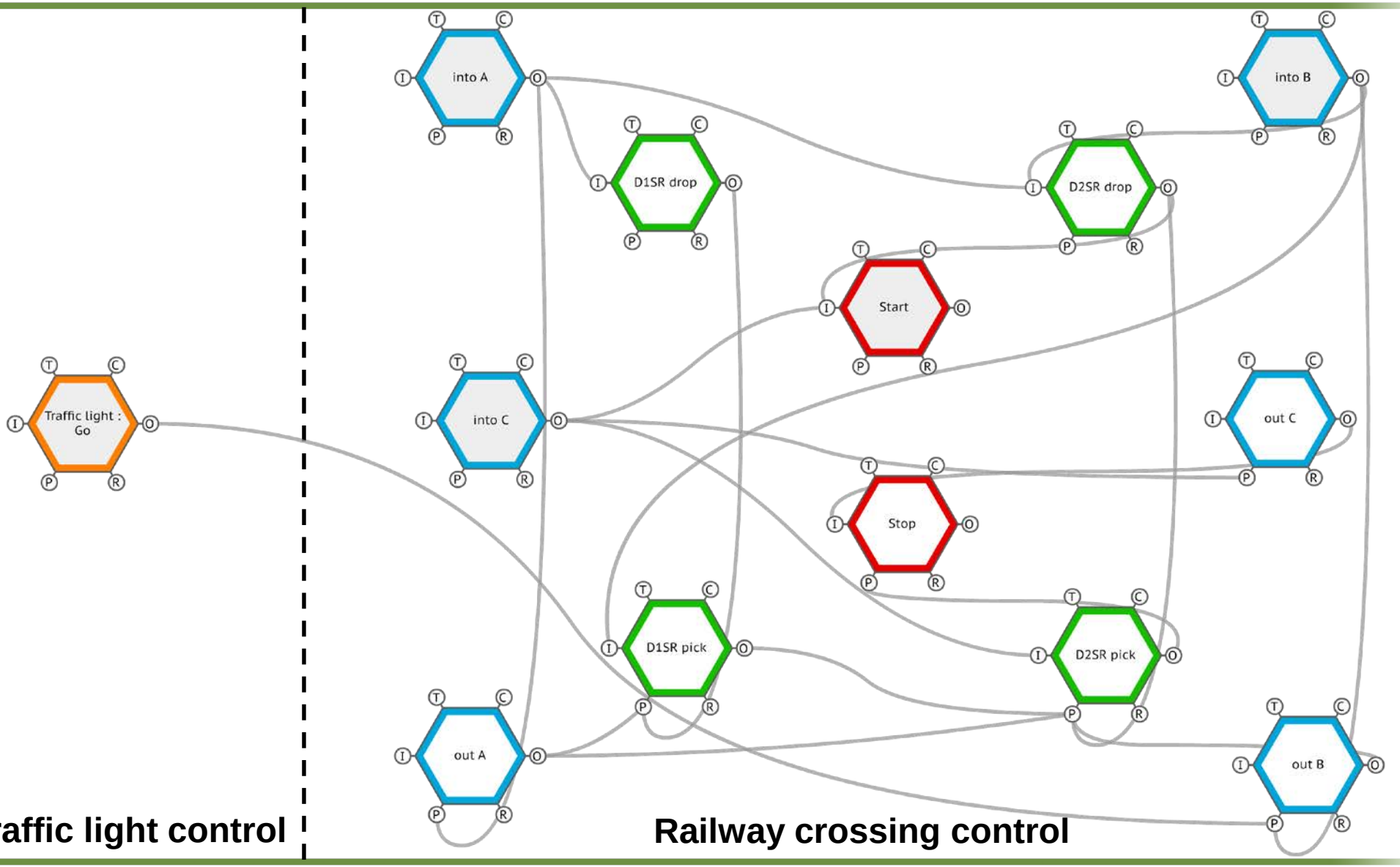
FRAM Model



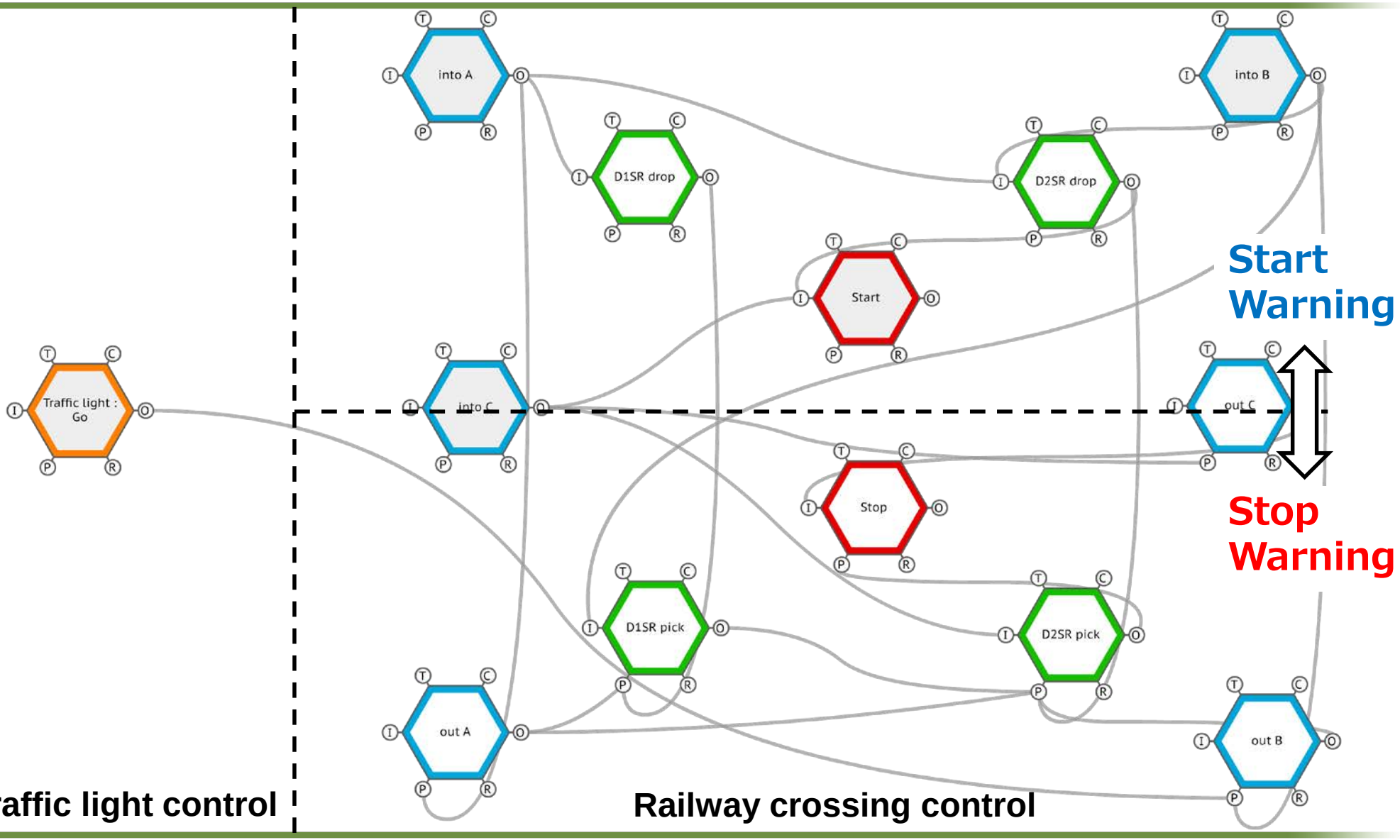
FRAM Model



