Edge Requirements

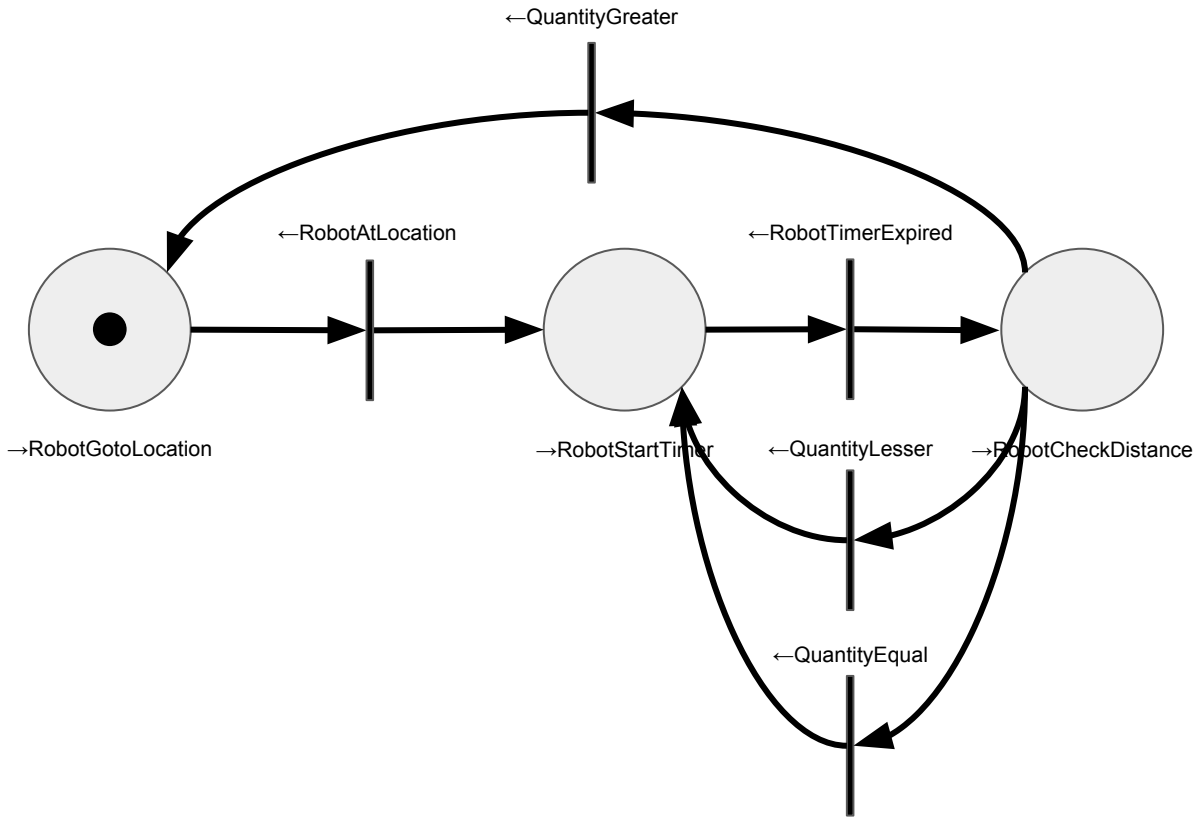
With the addition of output events we can send commands to the robot.
With the addition of input events we can receive information from the robot.
With the addition of tokens we can represent the robot's status.

However, we don't have a method for moving the robot's token between places as its status changes. We will do this by firing transitions as status changes occur and subsequently moving tokens between places according to edge requirements.

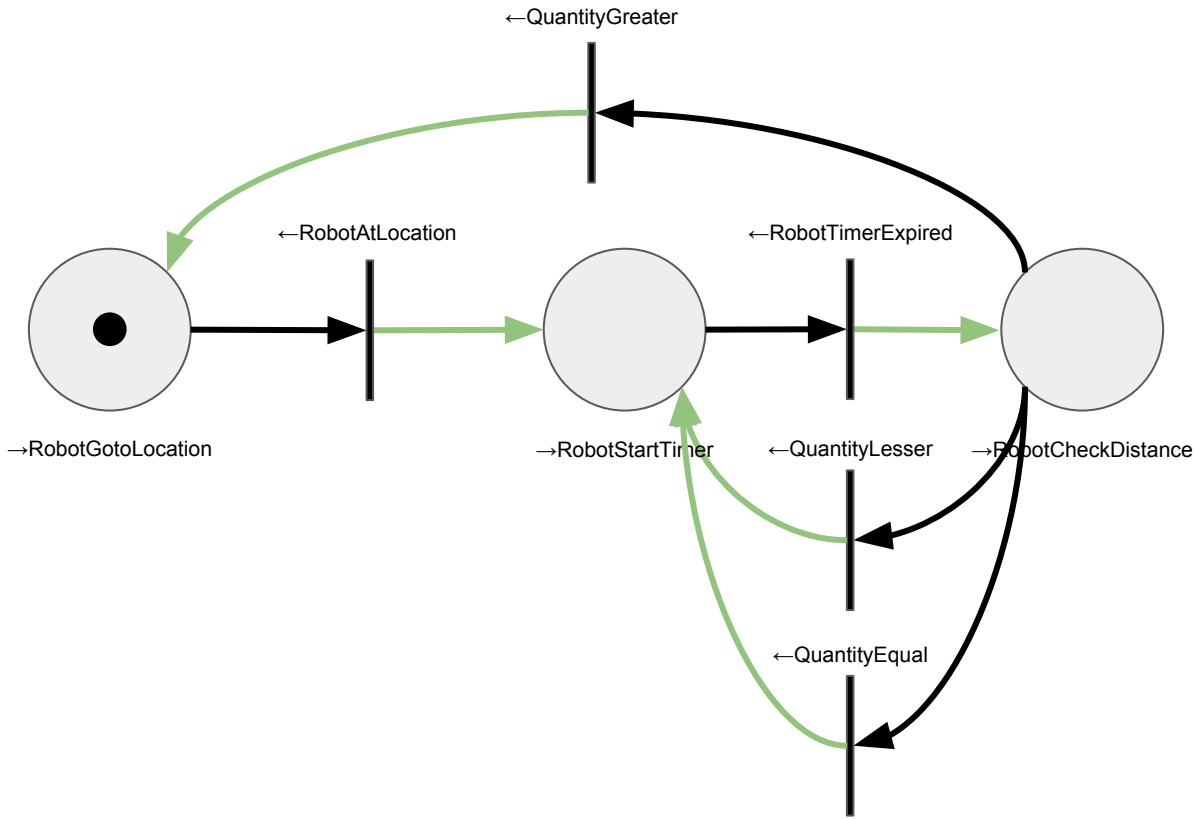
There are two types of edge requirements. First we will look at out edge requirements.

Out edge requirements: Are put on Out Edges and describe what to do with tokens when a transition connected to it fires

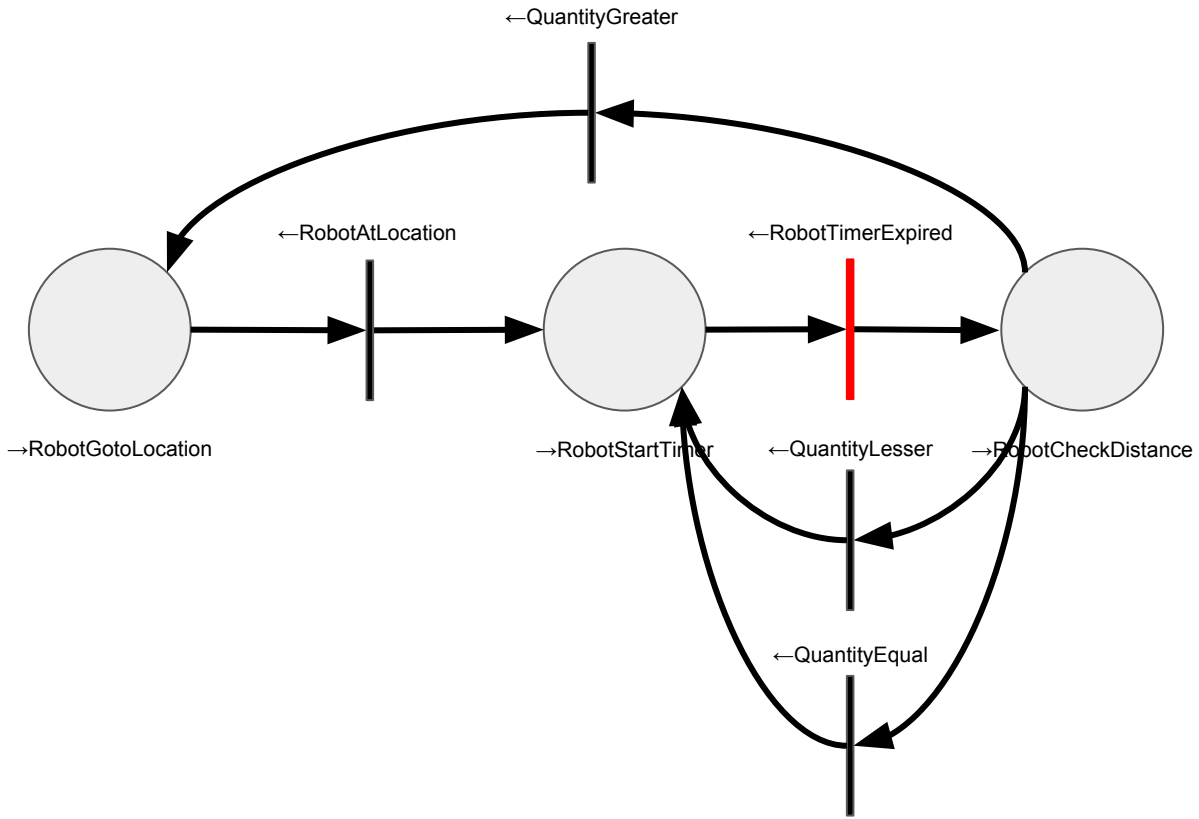
Quiz 5-1: Identify the out edges



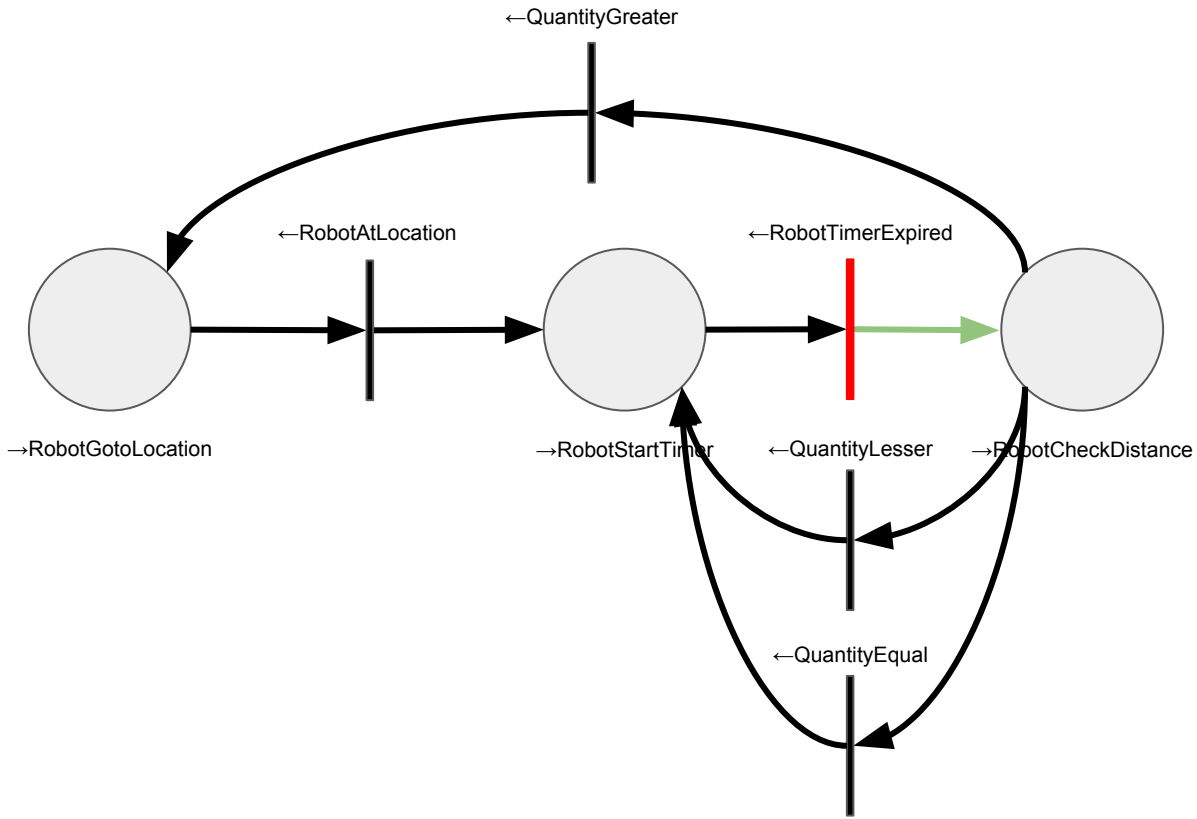
Quiz 5-1 Solution



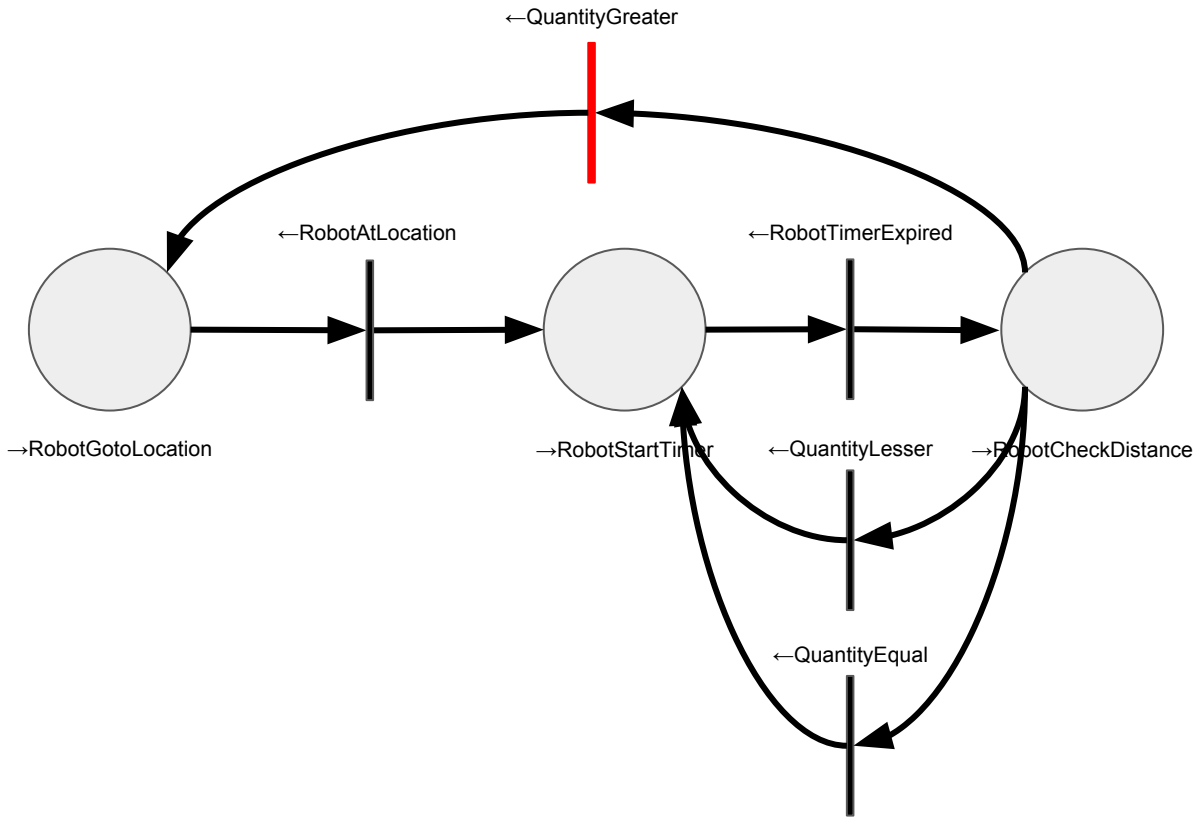
Quiz 5-2: Identify the out edges connected to the “firing” transition



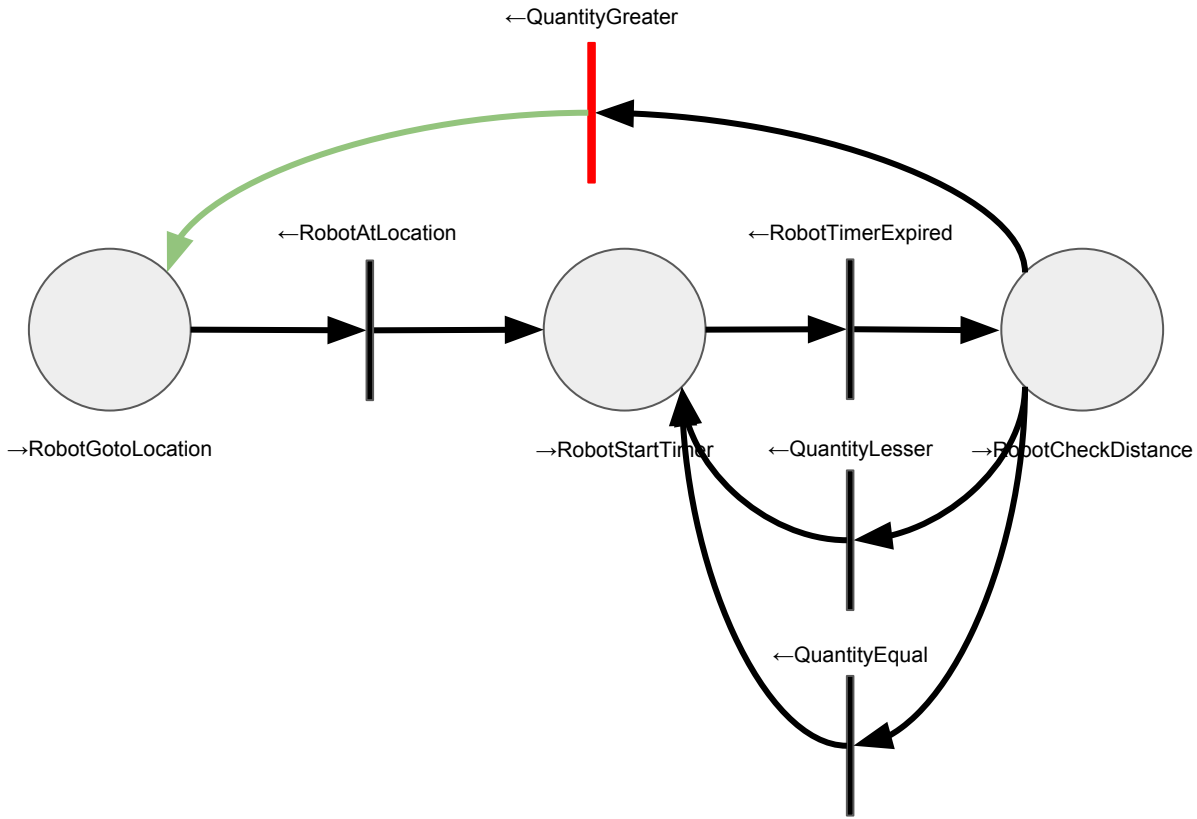
Quiz 5-2 Solution



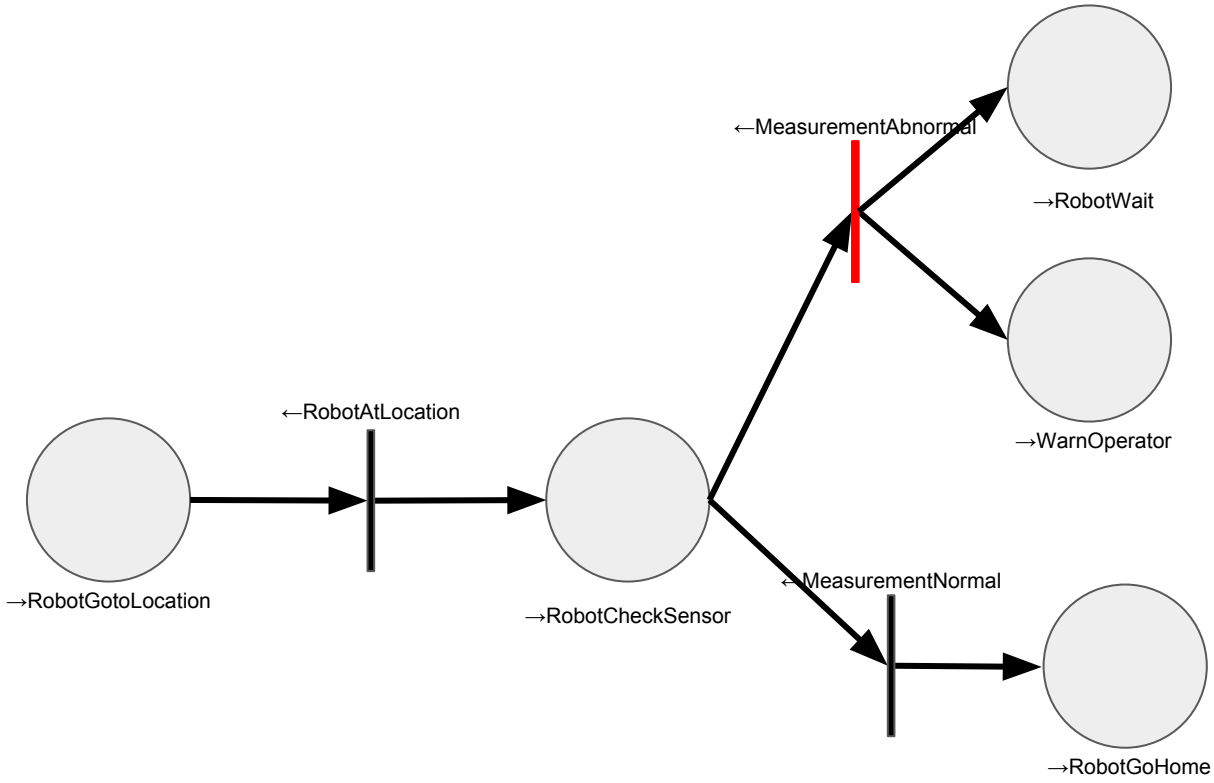
Quiz 5-3: Identify the out edges connected to the “firing” transition