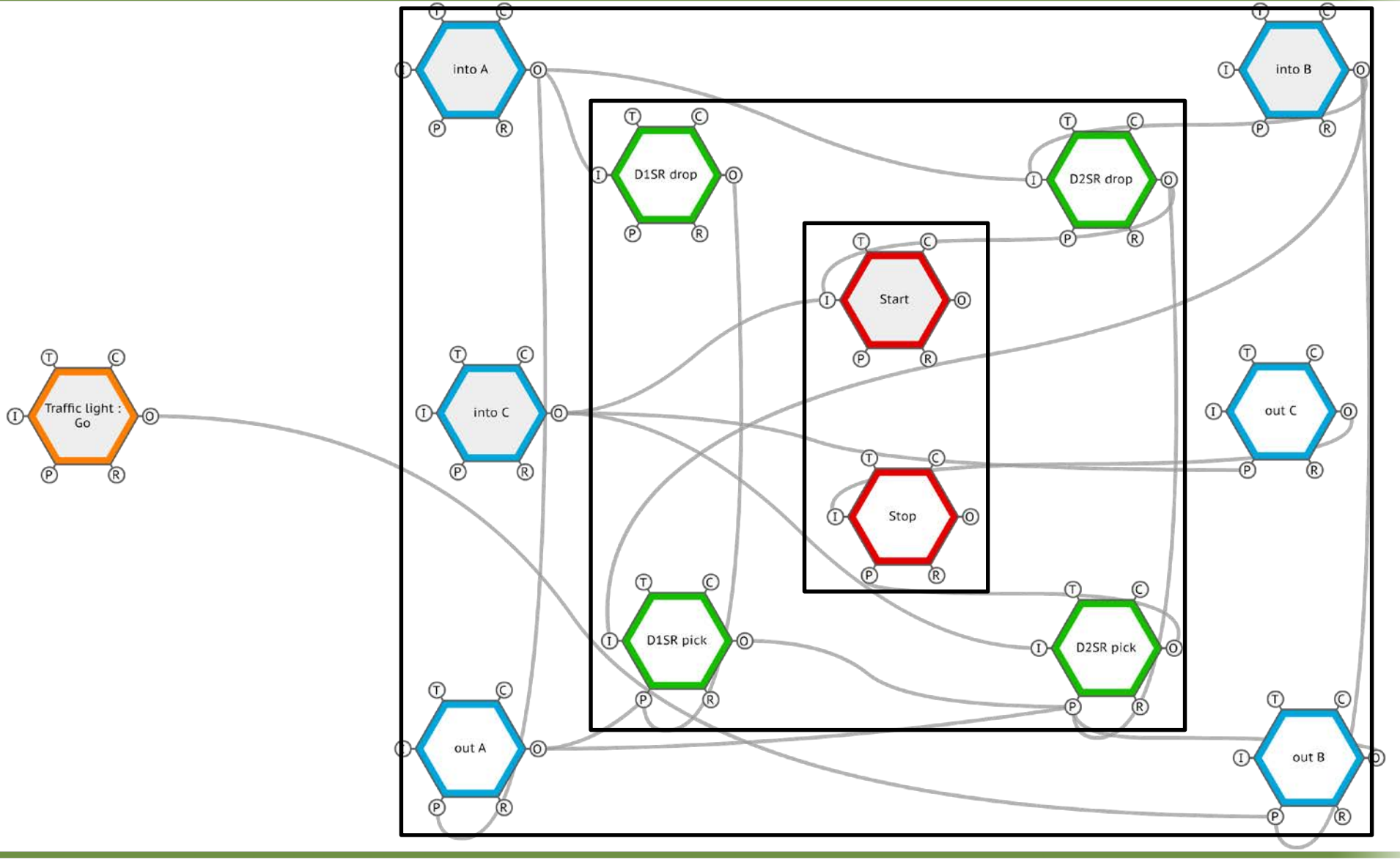
FRAM Model



FRAM Model

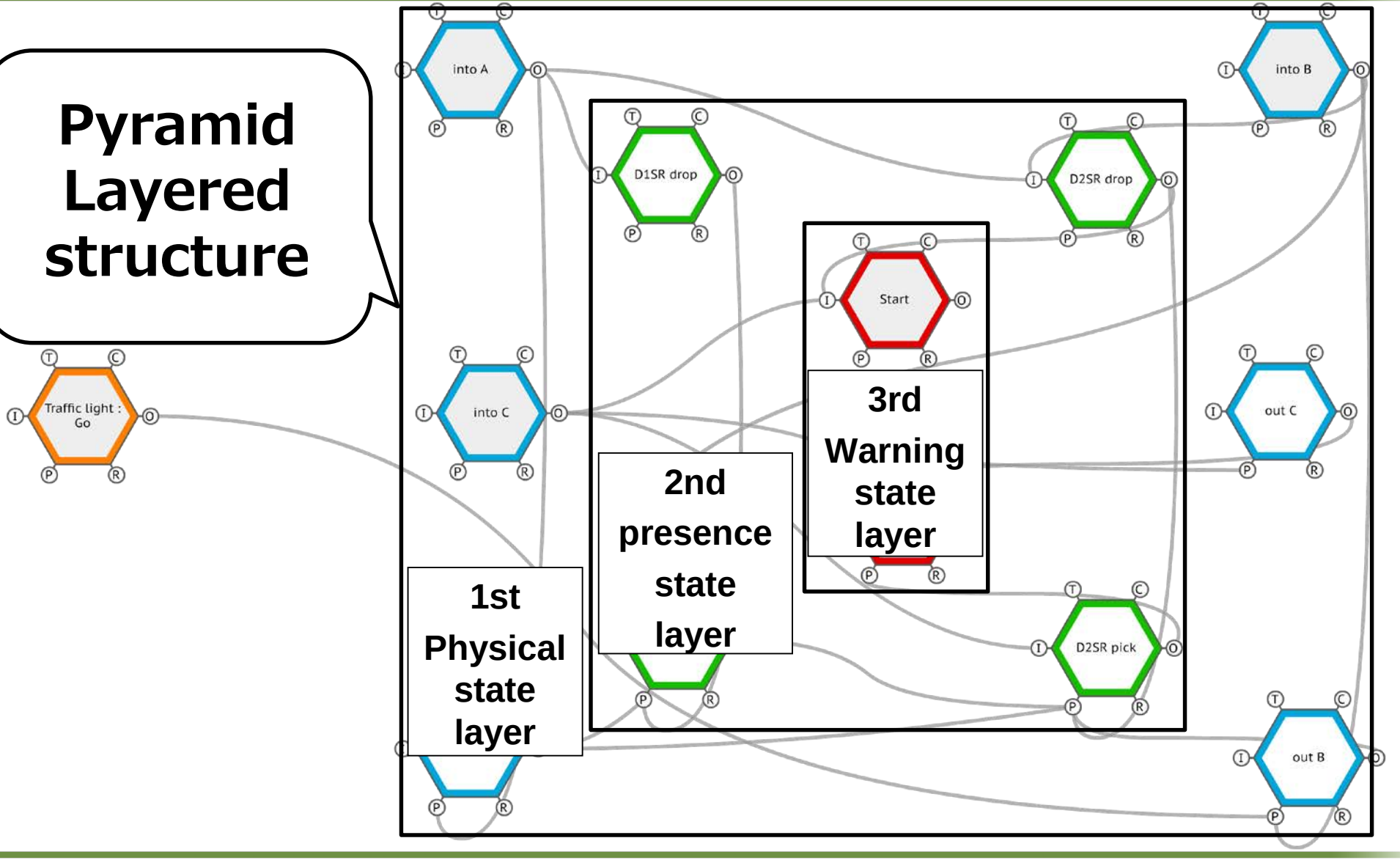


FRAM Model

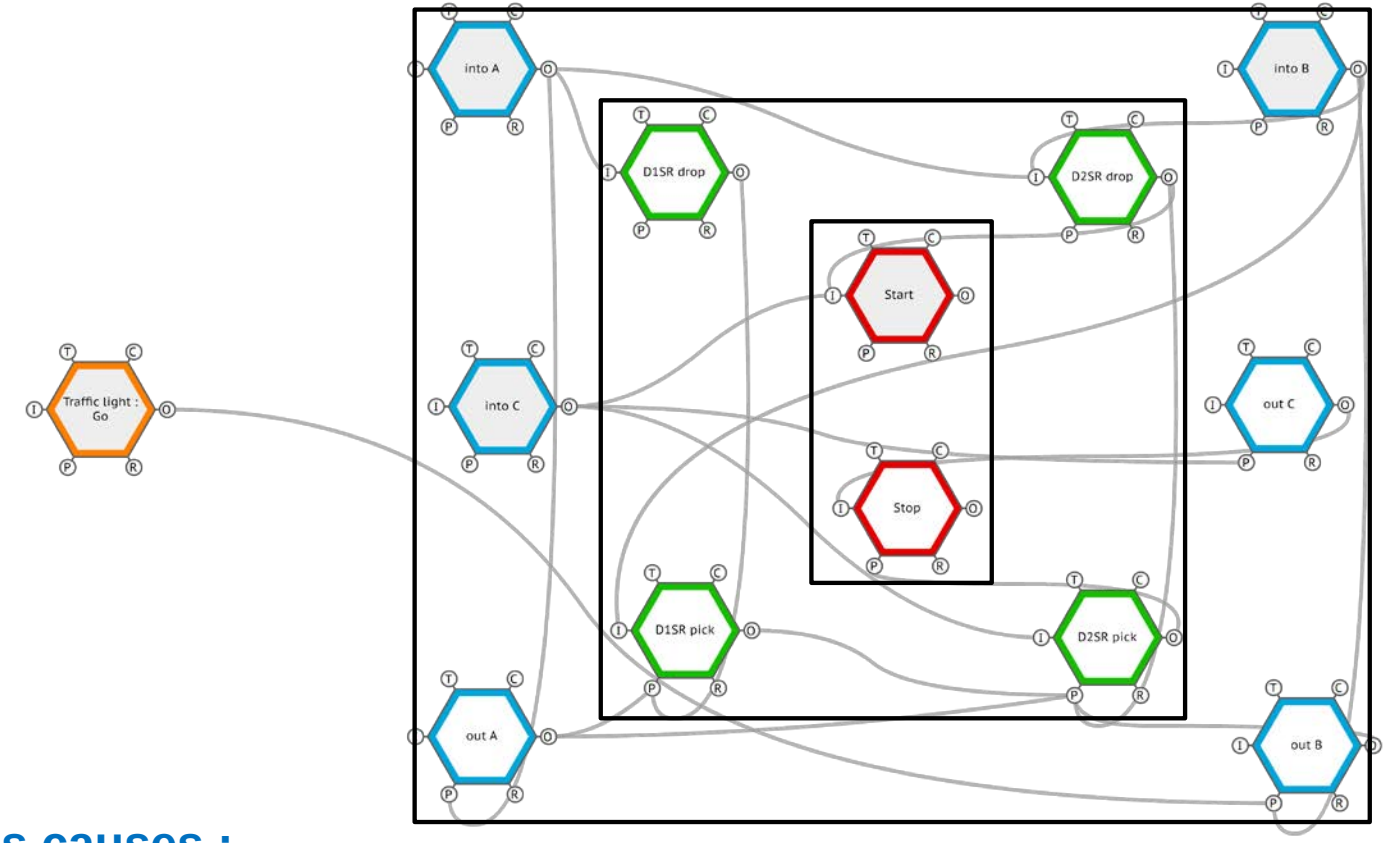


FRAM Model

Pyramid Layered structure