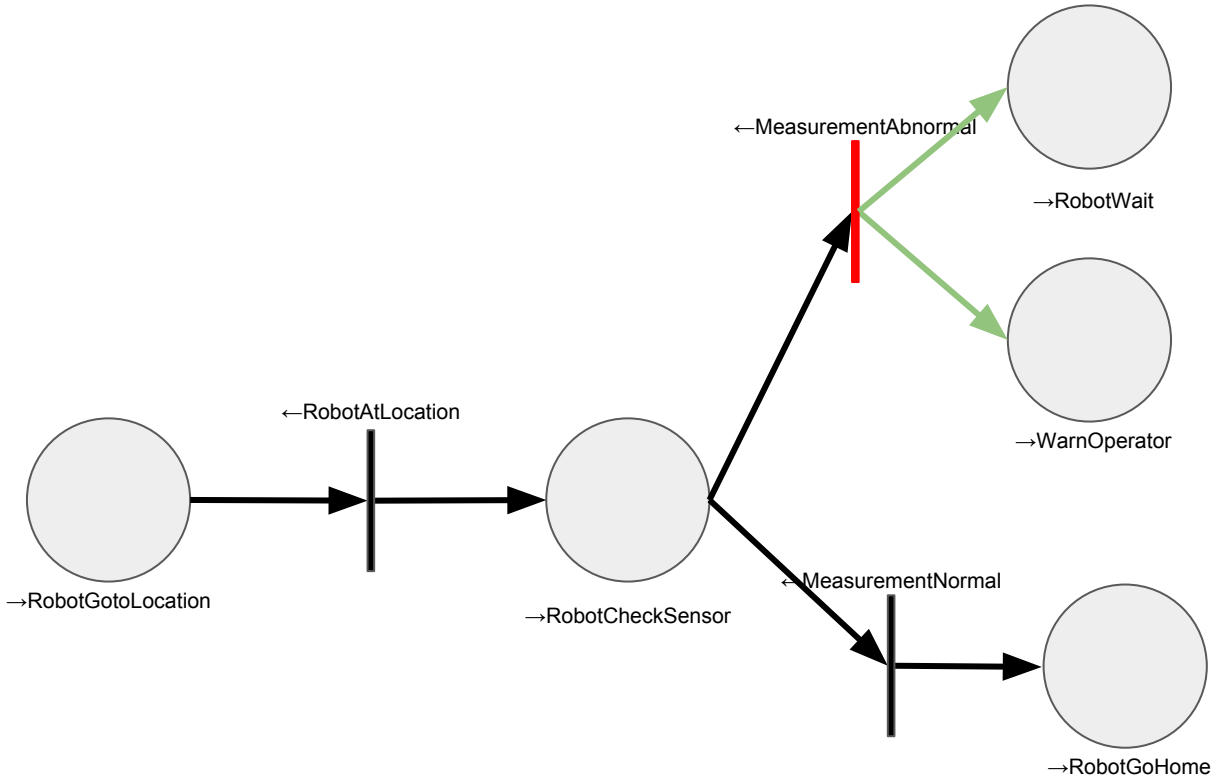
Quiz 5-3 Solution



Quiz 5-4: Identify the out edges connected to the “firing” transition



Quiz 5-4 Solution

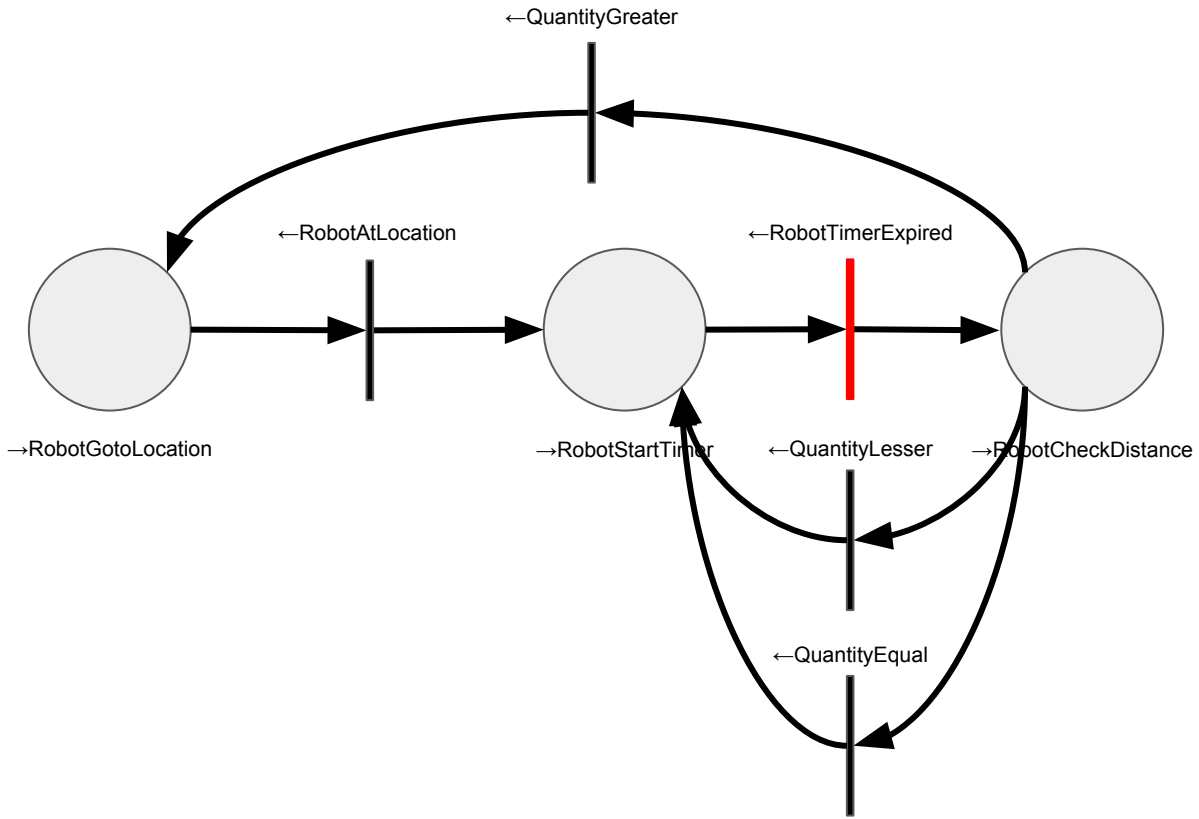


Out edge requirements: Are put on Out Edges and describe what to do with tokens when a transition connected to it fires

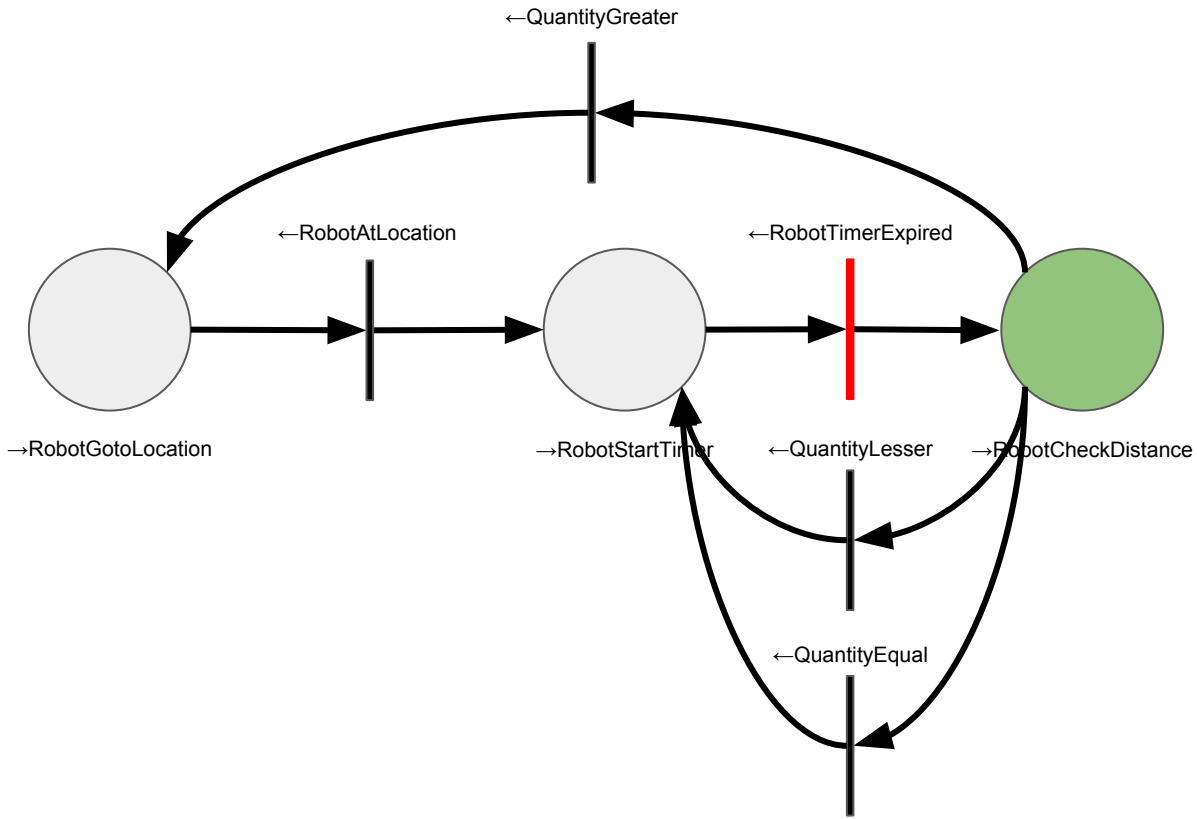
An out edge requirement can affect tokens several places: “out” places and “in” places.

- “Out” places are places connected to the firing transition via one of its out edges

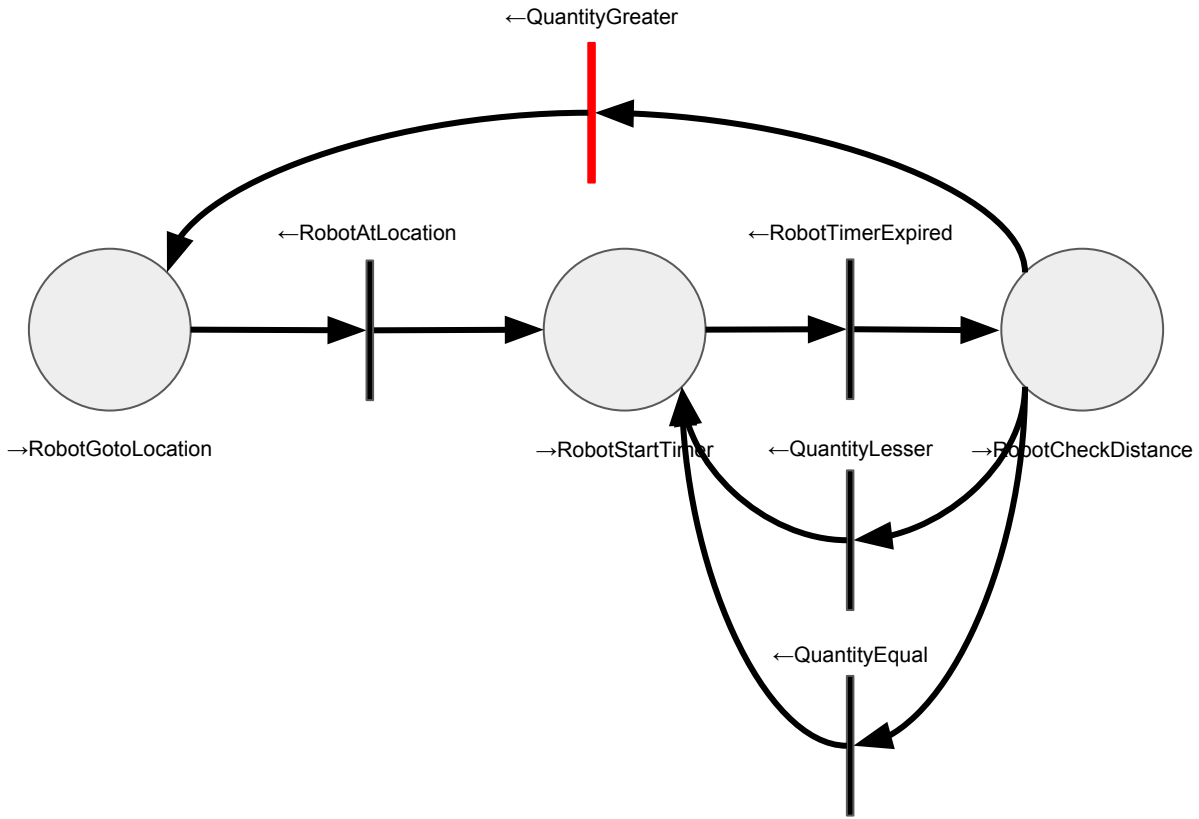
Quiz 5-5: Identify the out places for the “firing” transition



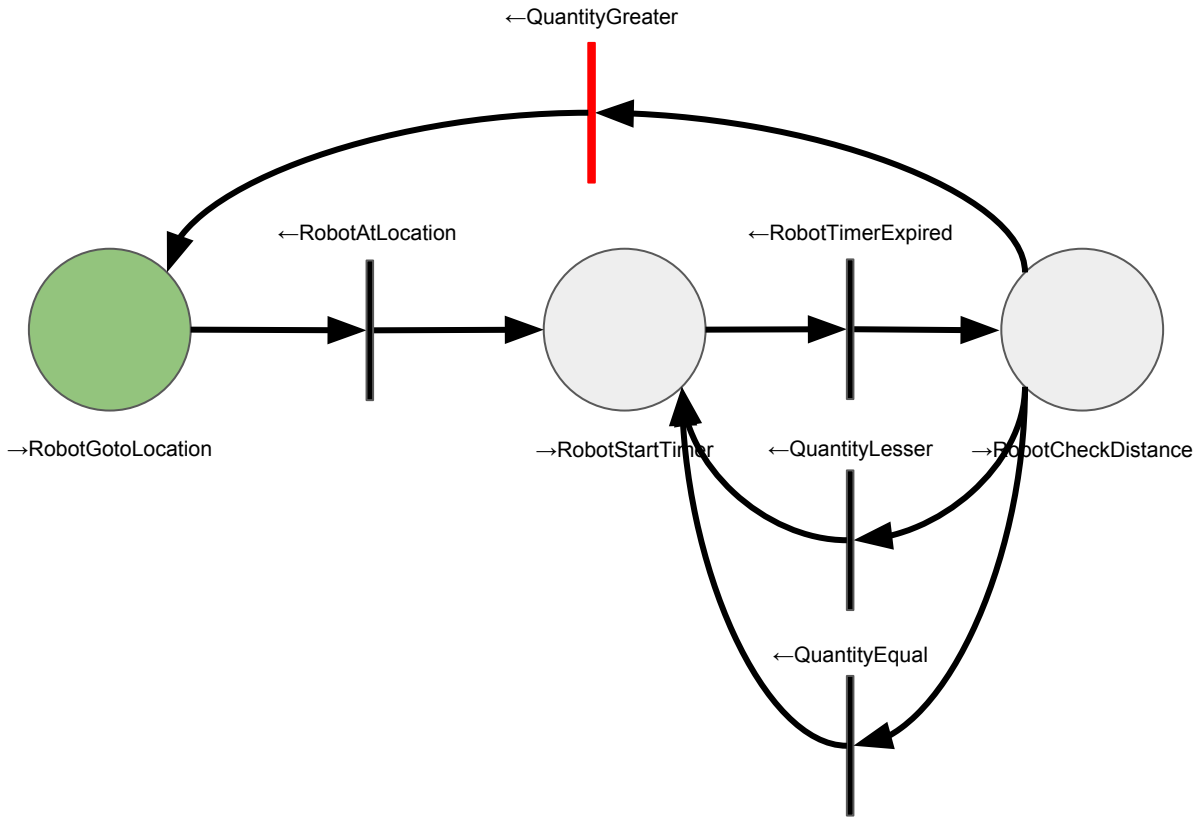
Quiz 5-5 Solution



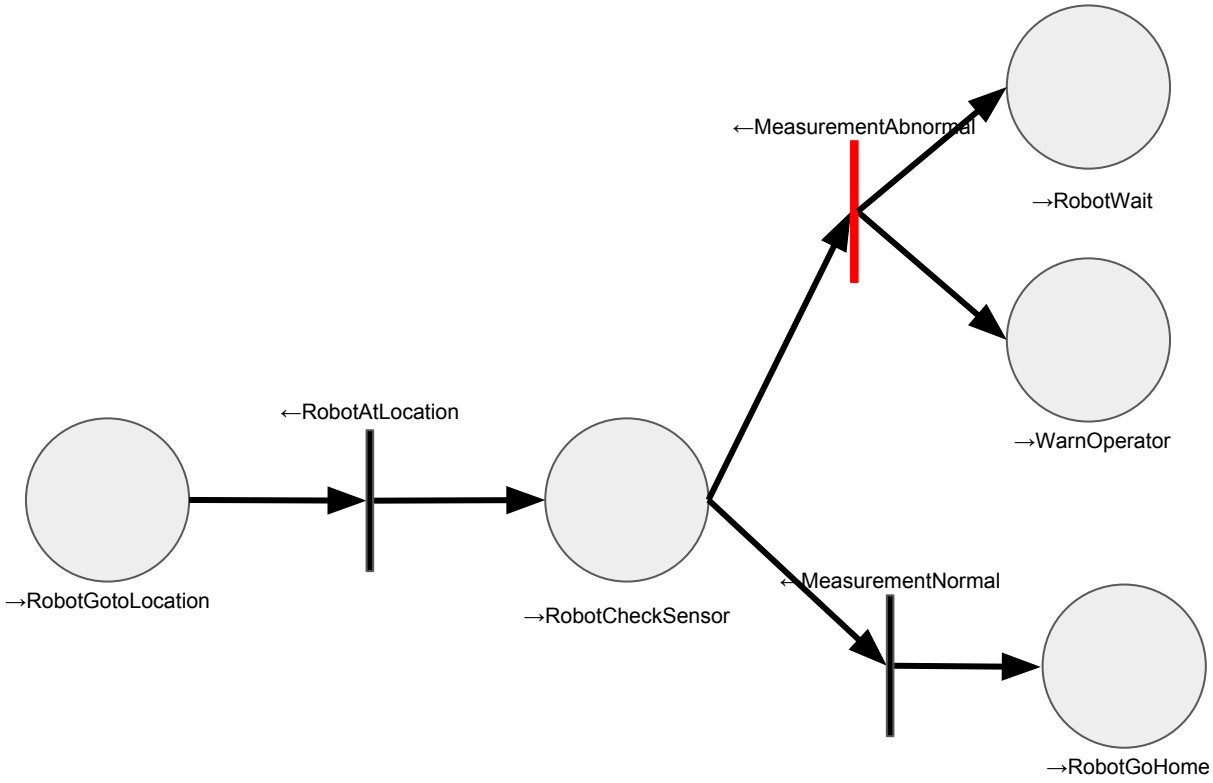
Quiz 5-6: Identify the out places for the transition



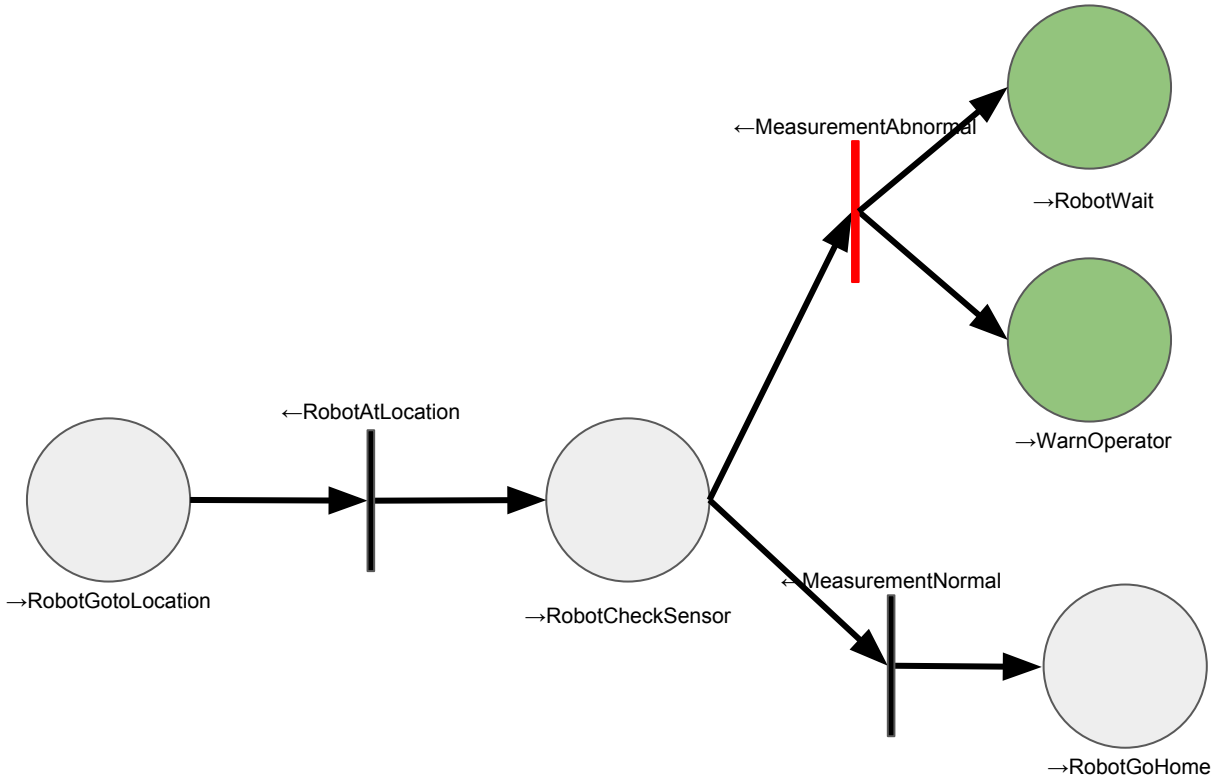
Quiz 5-6 Solution



Quiz 5-7: Identify the out places for the transition



Quiz 5-7 Solution

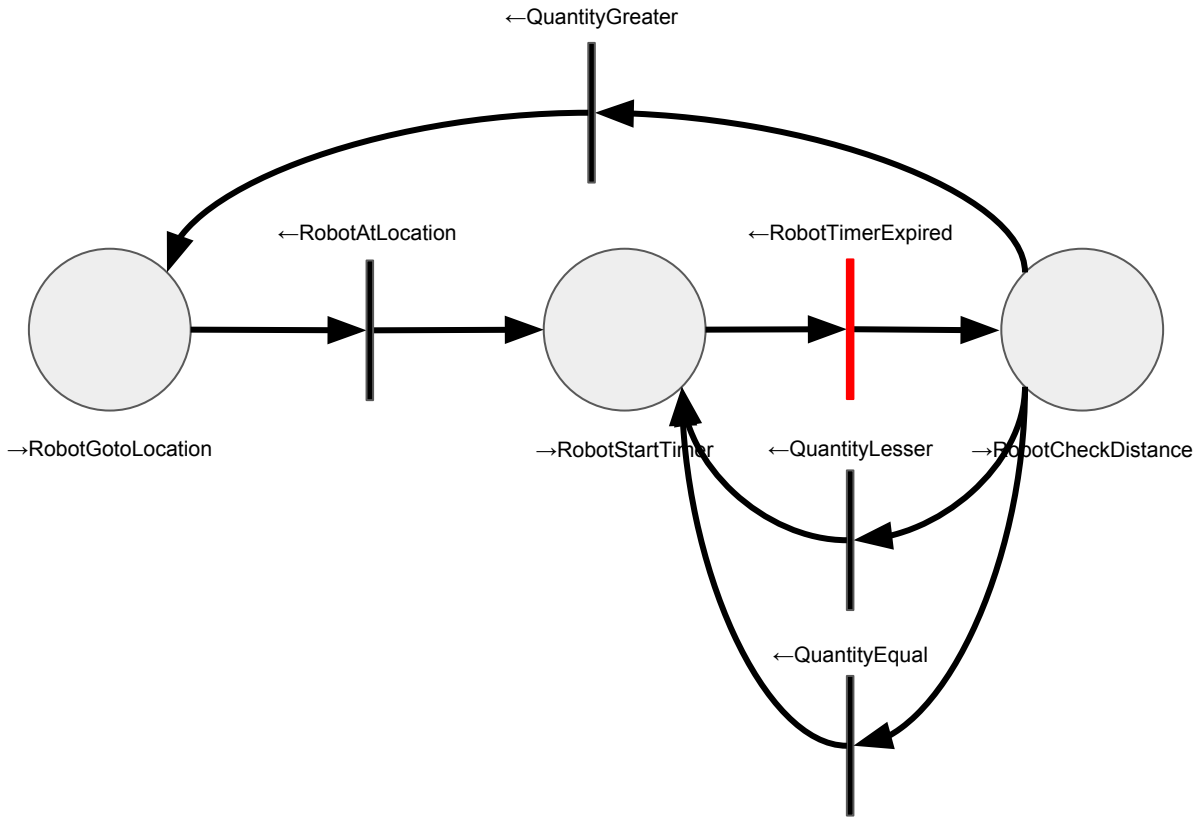


Out edge requirements: Are put on Out Edges and describe what to do with tokens when a transition connected to it fires.