Success cause / Risk cause



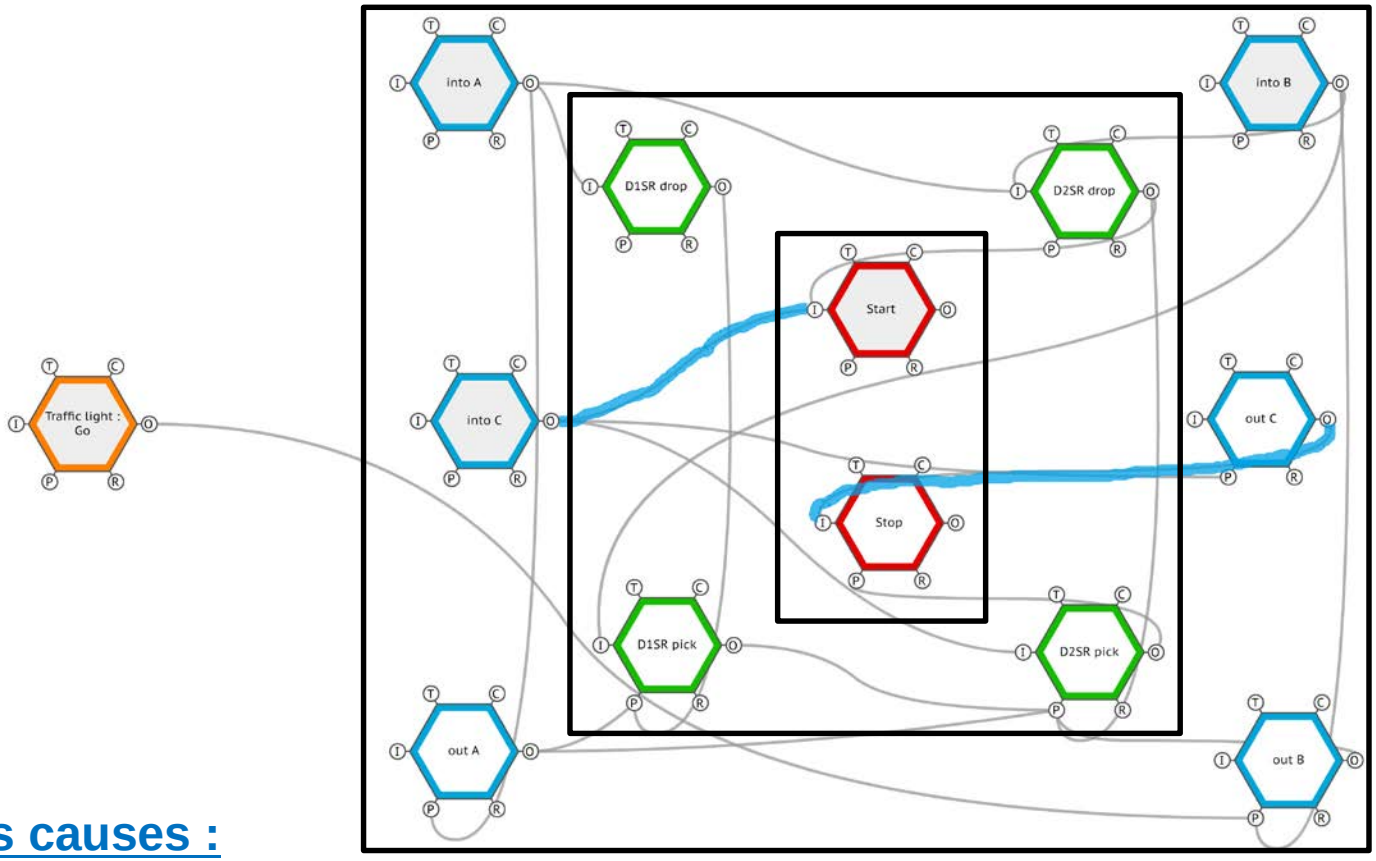
Success causes :

1. Pyramid Layered structure

   1.1. Process of start and stop warning has **similar feature**.

   1.2. The network configuration of the entire system is not easily affected because **layers should take care of interaction with only next layers.**