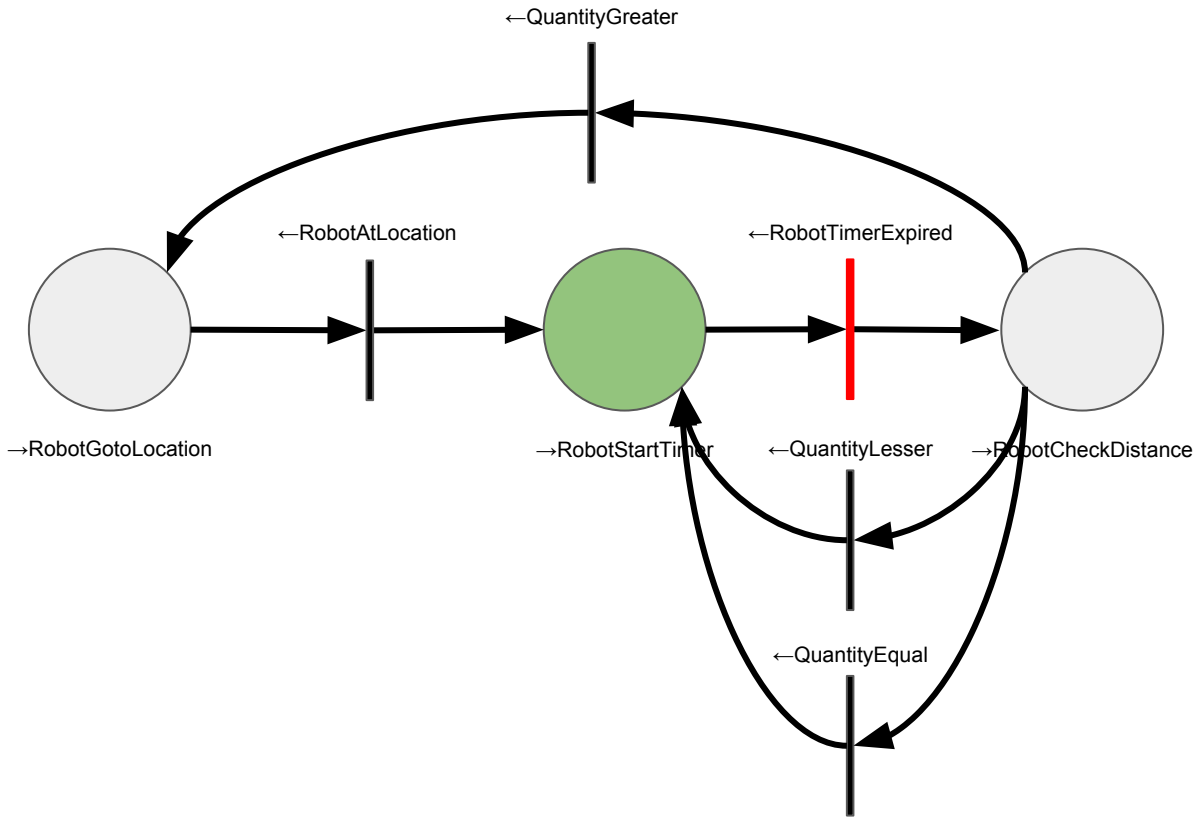
The requirements can affect tokens in certain places: “in” places and “out” places.

- “Out” places are places connected to the firing transition via an out edge
- “In” places are places connected to the firing transition via an in edge

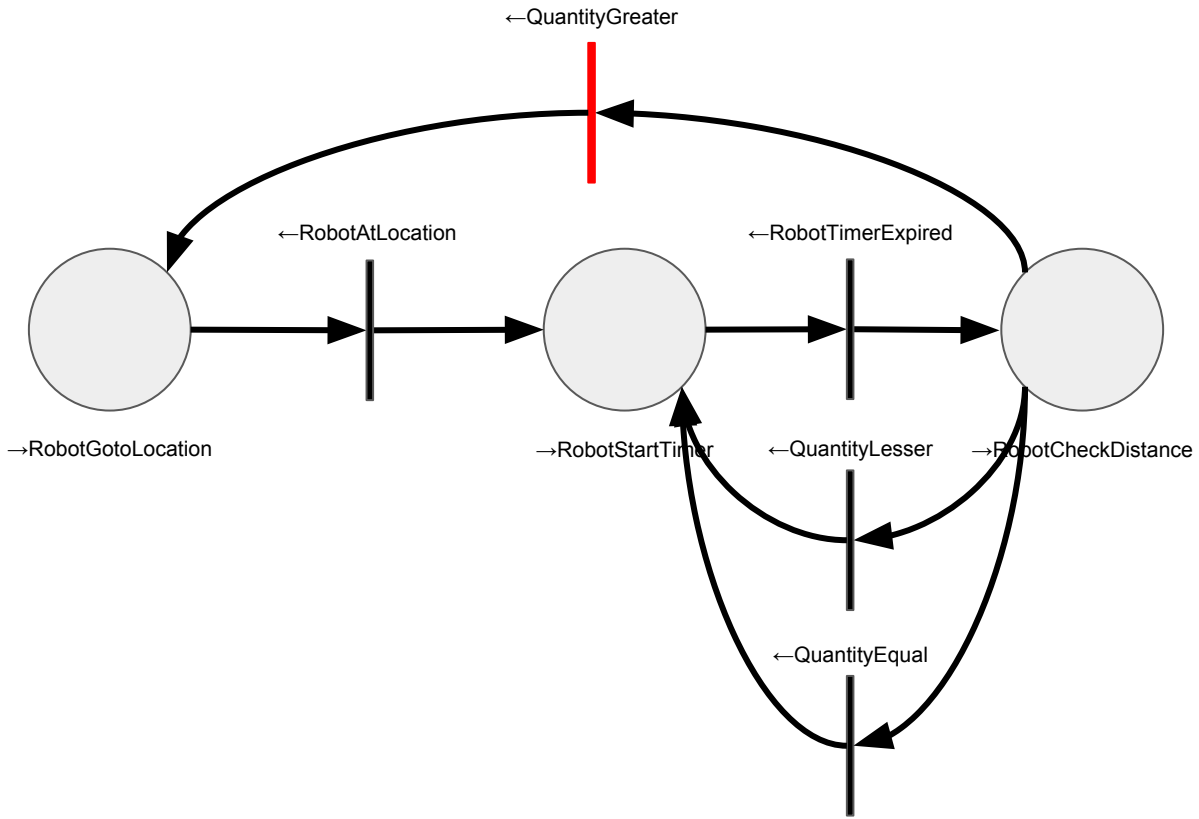
Quiz 5-8: Identify the in places for the transition



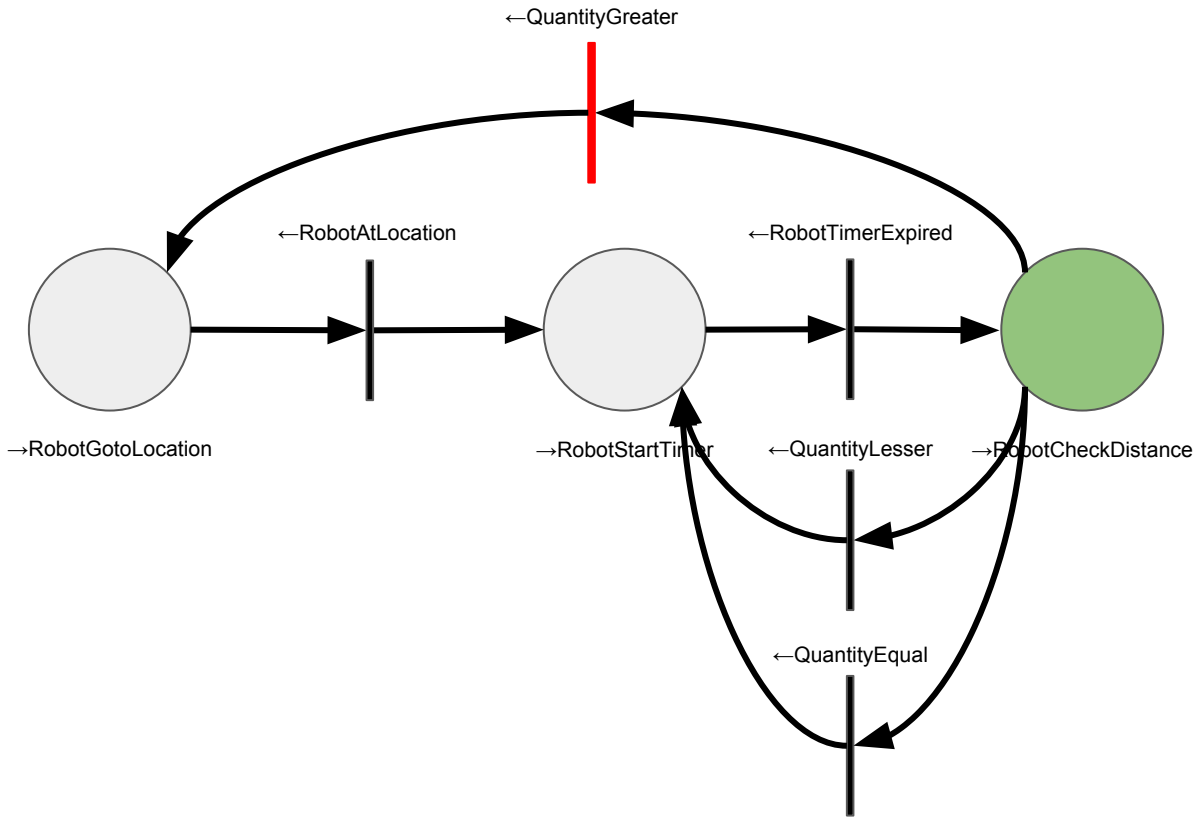
Quiz 5-8 Solution



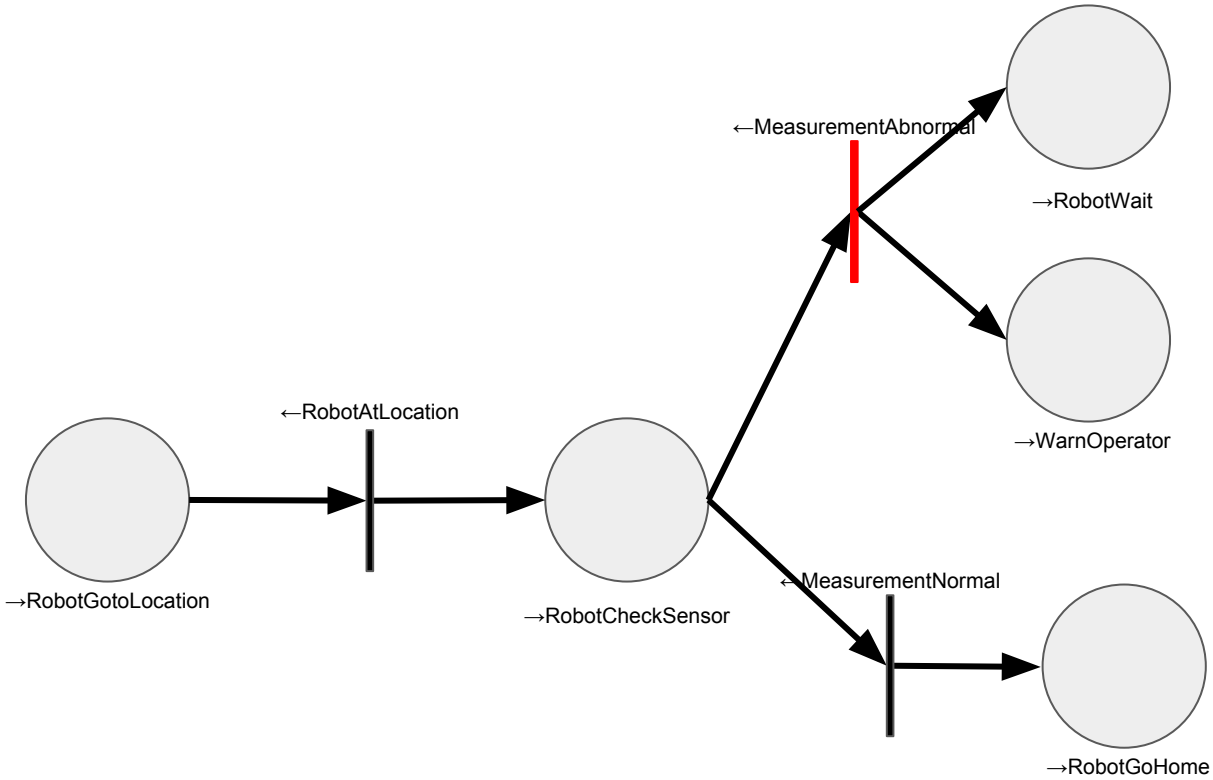
Quiz 5-9: Identify the in places for the transition



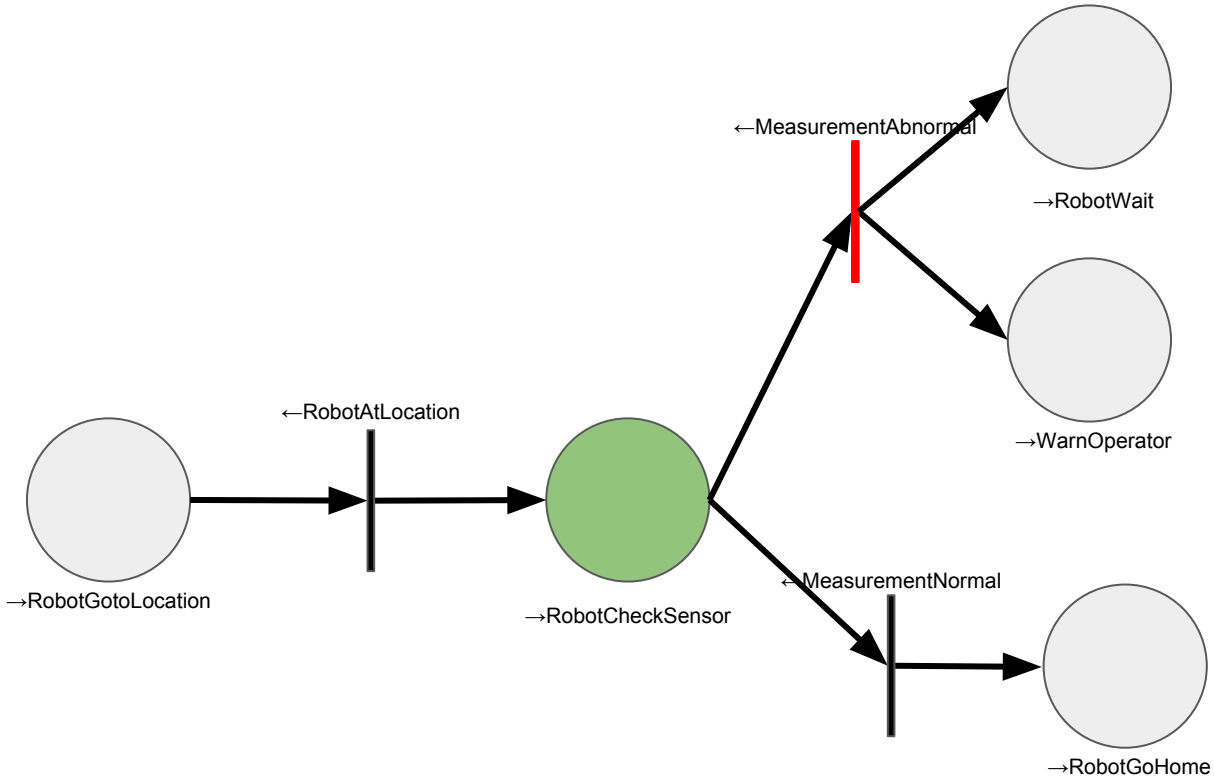
Quiz 5-9 Solution



Quiz 5-10: Identify the in places for the transition



Quiz 5-10 Solution



Out edge requirements: Are put on Out Edges and describe what to do with tokens when a transition connected to it fires

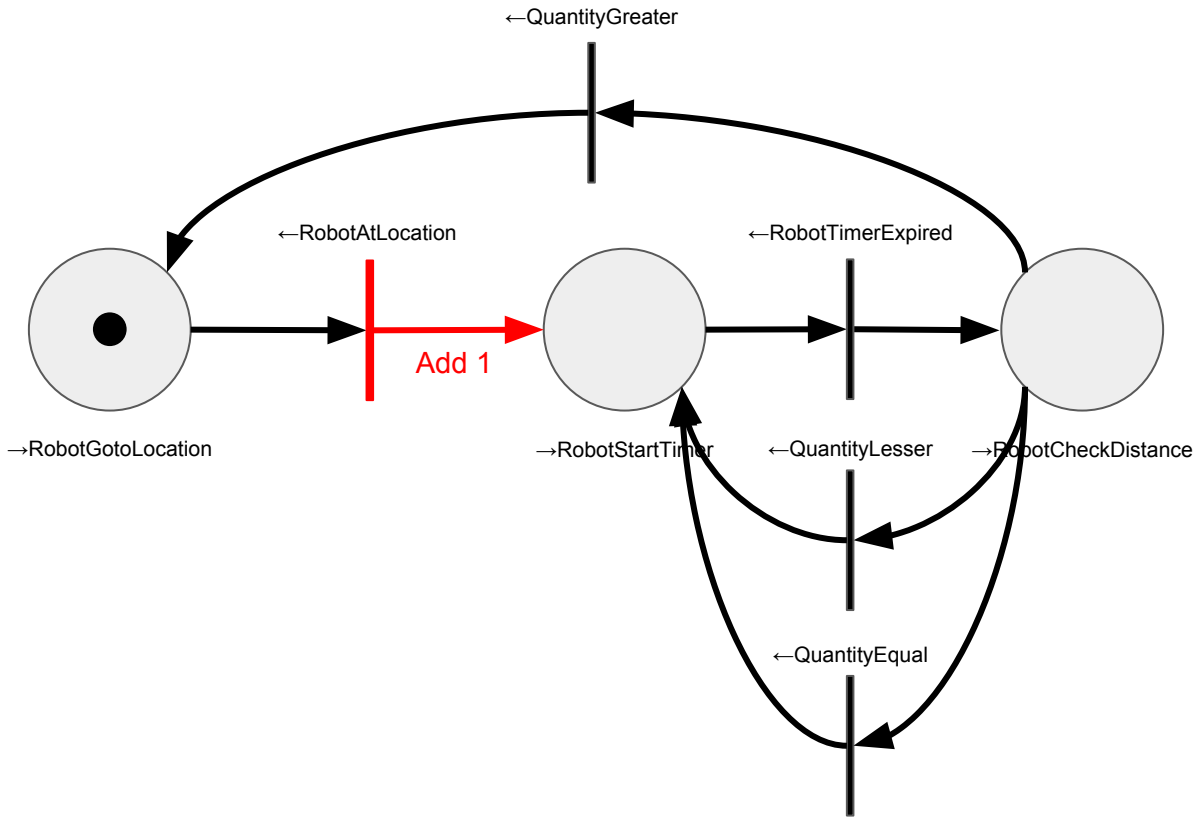
The requirements can affect tokens in certain places: “in” places and “out” places.

- “Out” places are places connected to the firing transition via an out edge
- “In” places are places connected to the firing transition via an in edge

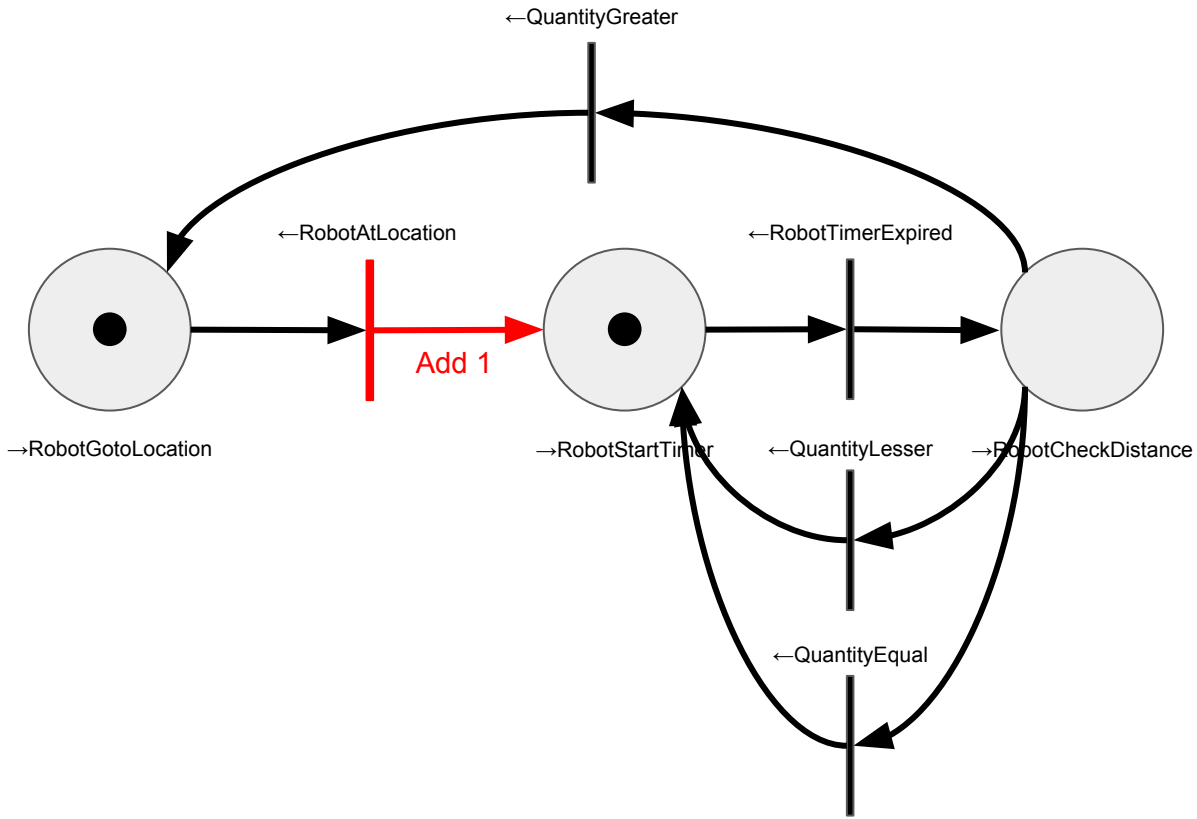
For now, let’s consider 3 options for what we can do to tokens when a transition fires

- Add: Adds a specified number of tokens to all out places

Example: Here is the SPN before the transition highlighted in red fires



Example: Here is the SPN after the transition highlighted in red fires and 1 token is added.



While it is fine to have tokens in multiple places and also fine to have multiple tokens in a place, here it doesn’t make much sense. We do not want the robot to be moving and waiting at the same time.

Let’s look at another option.

Out edge requirements: Are put on Out Edges and describe what to do with tokens when a transition connected to it fires

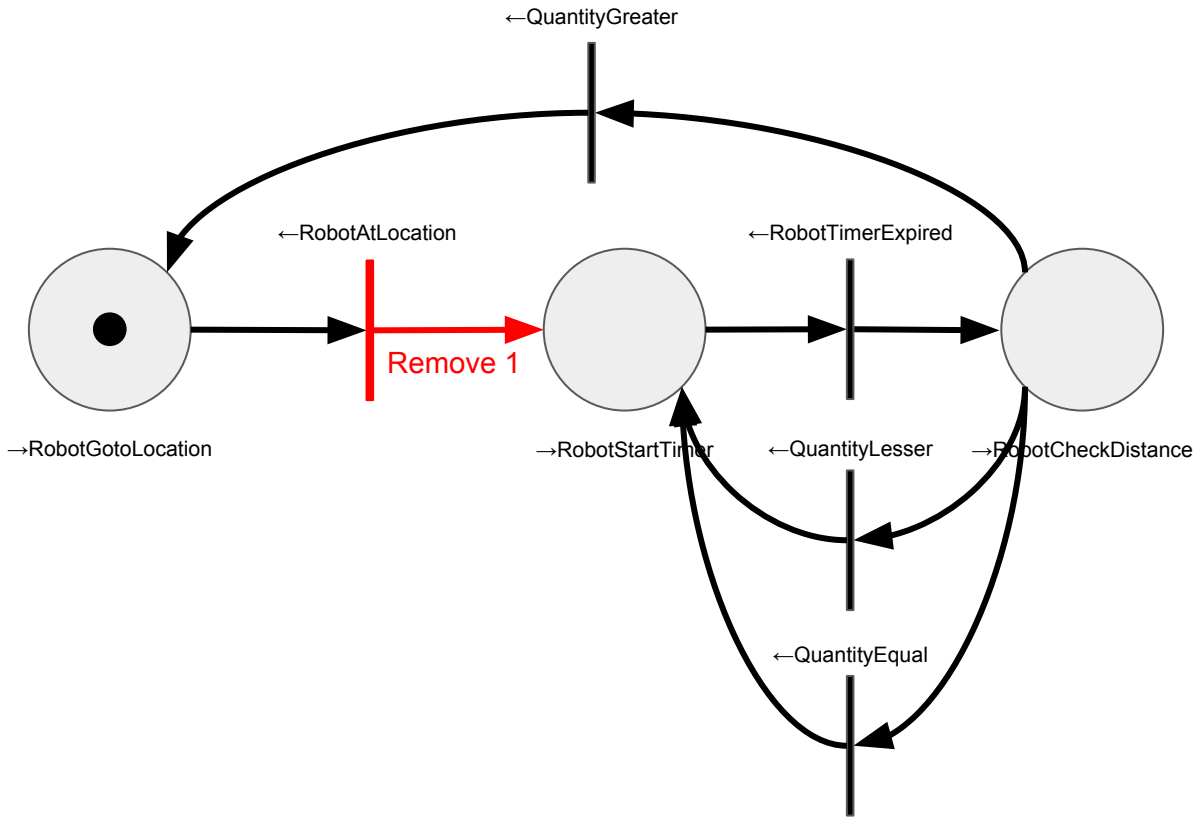
The requirements can affect tokens in certain places: “in” places and “out” places.

- “Out” places are places connected to the firing transition via an out edge
- “In” places are places connected to the firing transition via an in edge

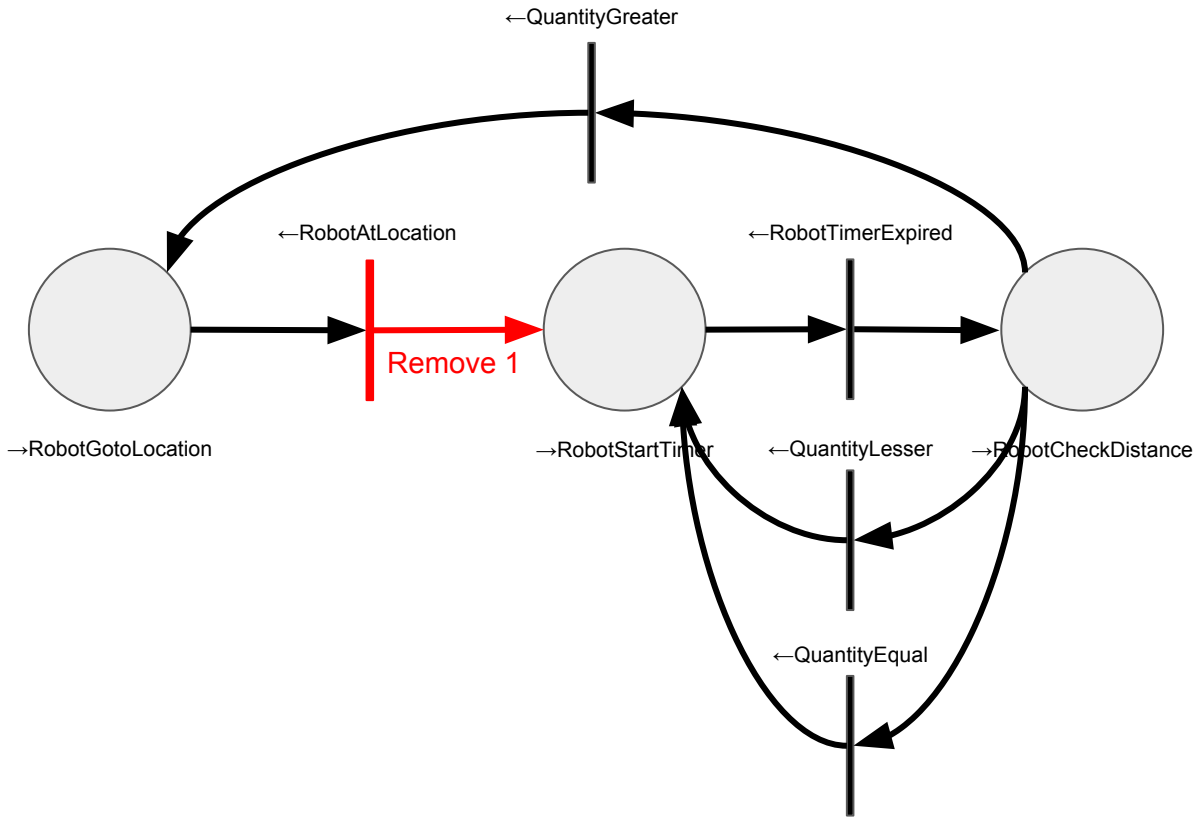
For now, let’s consider 3 options for what to do with tokens

- Add: Adds a specified number of tokens to all out places
- Consume: Removes a specified number of tokens from all in places, if possible

Example: Here is the SPN before the transition highlighted in red fires



Example: Here is the SPN after the transition highlighted in red fires and removes 1 token.



Now there are no tokens in the SPN, so we do not know what the status of the robot is. Clearly this does not make sense.

Let’s look at the third option.

Out edge requirements: Are put on Out Edges and describe what to do with tokens when a transition connected to it fires

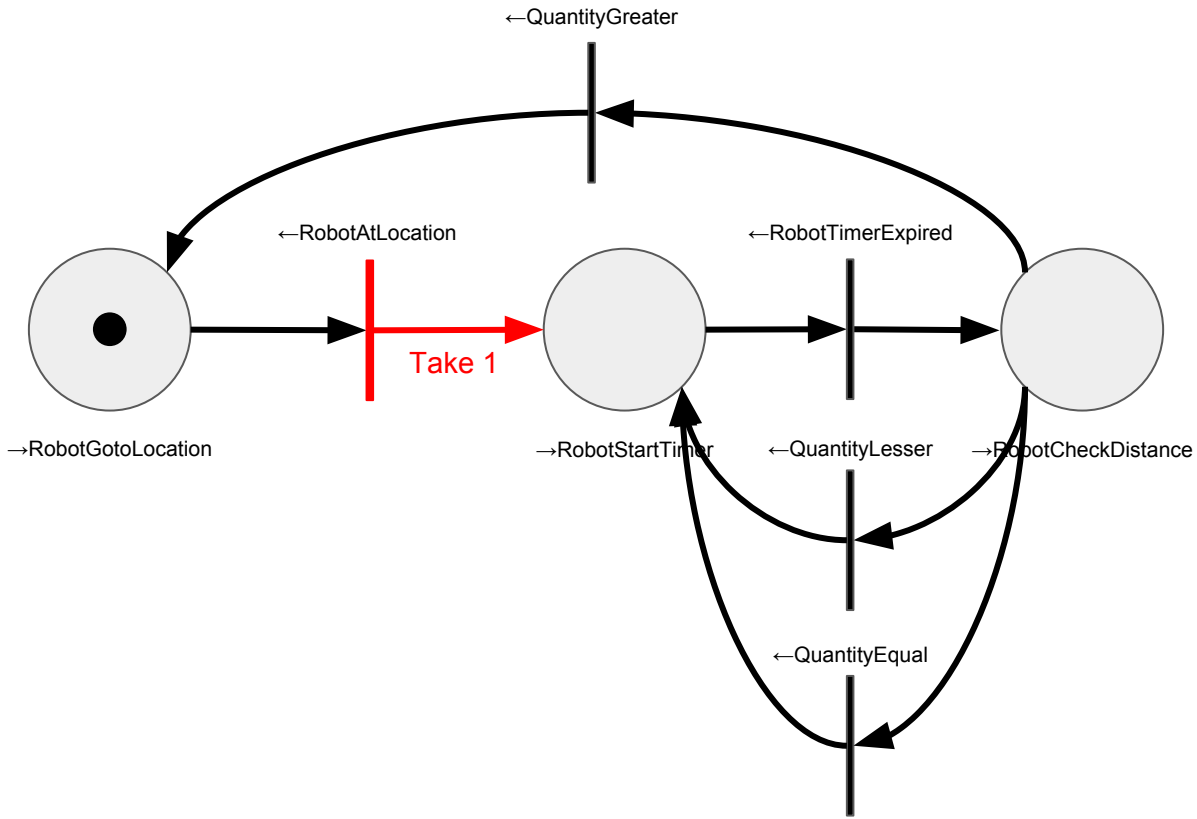
The requirements can affect tokens in certain places: “in” places and “out” places.

- “Out” places are places connected to the firing transition via an out edge
- “In” places are places connected to the firing transition via an in edge

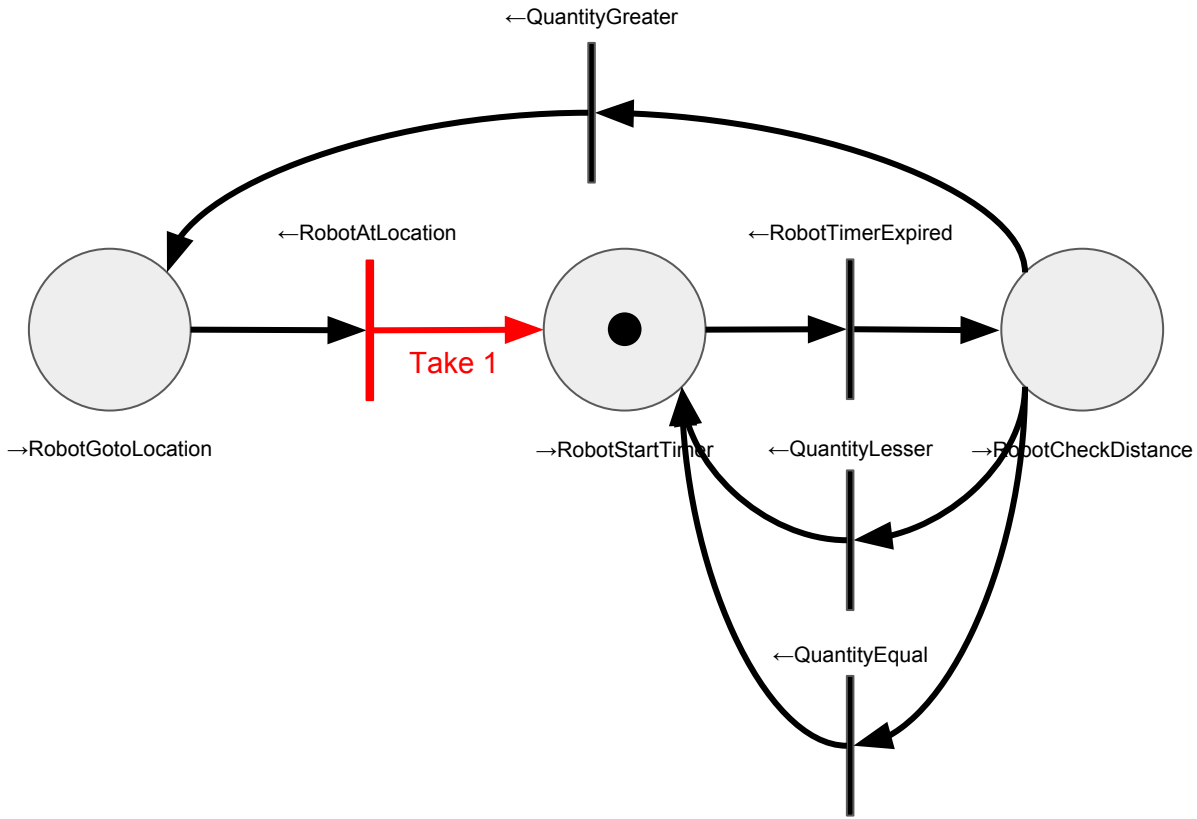
For now, let’s consider 3 options for what to do with tokens

- Add: Adds a specified number of tokens to all out places
- Consume: Removes a specified number of tokens from all in places, if possible
- Take: Removes a specified number of tokens from all in places, if possible, AND adds the specified number of tokens to all out places

Example: Here is the SPN before the transition highlighted in red fires



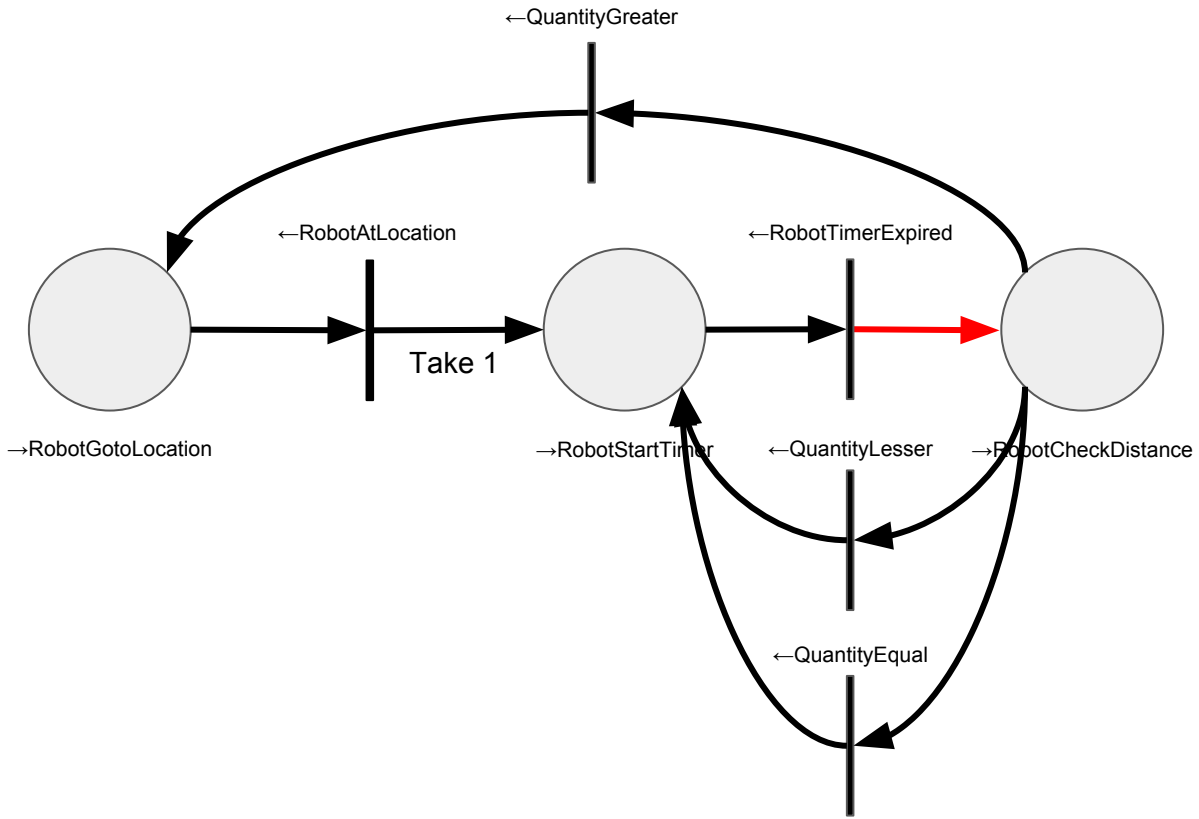
Example: Here is the SPN after the transition highlighted in red fires and takes 1 token



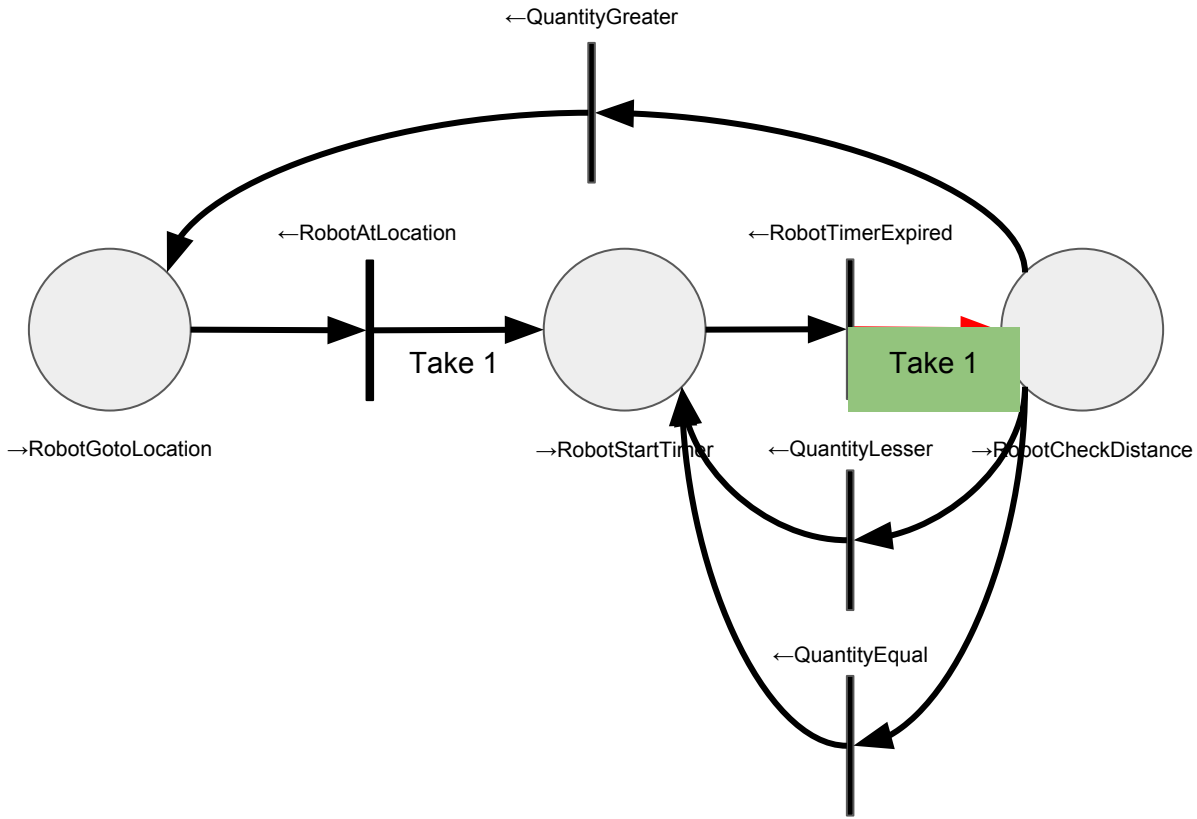
Now we have moved the token from the “Robot is moving to location” place into the “Robot is waiting” place. As we would expect, the robot is in only one of the places describing its status.

Let’s fill out the rest of the out edge requirements.