Success cause / Risk cause



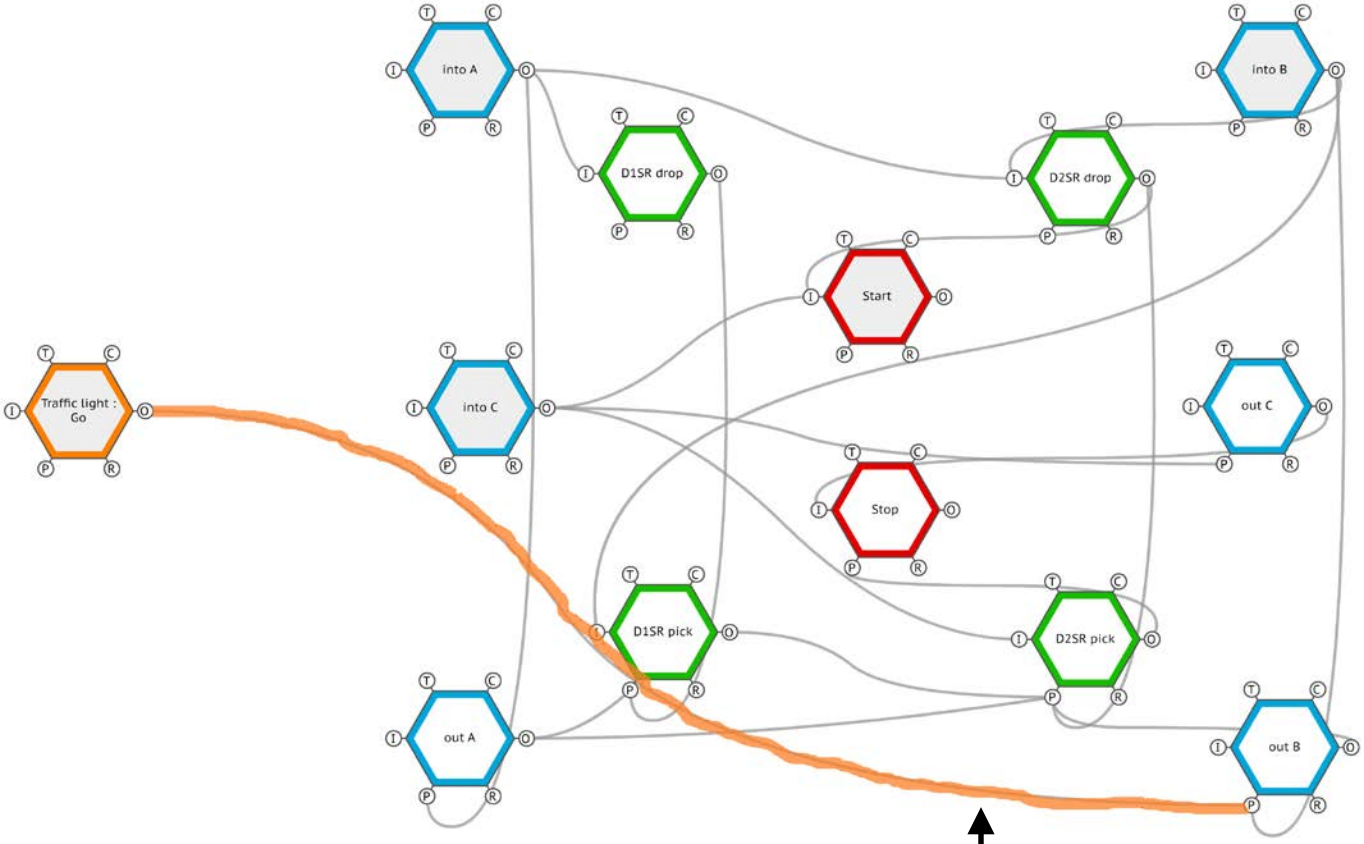
Success causes :

2. Direct interaction of point C from bottom to top layer

Point C can **interact directly from bottom to top** layer.

Point C can stop warning and start warning(when C is out of order) by direct interaction.