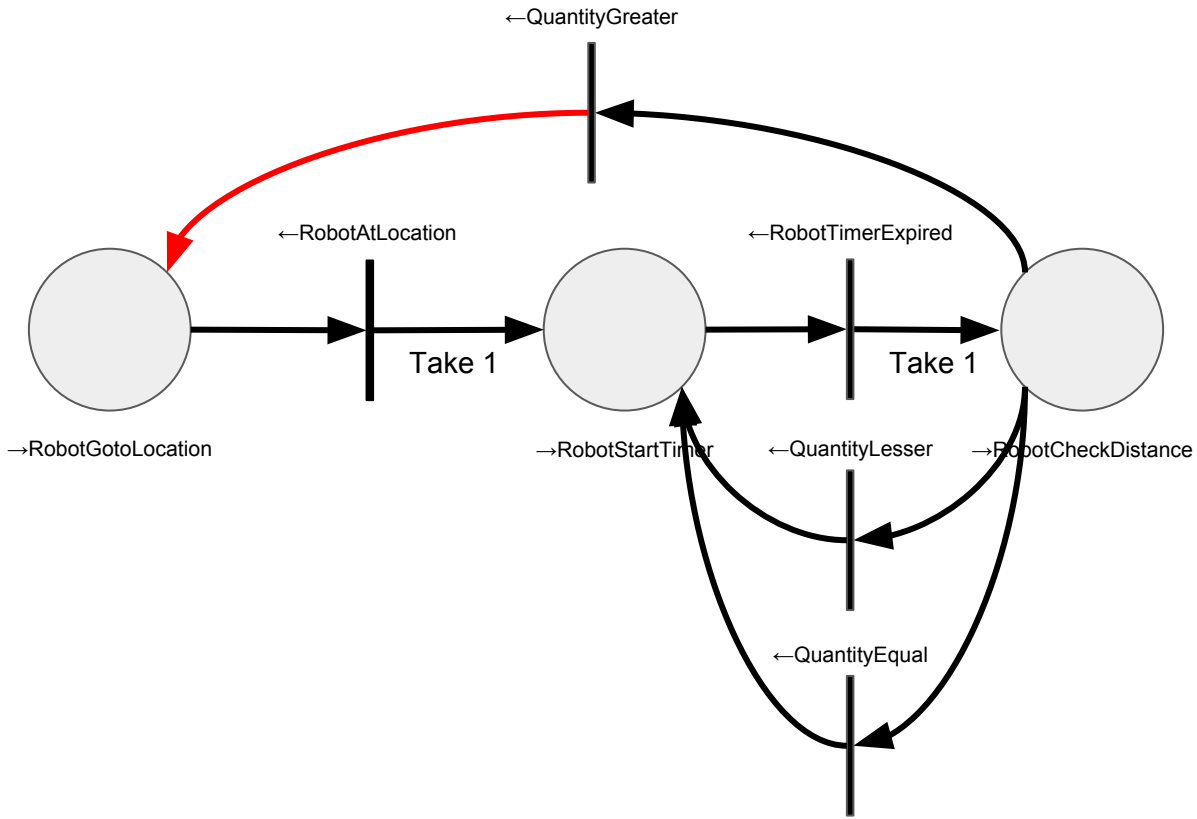
Quiz 5-11: Choose the requirement for the out edge



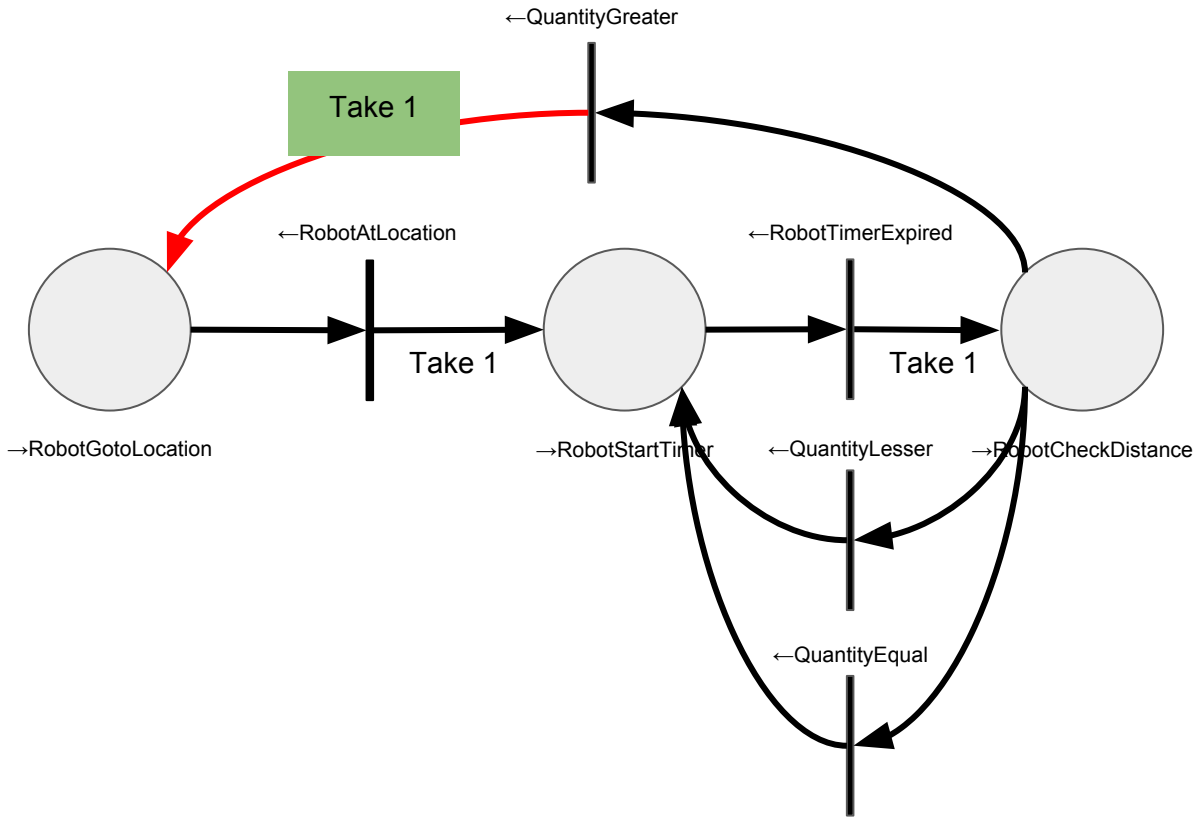
Quiz 5-11 Solution



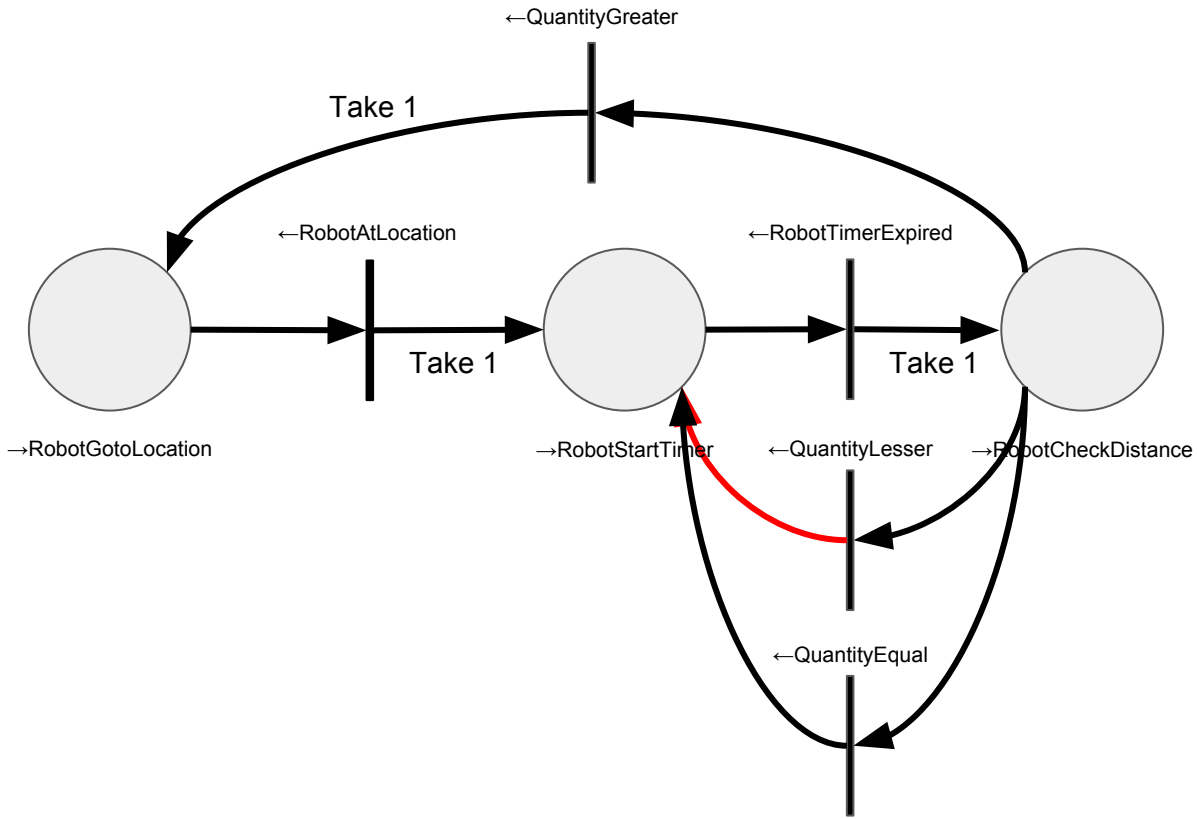
Quiz 5-12: Choose the requirement for the out edge



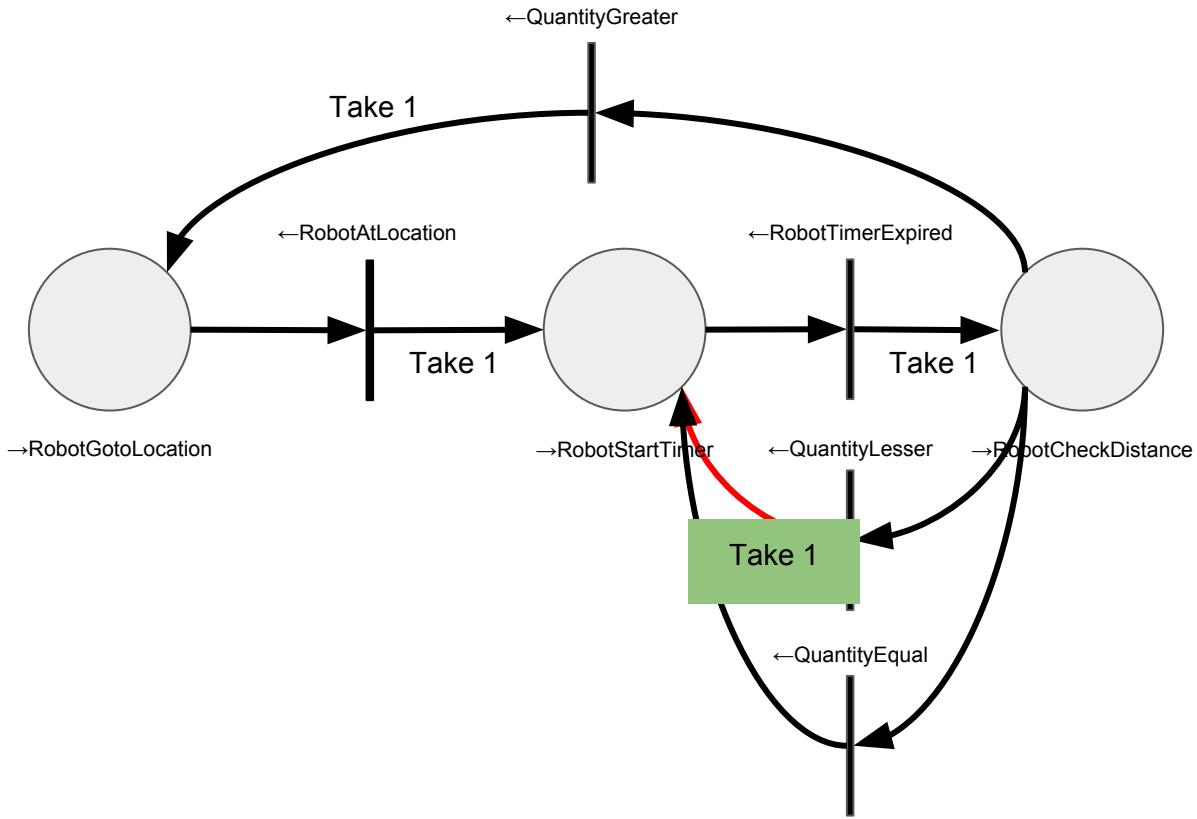
Quiz 5-12 Solution



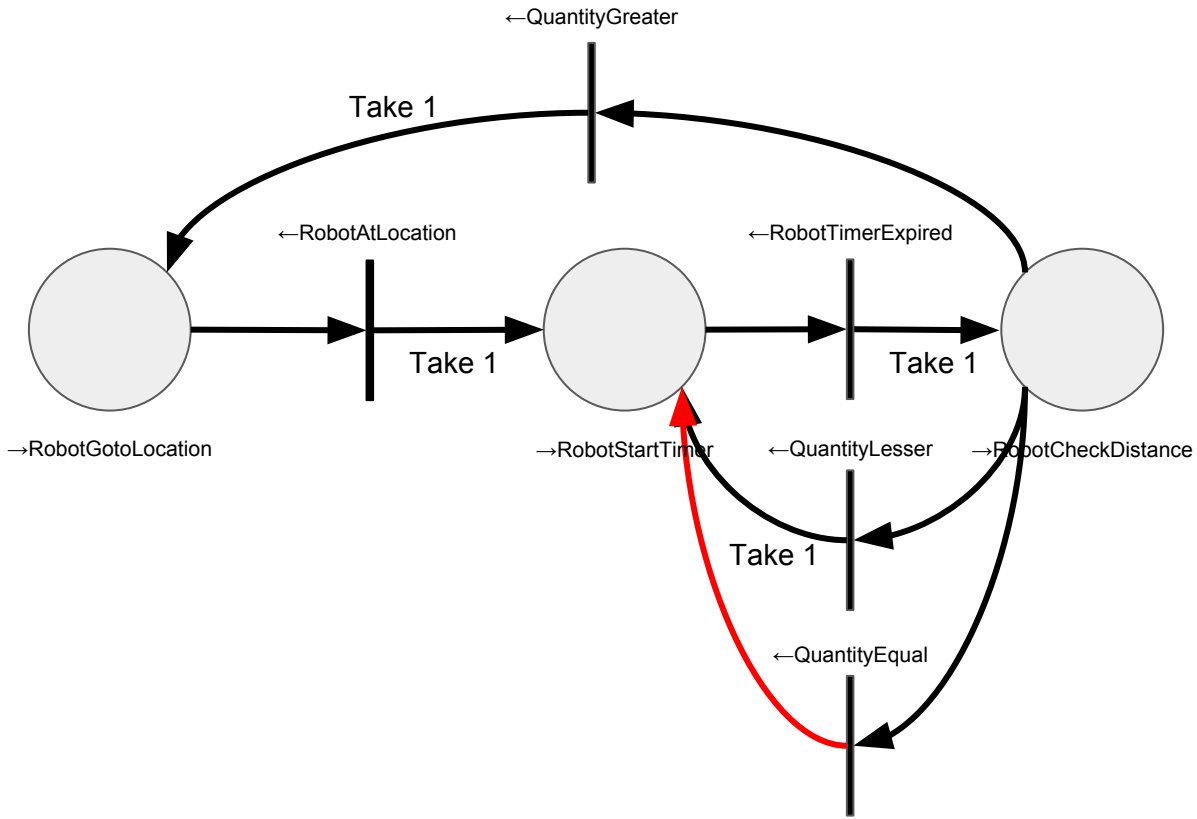
Quiz 5-13: Choose the requirement for the out edge



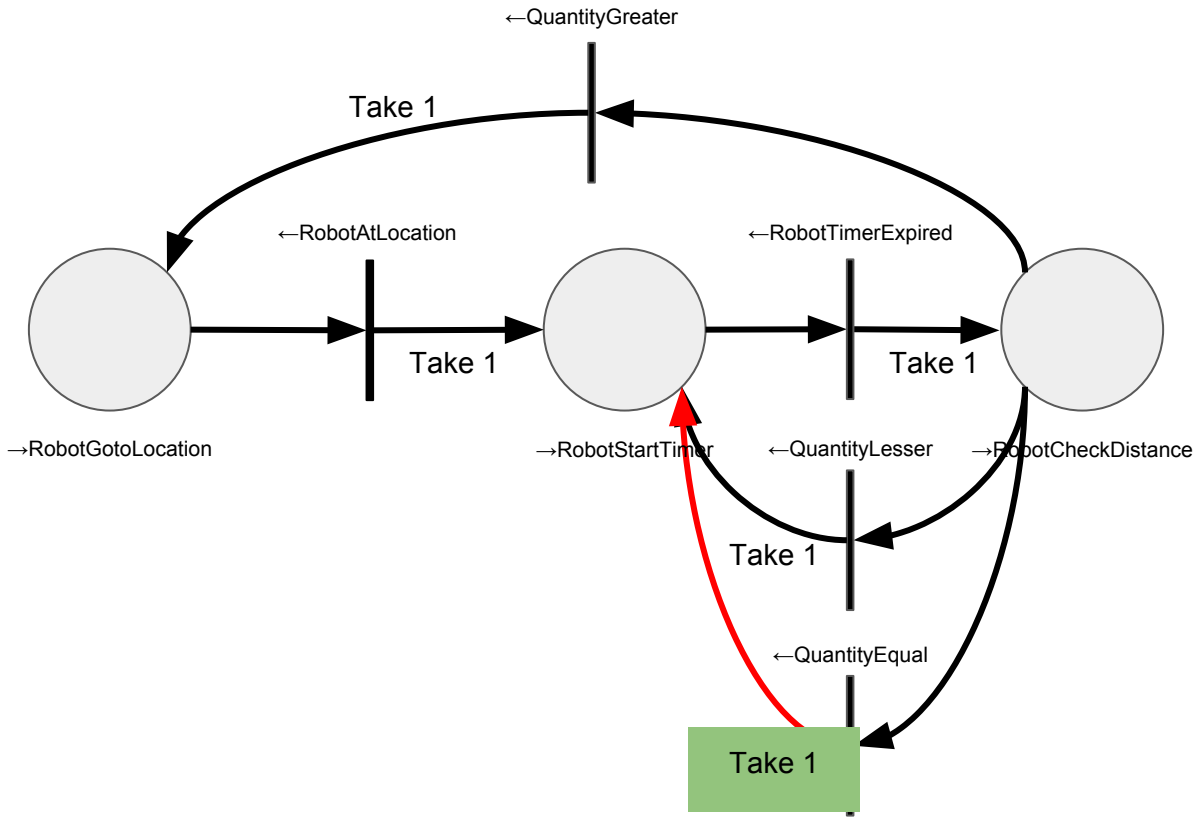
Quiz 5-13 Solution

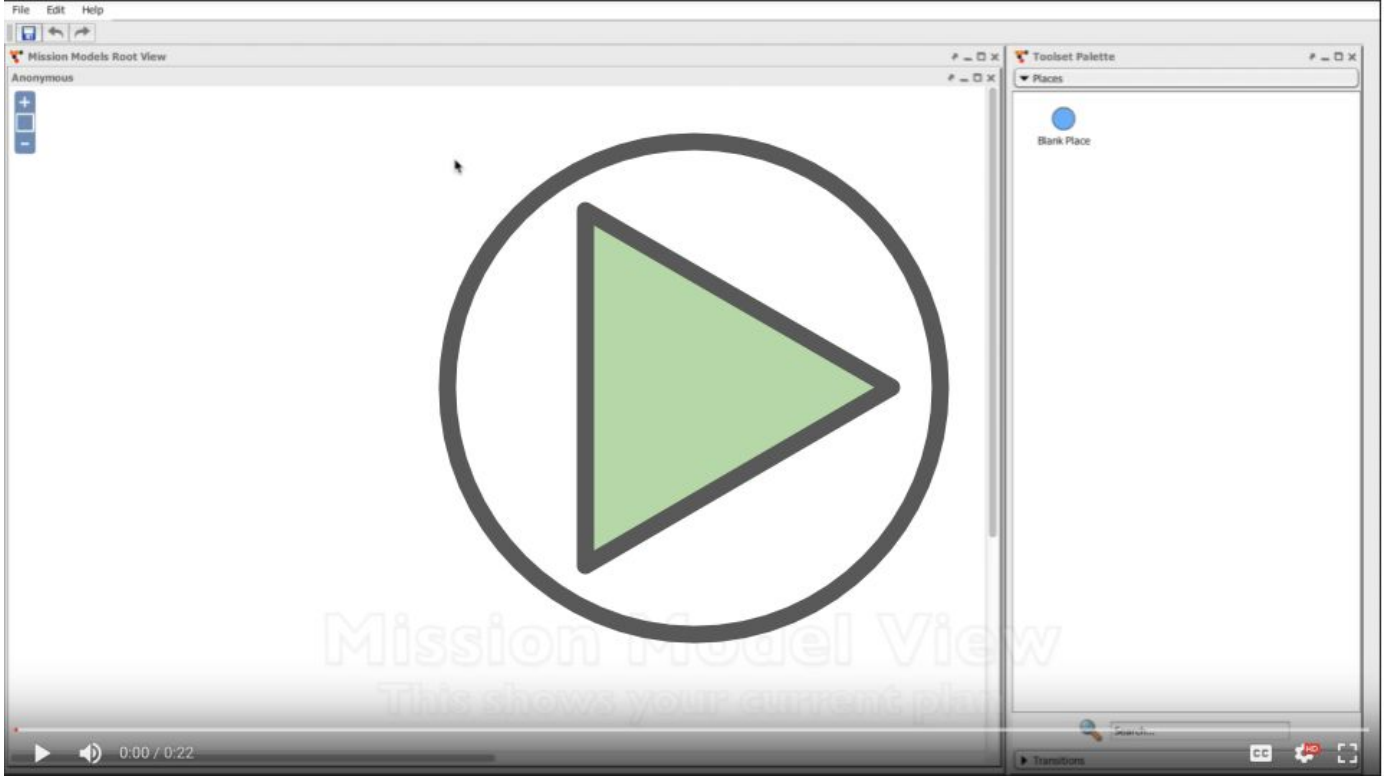


Quiz 5-14: Choose the requirement for the out edge



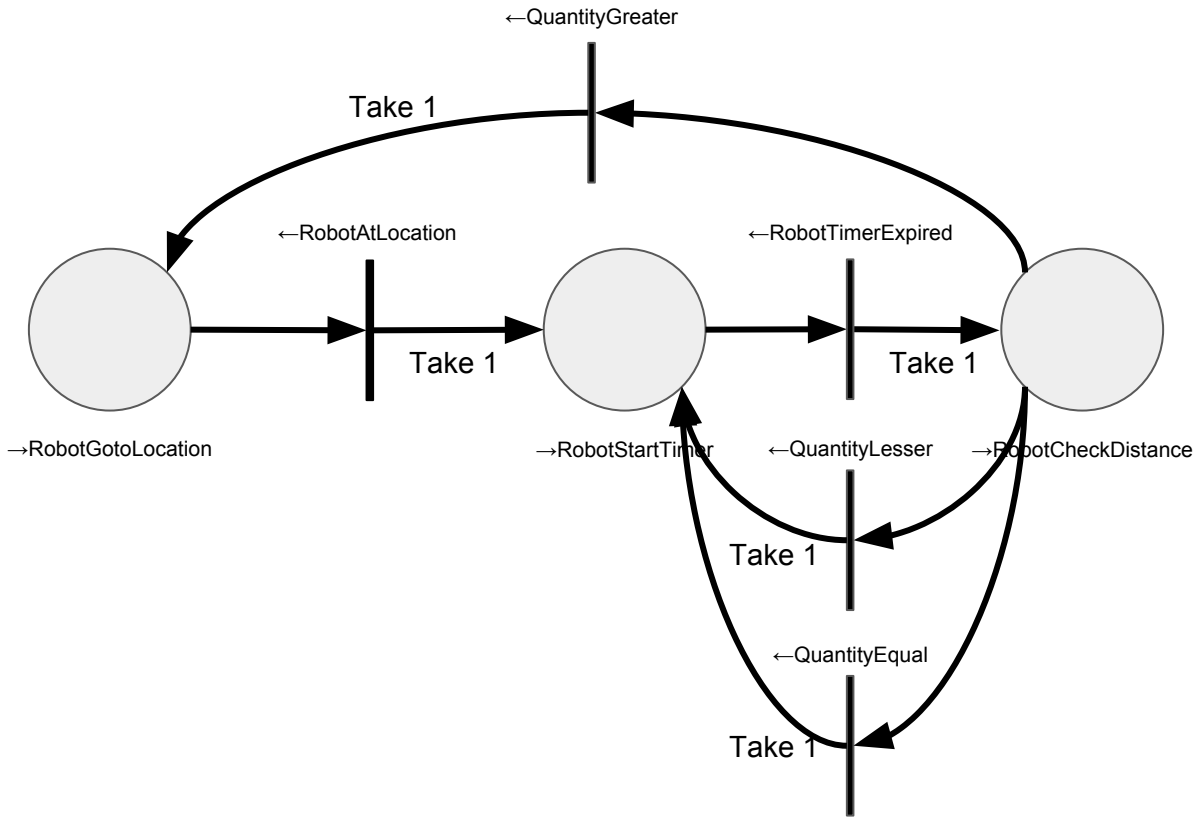
Quiz 5-14 Solution





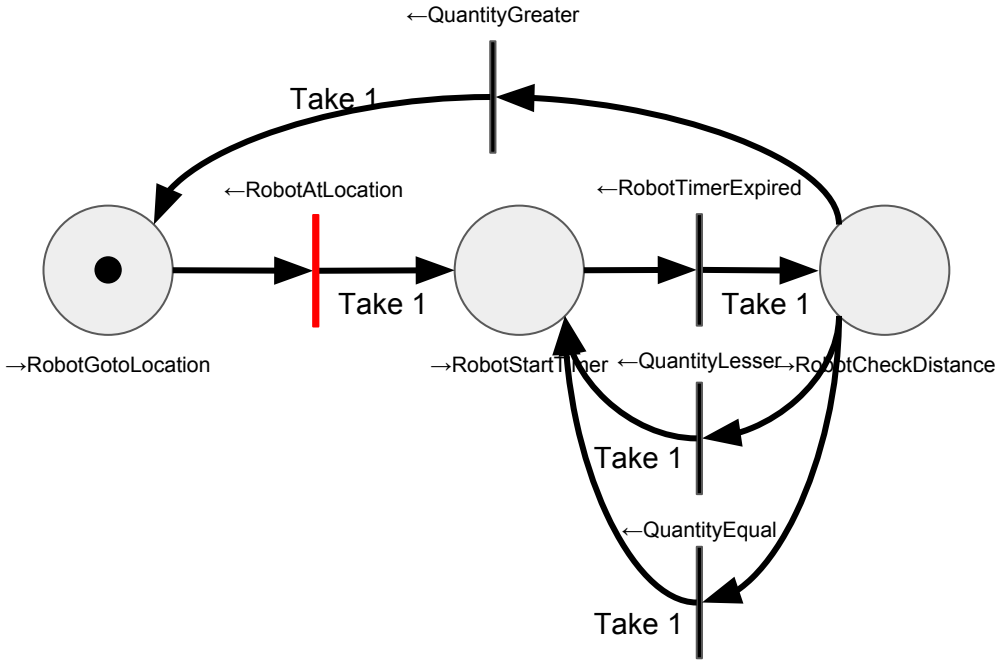
Watch “Output Requirements”: This video will show you how to add out edge requirements.

Job 5-1: Add the following out edge requirements to the SPN



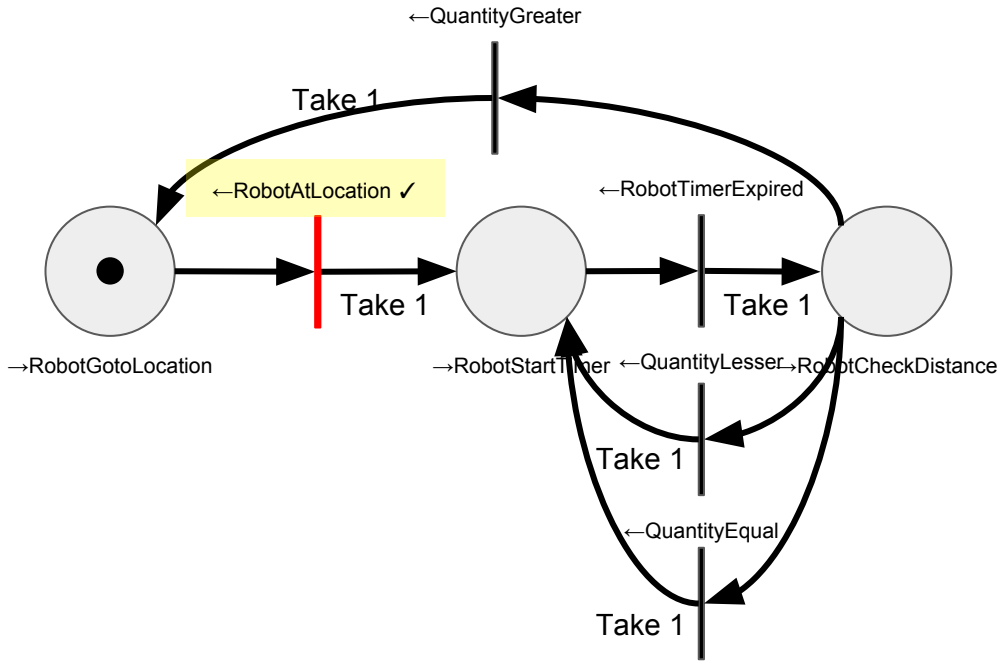
Now we know what to do with tokens when a transition fires. Next we will talk about WHEN a transition should fire: when certain information has been received and certain tokens are present.

In this scenario, when the transition with “←RobotAtLocation” fires, it will move the robot’s token from place with “→RobotGotoLocation” to the place with “→RobotStartTimer.” We want the transition to fire when two conditions are met:
1) Robot was moving to its location
2) Robot arrived at its destination



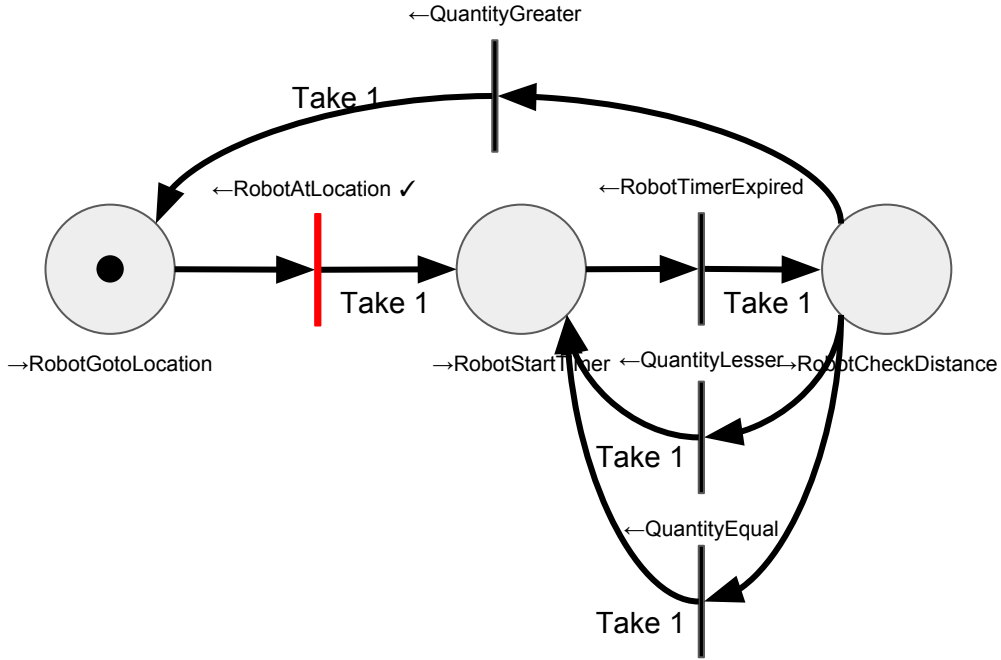
Let’s look at #2 first:
2) Robot arrived at its destination

We will know this when the “←RobotAtLocation” input event is received. We will put a “✓” by an input event to indicate it has been received.



Now let's look at #1
1) Robot was moving to its location

We will know this is true if the robot's token is in the place with "→RobotGotoLocation". This is what the second type of edge requirement is used for.



There are two types of edge requirements.

- Out edge requirements: Are put on Out Edges and describe what to do with tokens when a transition connected to it fires
- In edge requirements: Are put on In Edges and list tokens necessary for a transition connected to it to fire

There are two types of edge requirements.

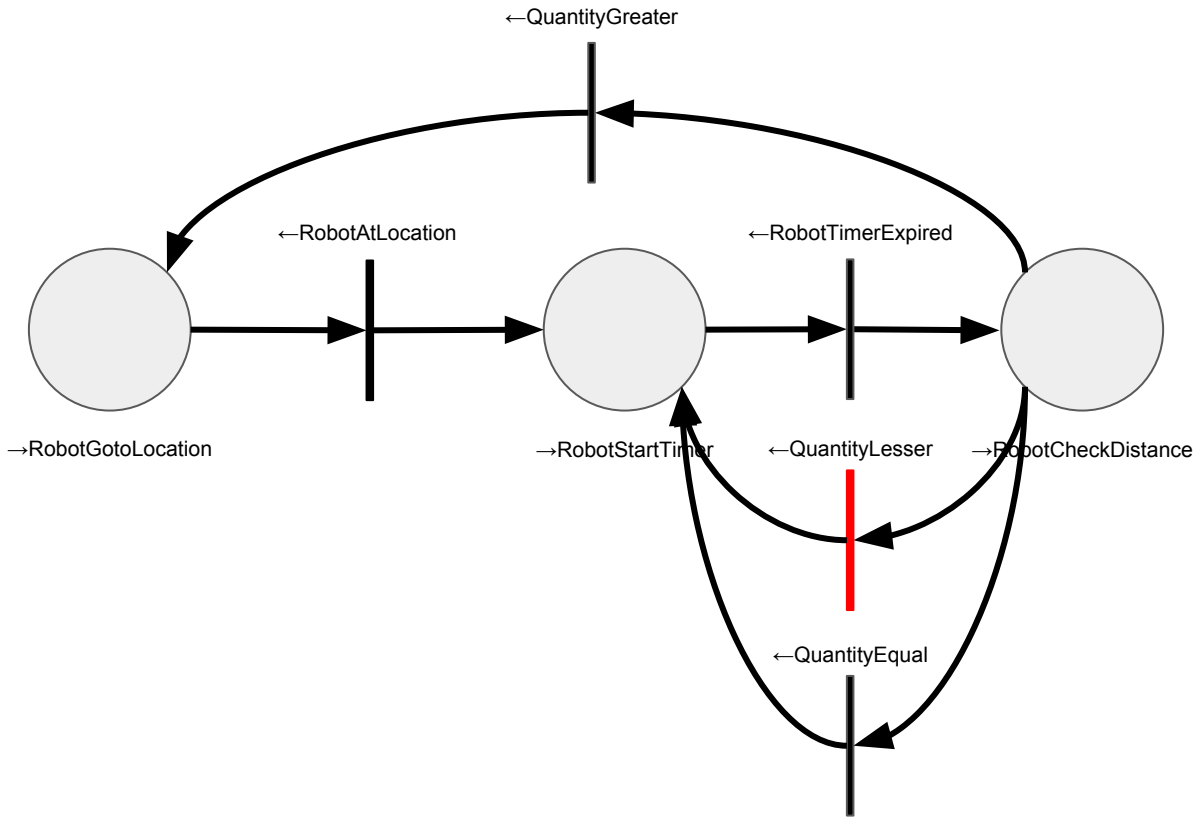
- Out edge requirements: Are put on Out Edges and describe what to do with tokens when a transition connected to it fires
- In edge requirements: Are put on In Edges and list tokens necessary for a transition connected to it to fire

Specifically, in edge requirements can require that a number of tokens be present OR be absent from the connected place in order for the transition to fire.

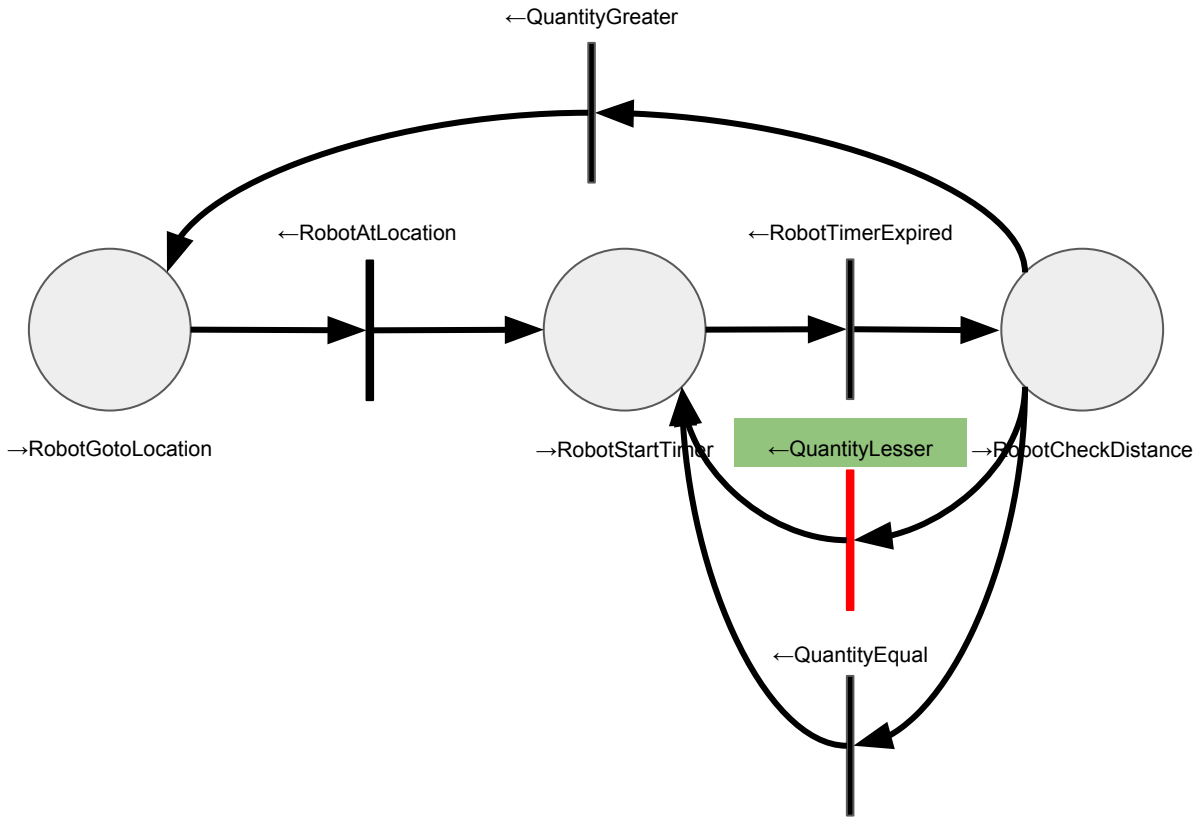
Now for a transition to fire, each of the following must be true.

- All input events on the transition must have been received
- All in edge requirements on in edges connected to the transition must be satisfied

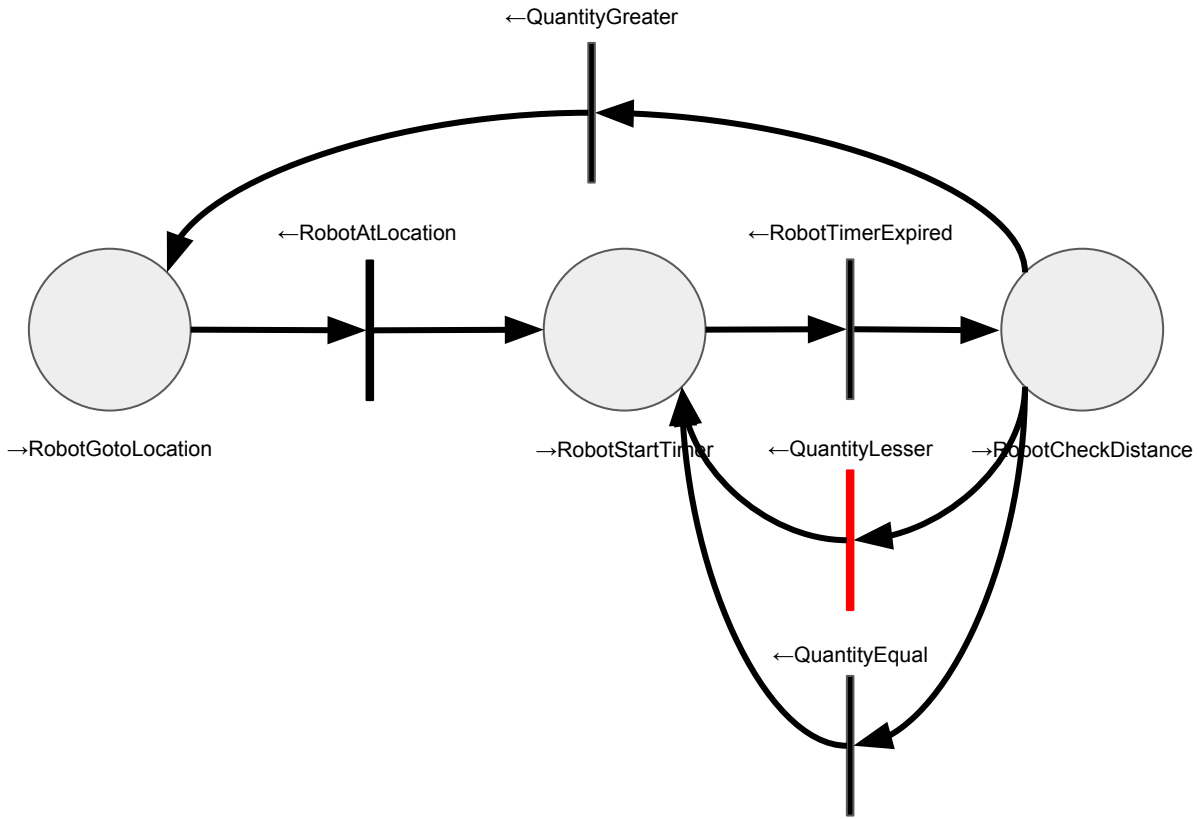
Quiz 5-15: Select the input events necessary for the transition to fire



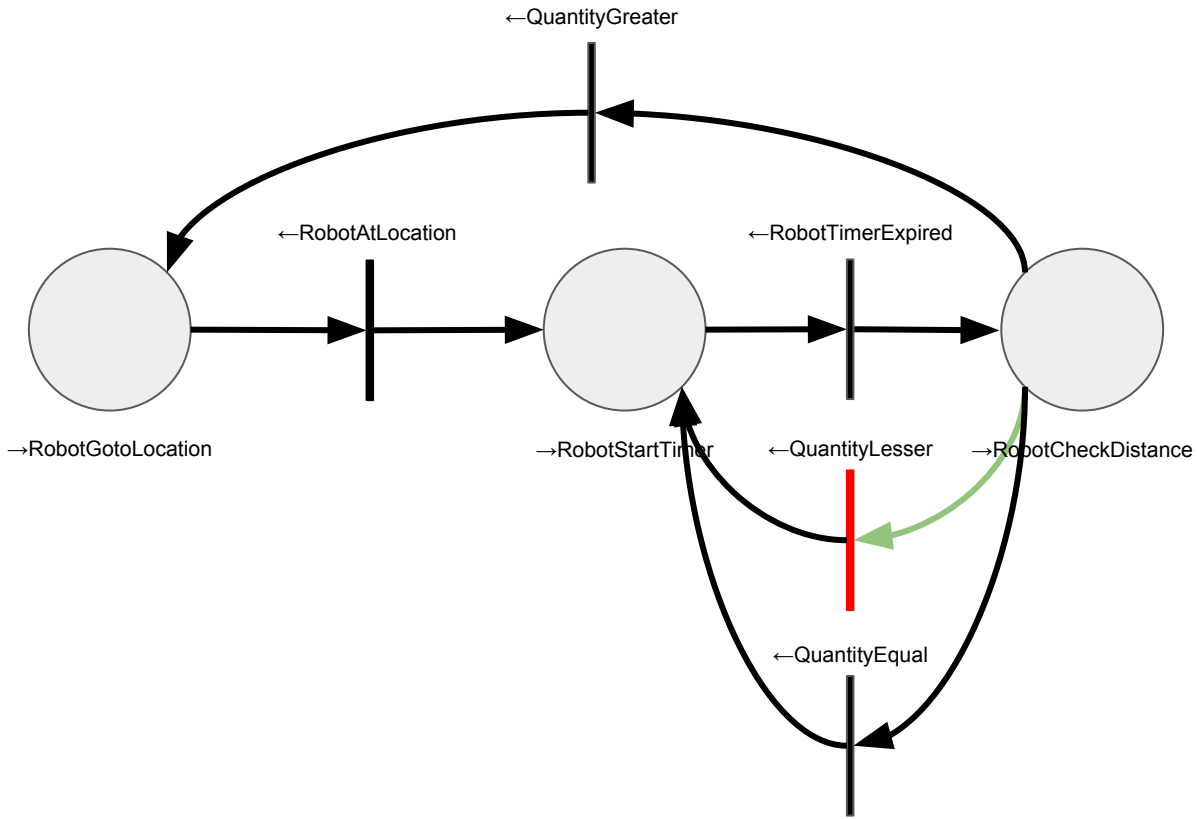
Quiz 5-15 Solution



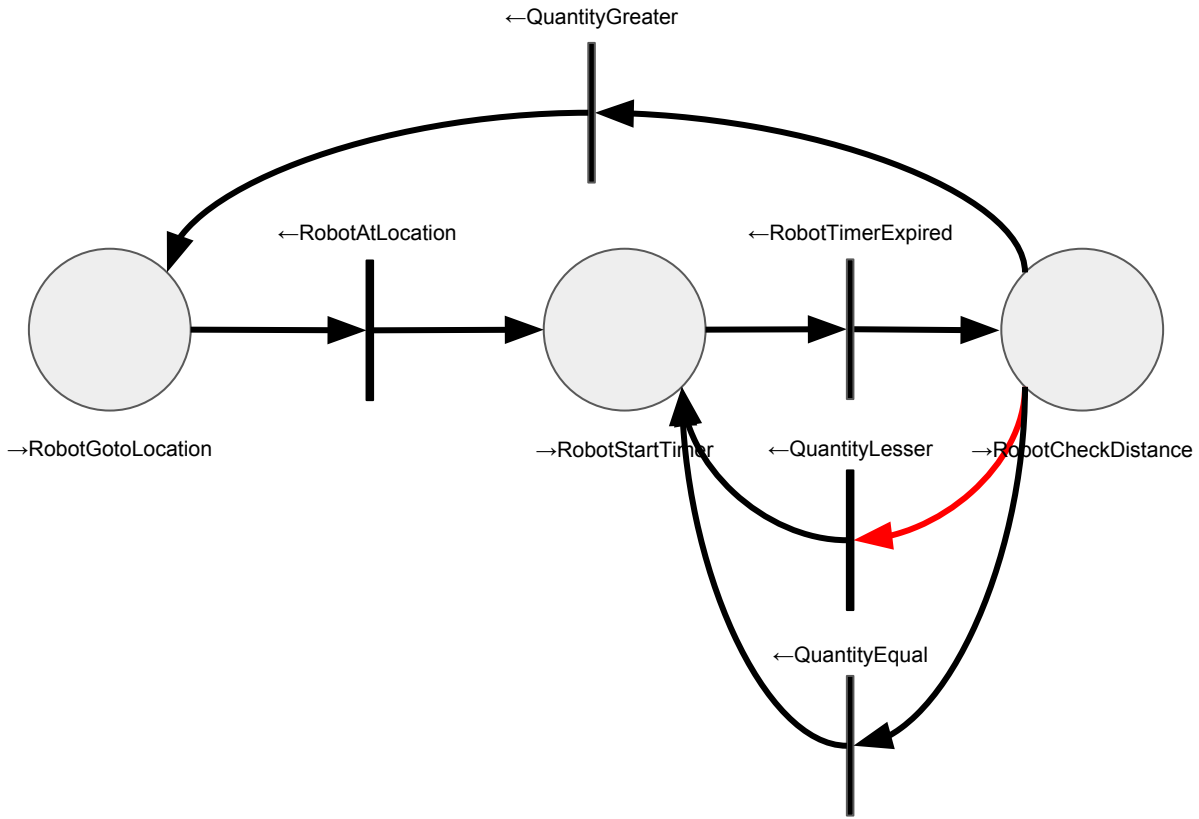
Quiz 5-16: Select the in edges connected to the transition