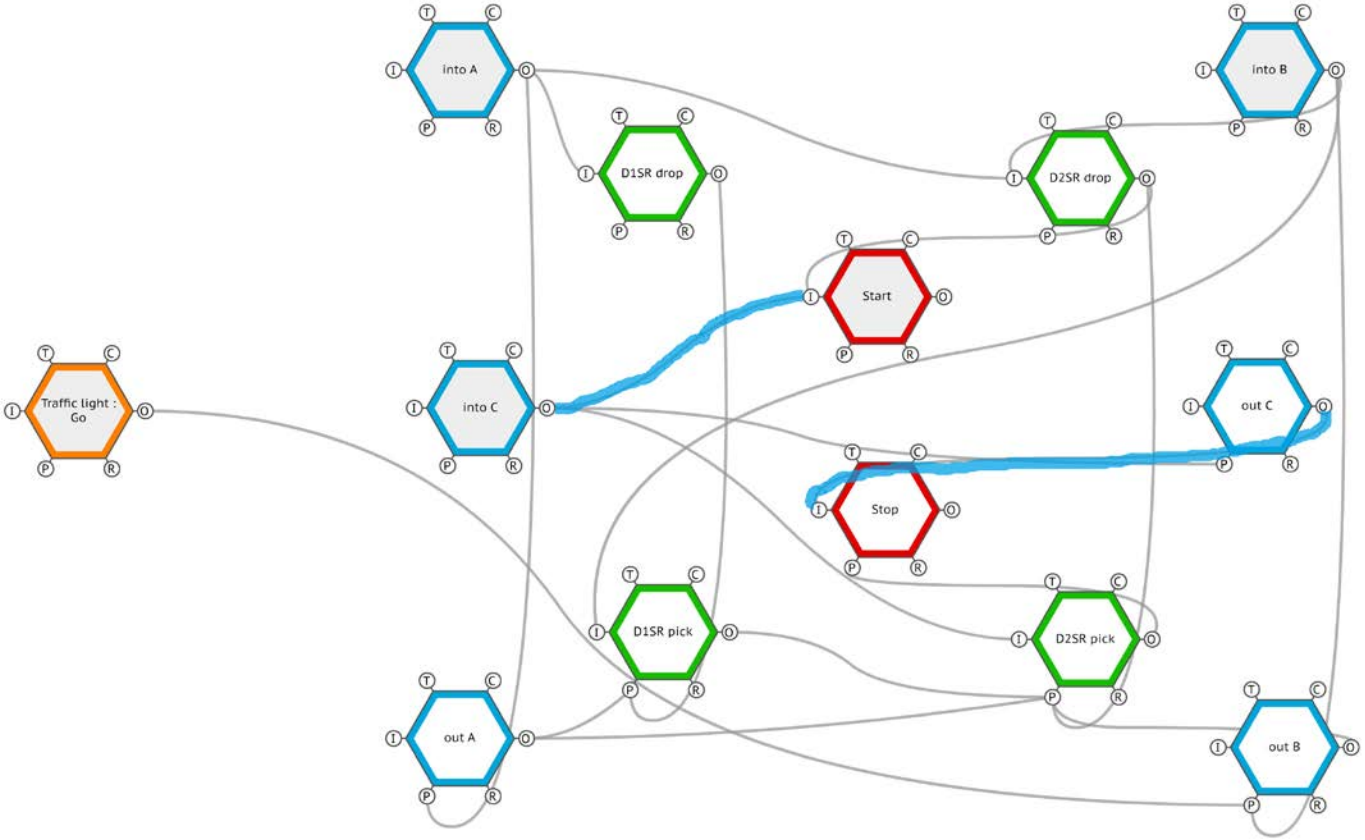
Success cause / Risk cause



Risk causes :

1. Control logic of railway crossing will collapse if **this interaction**(constraint) is broken.

Success cause / Risk cause



Risk causes :

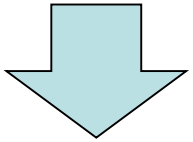
2. Failure of point C result in failure of control directly because of direct interaction from point C to top layer.

Extracted design requirements

Extracted design requirements

By applying FRAM to several type of control logic of railway crossing, we succeeded in extracting 9 design requirements.

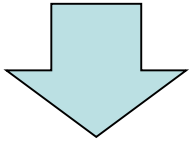
Success cause No.1 : Pyramid Layered structure



Requirement :

The architecture of control logic of railway crossing should be pyramid layered structure.

Risk cause No.1 : Relationship between traffic light control and railway crossing control



Requirement :

Control logic of traffic light should be merged to control logic of railway crossing.

Conclusion

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・Applying FRAM to control logic of railway crossing

・East Japan Railway Company and JAMSS created FRAM model by different approach, and analyze success and risk cause each other.

・Arrangement of functions on FRAM model is important to recognize success and risk cause.

・We succeeded in extracting design requirements that take success and risk cause into account.