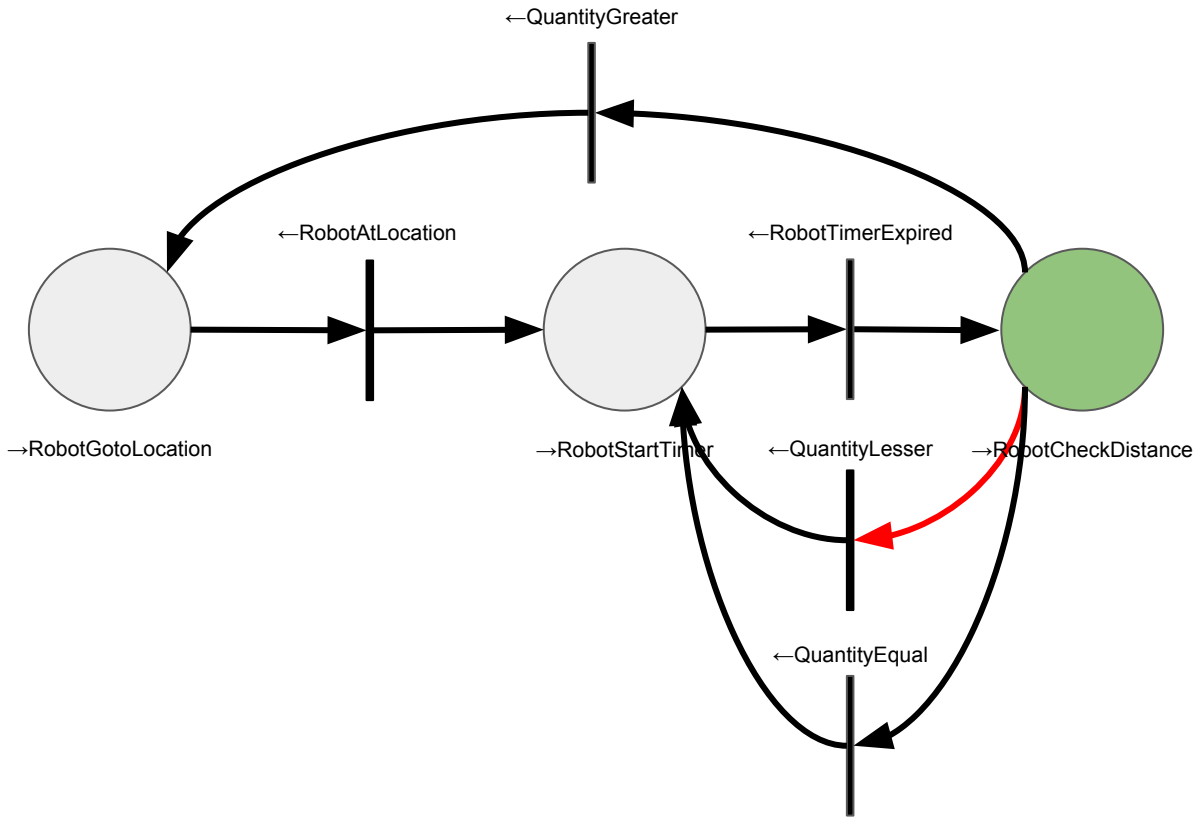
Quiz 5-16 Solution



Quiz 5-17: Select the place connected to the in edge



Quiz 5-17 Solution

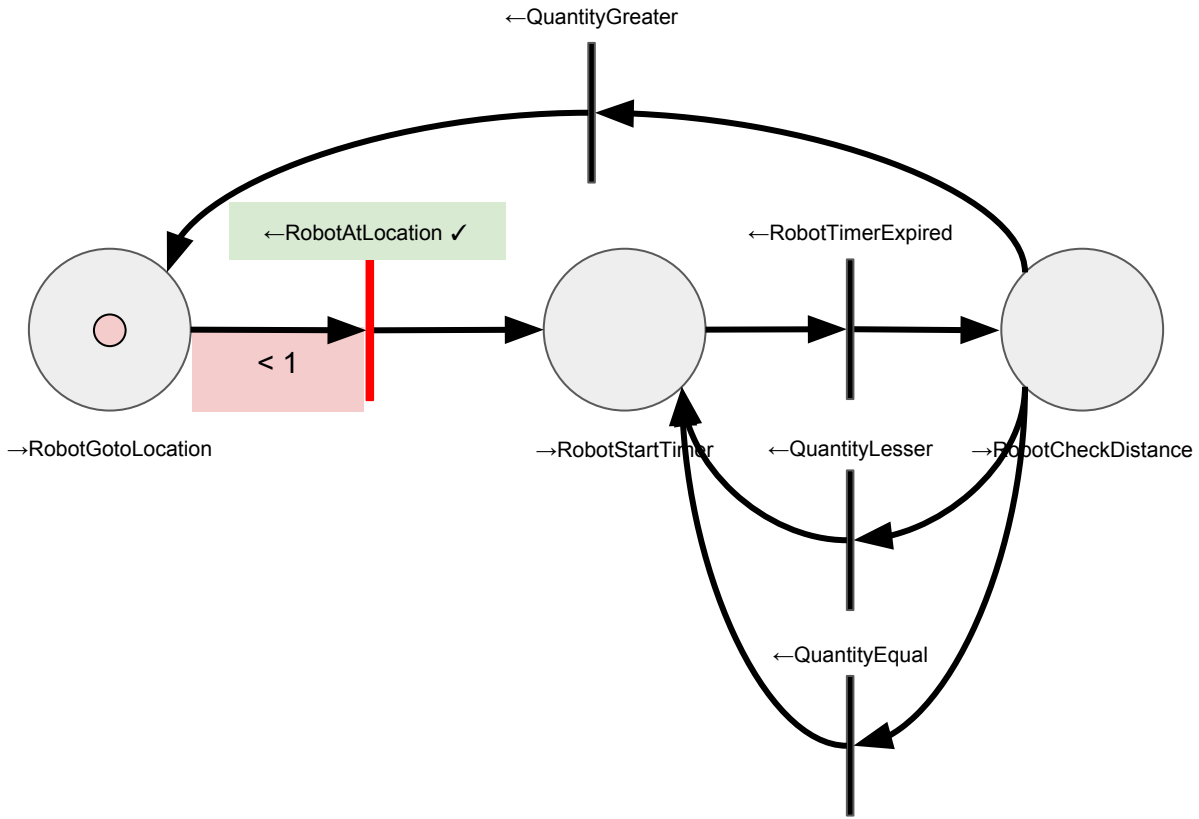


In edge requirements: Are put on In Edges and list tokens necessary for a transition connected to it to fire

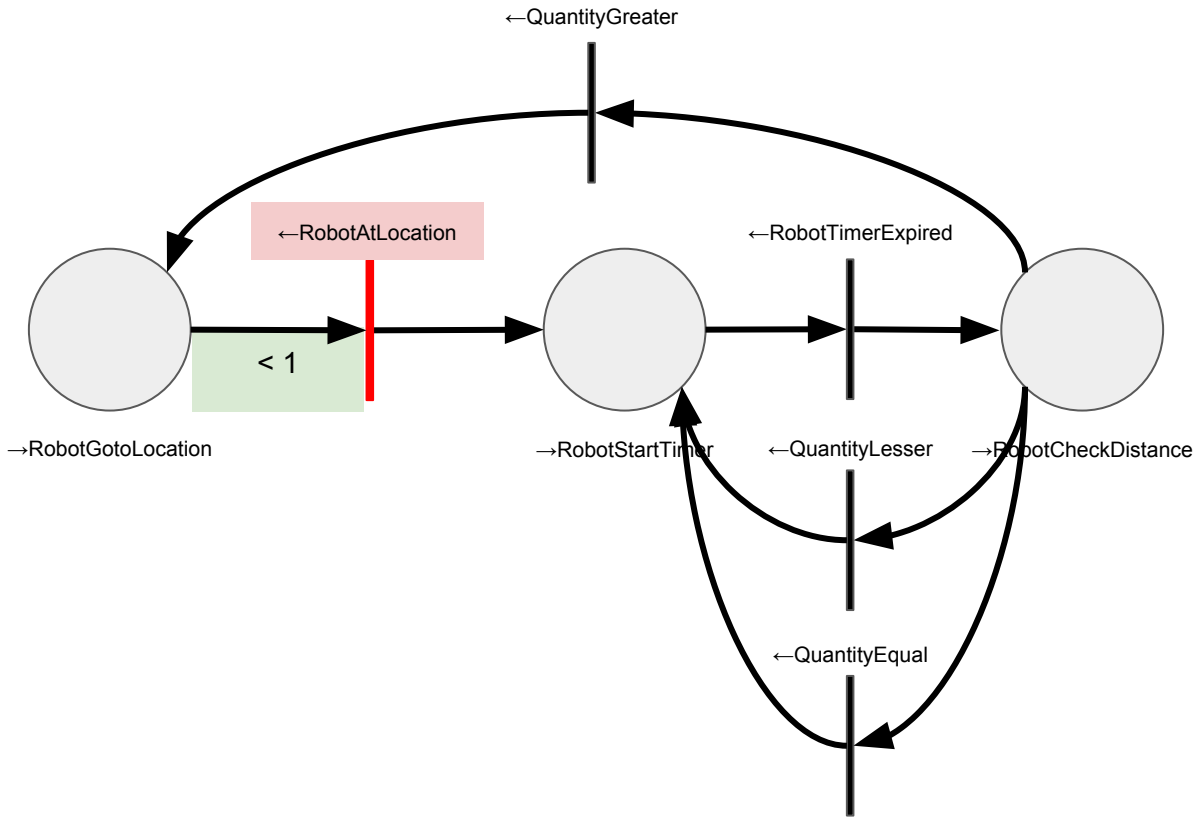
For now, let’s consider 2 options for requirement criteria

- Less Than: The place connected to the in edge must have less than a specified number of tokens

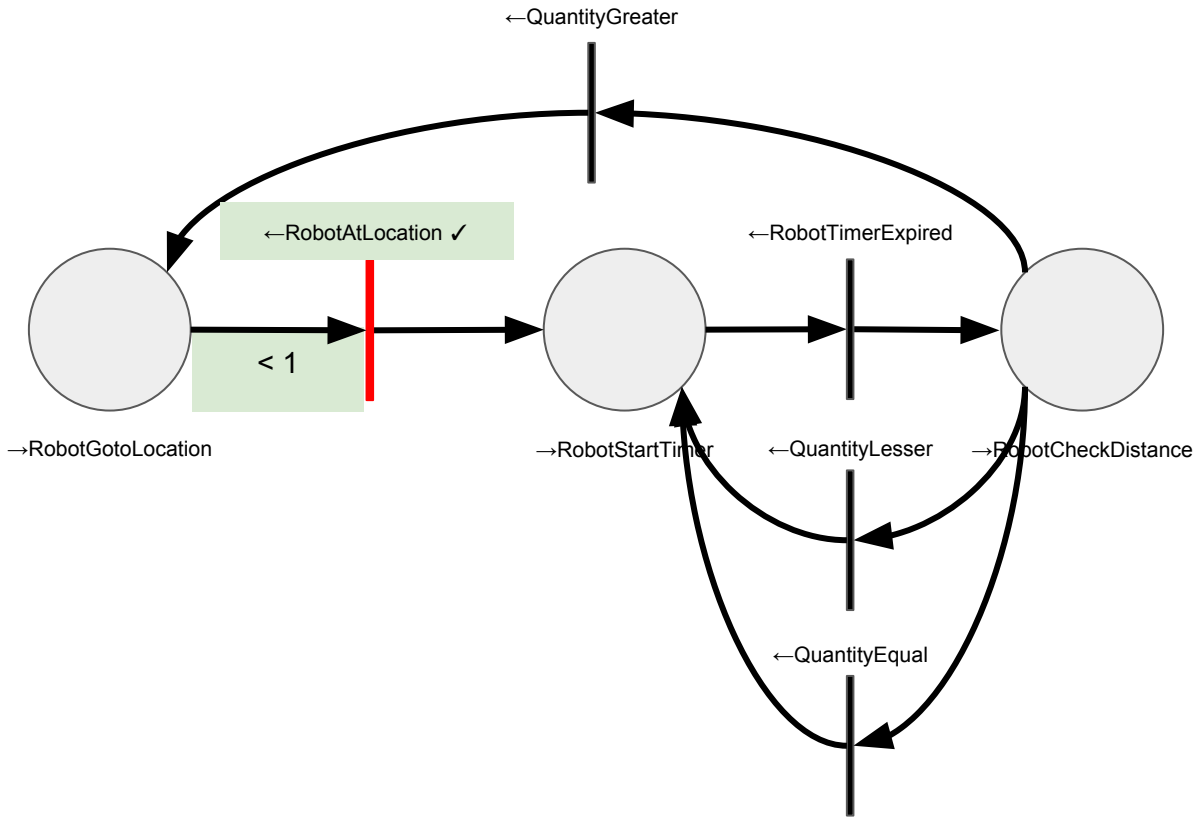
The transition does NOT fire: the input event on the transition has been received, but the in edge requirement is not satisfied



The transition does NOT fire: the in edge requirement is satisfied, but the input event on the transition has not been received



The transition does fire: the in edge requirement is satisfied and the input event on the transition has been received

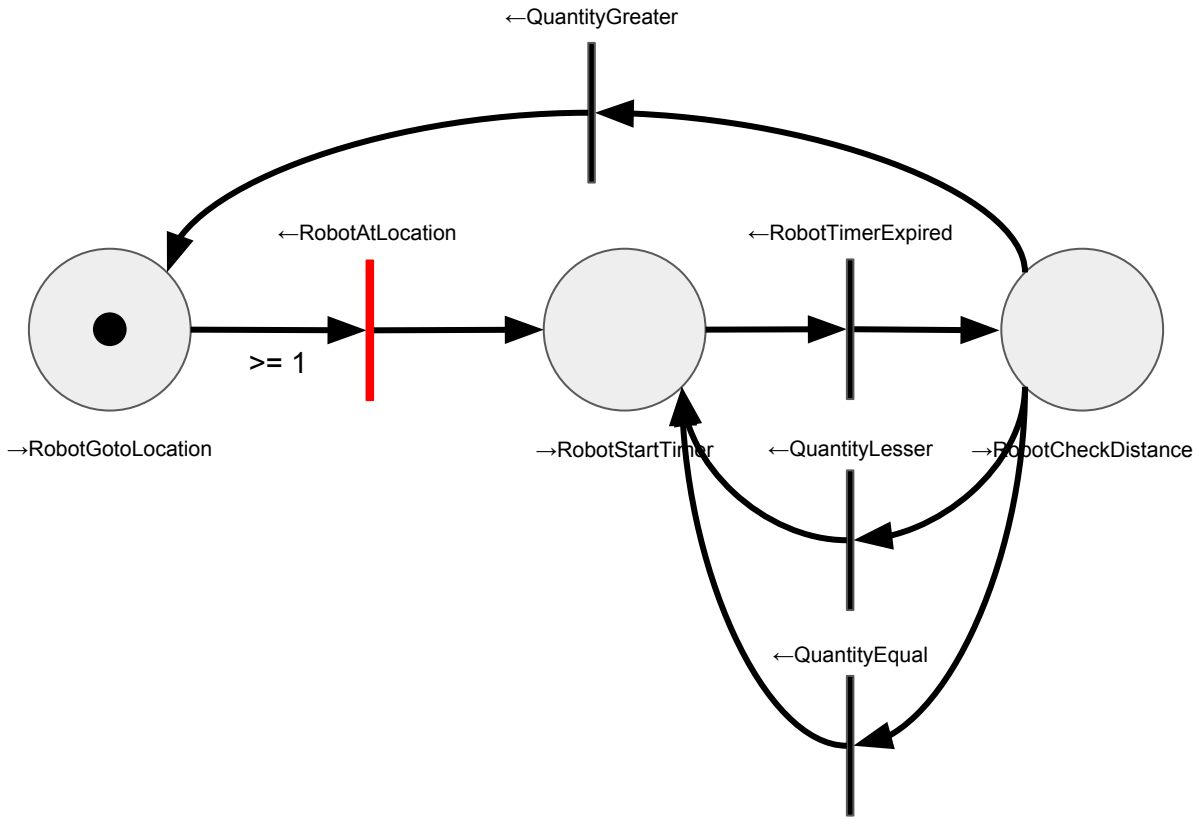


In edge requirements: Are put on In Edges and list other requirements necessary for a transition connected to it to fire

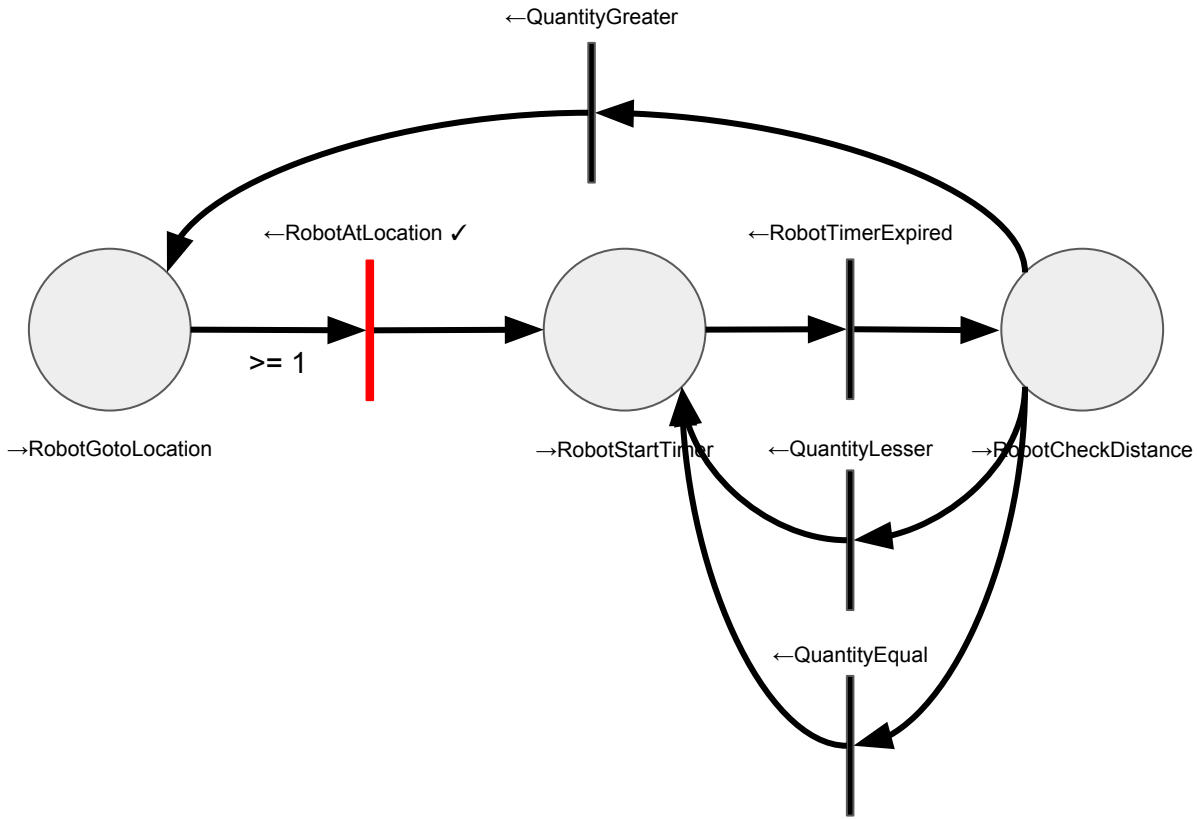
For now, let's consider 2 options for requirement criteria

- Less Than: The place connected to the in edge must have less than a specified number of tokens
- Greater Than or Equal To: The place connected to the in edge must have greater than or equal to a specified number of tokens

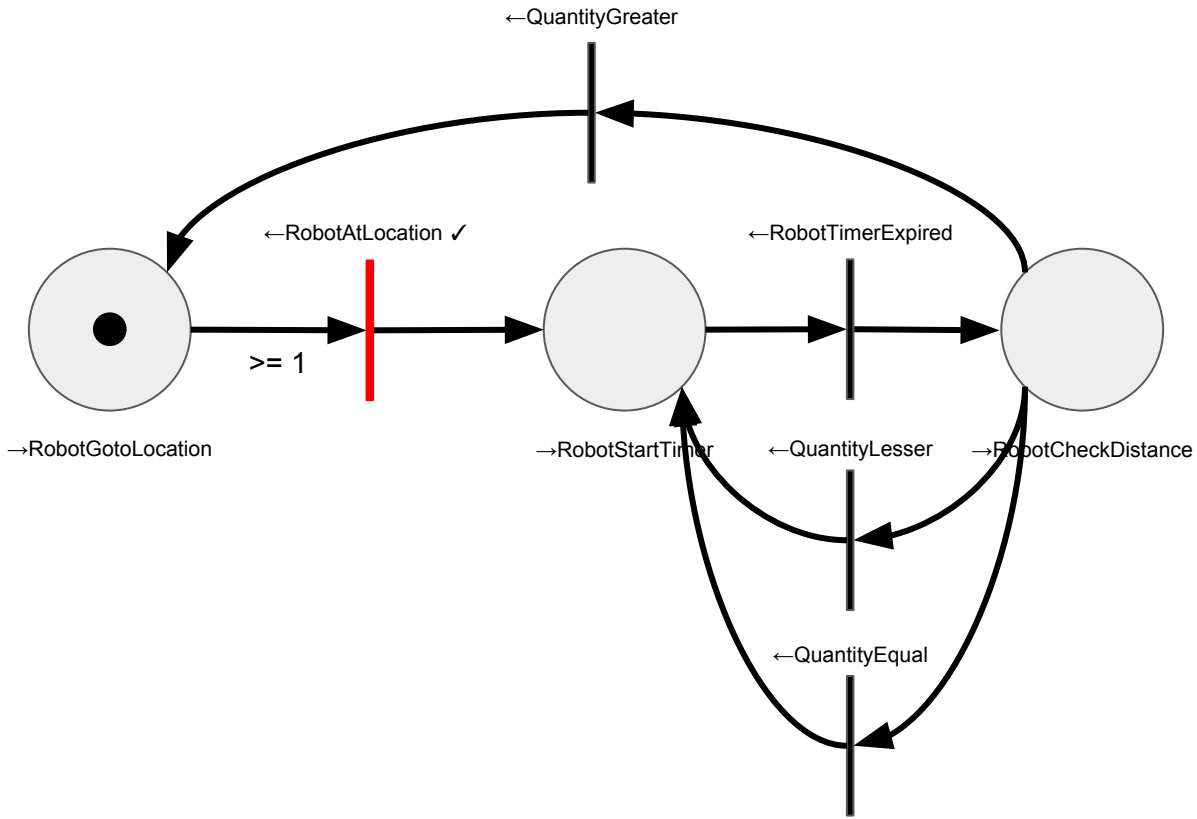
The transition does NOT fire: the in edge requirement is satisfied, but the input event on the transition has not been received.



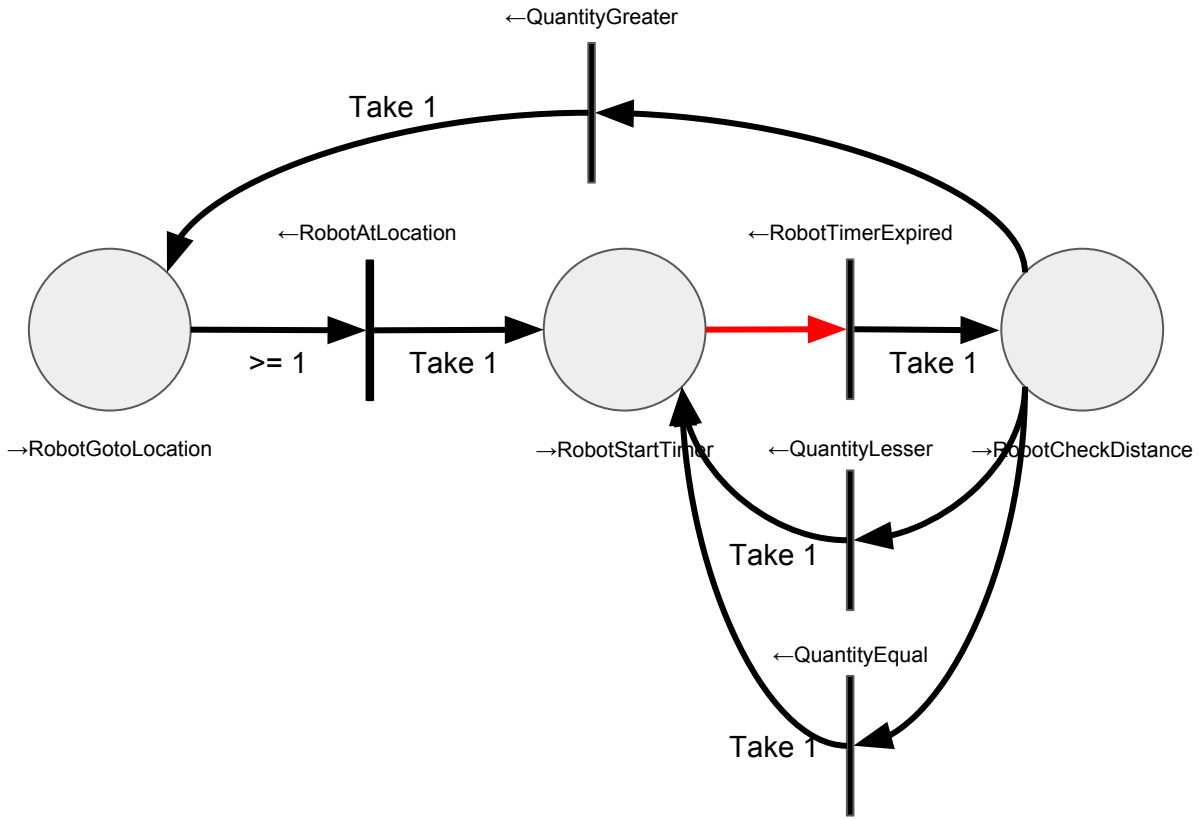
The transition does NOT fire: the input event on the transition has been received, but the in edge requirement is not satisfied



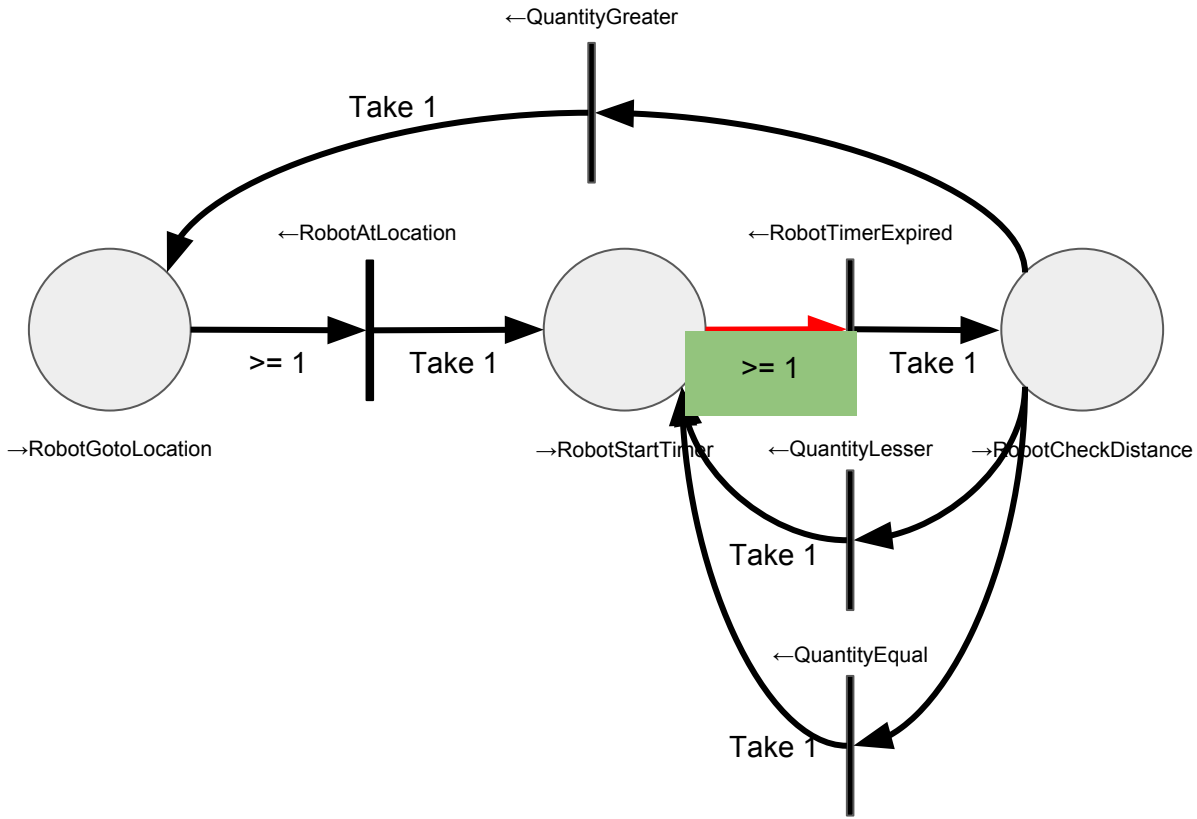
The transition does fire: the input event on the transition has been received and the in edge requirement is satisfied



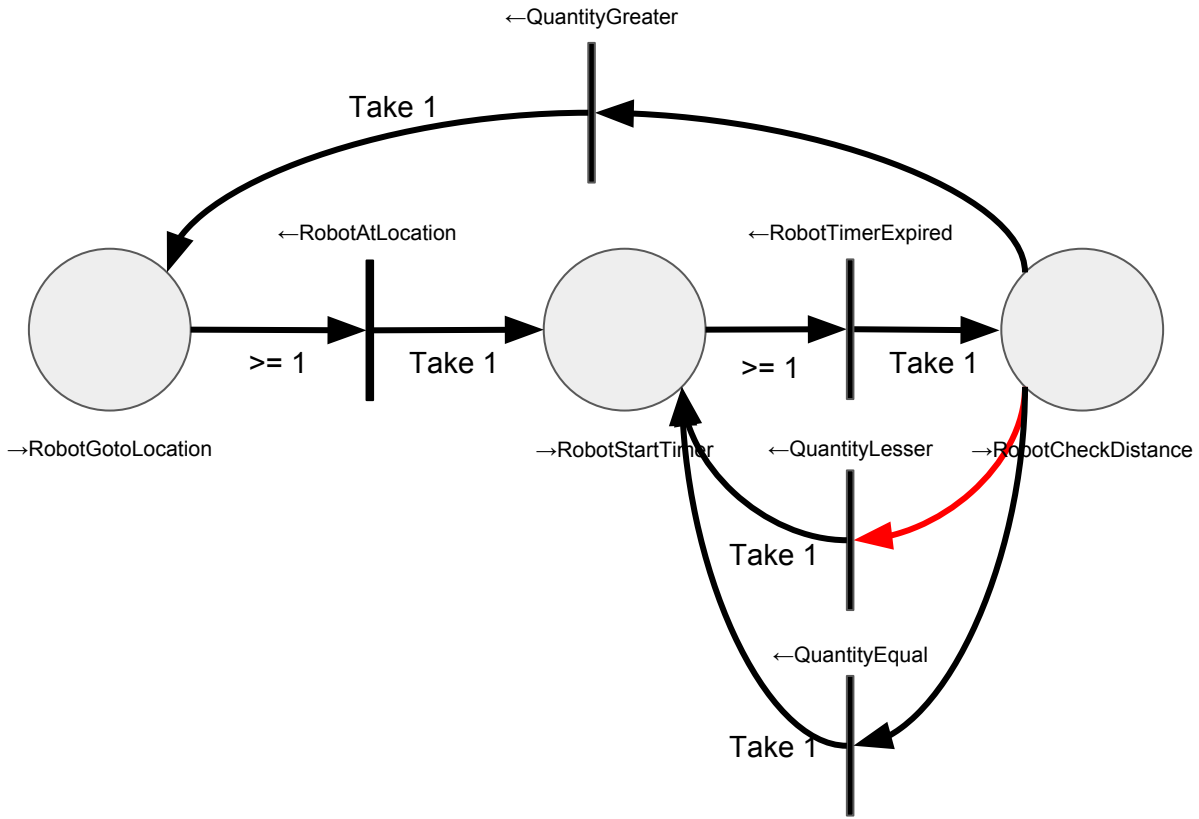
Quiz 5-18: Choose the requirement for the in edge



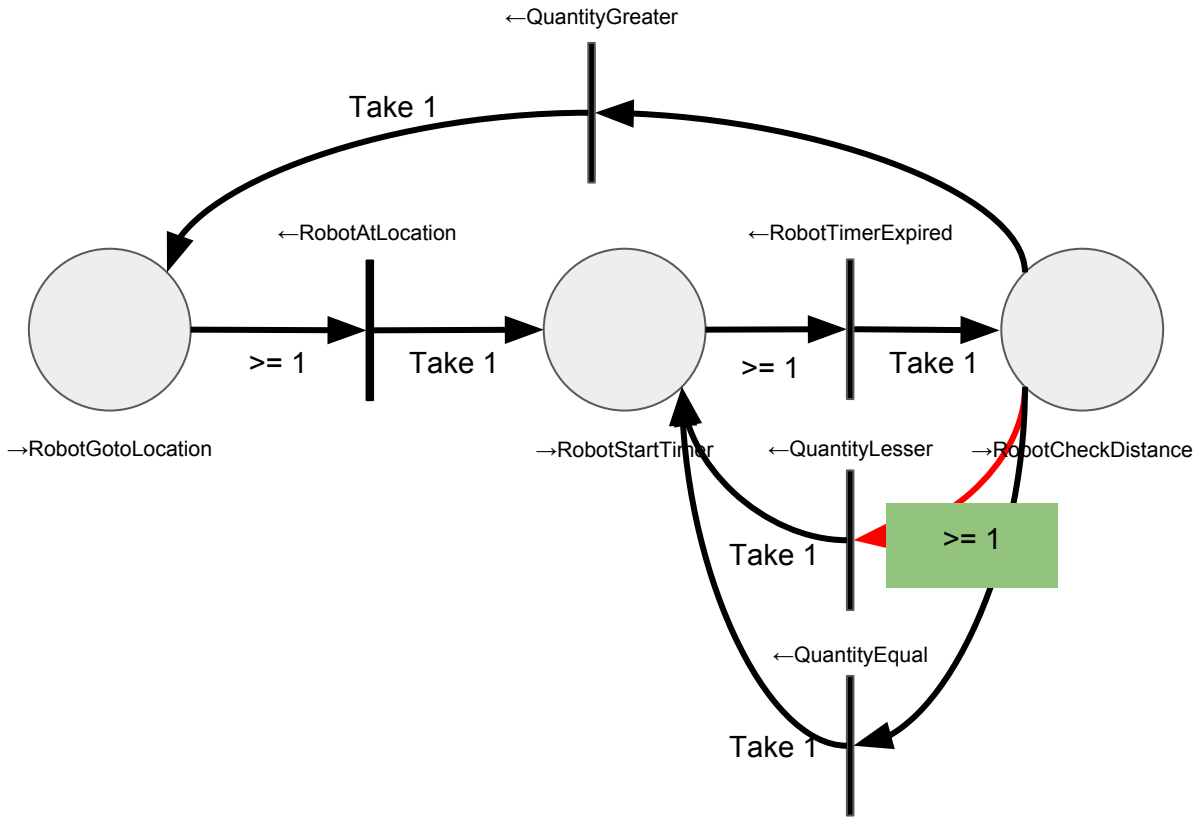
Quiz 5-18 Solution



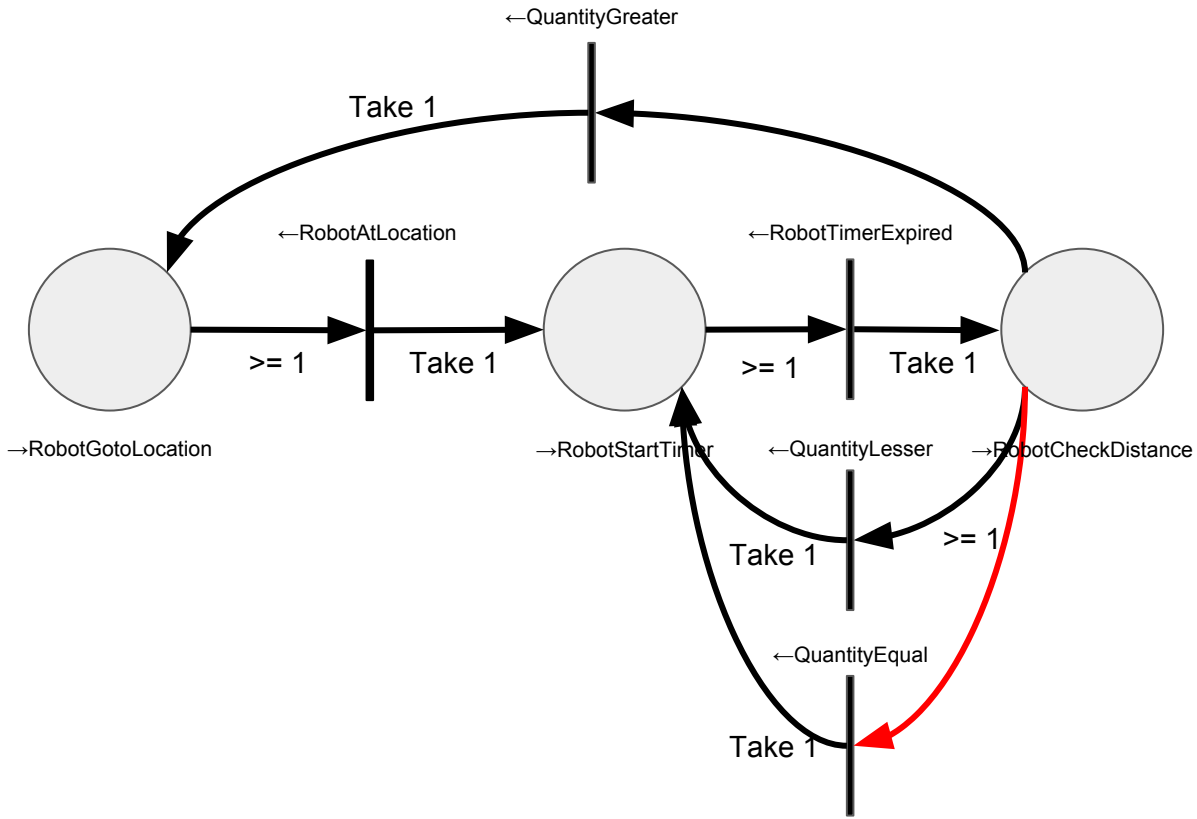
Quiz 5-19: Choose the requirement for the in edge



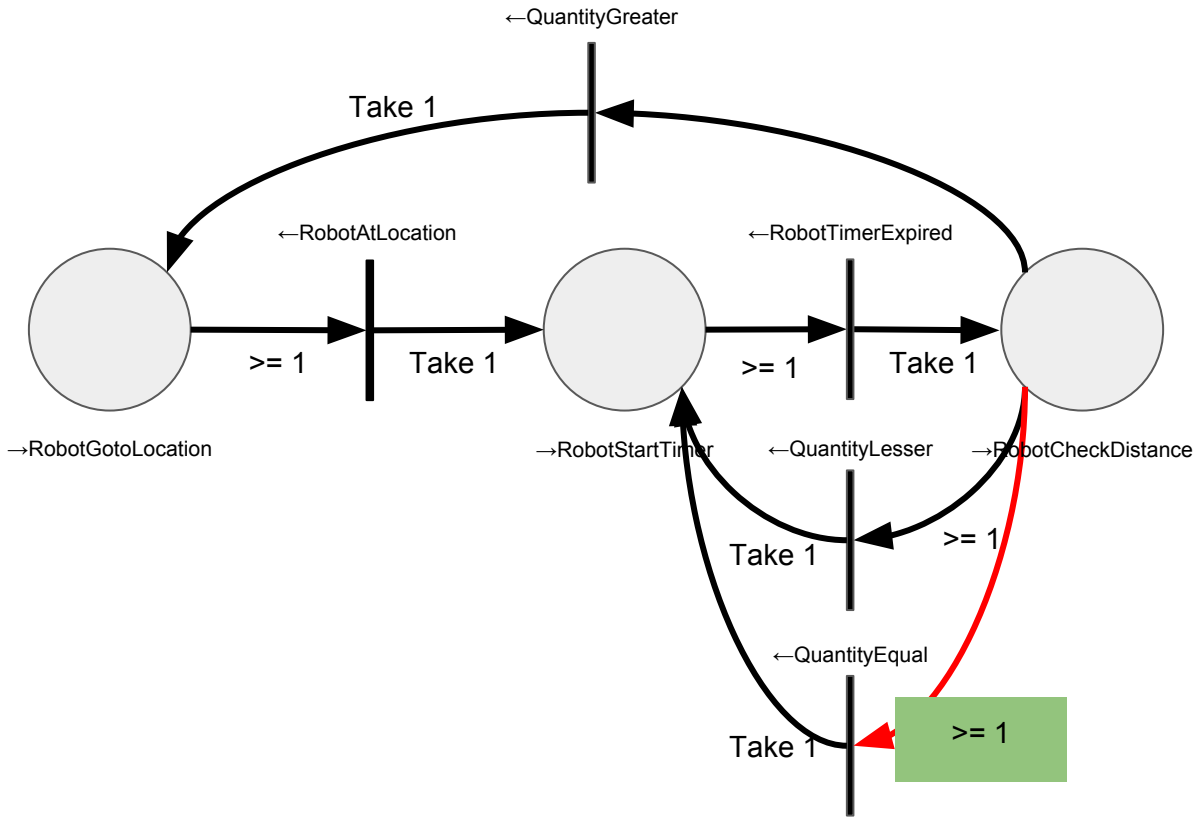
Quiz 5-19 Solution



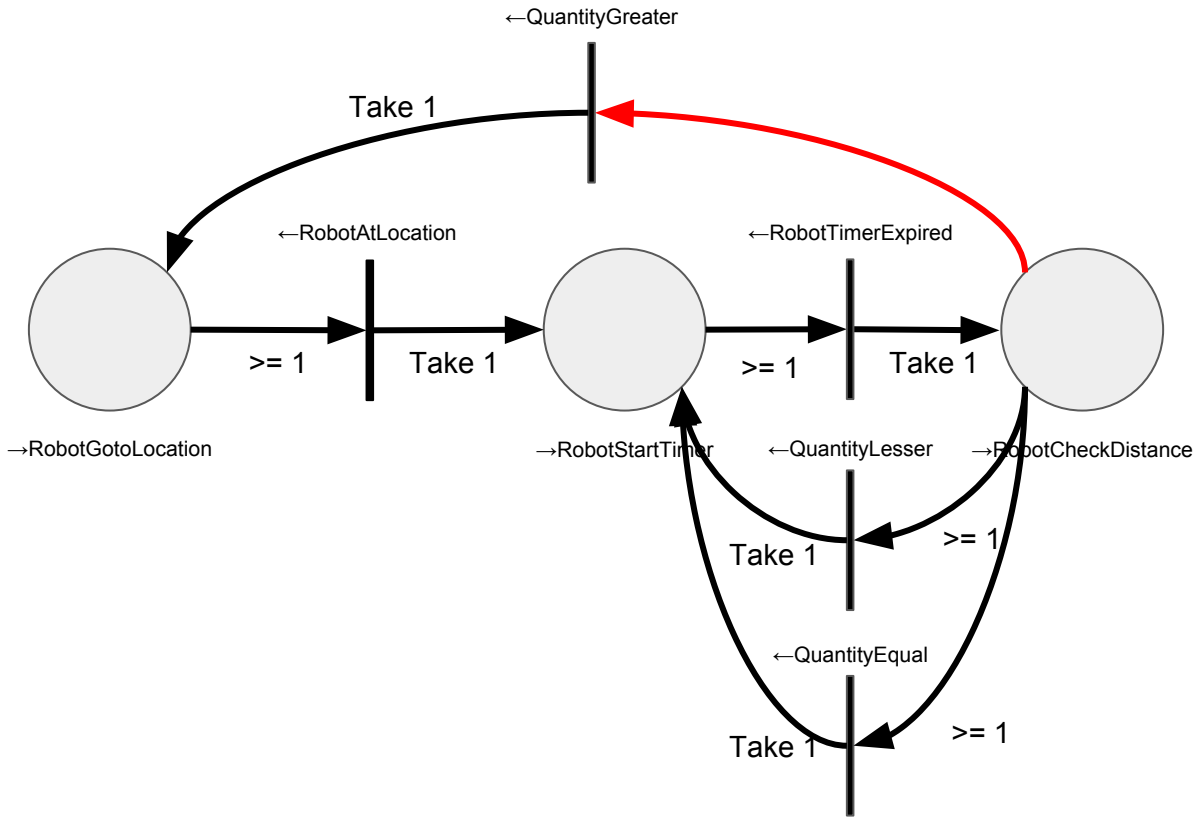
Quiz 5-20: Choose the requirement for the in edge



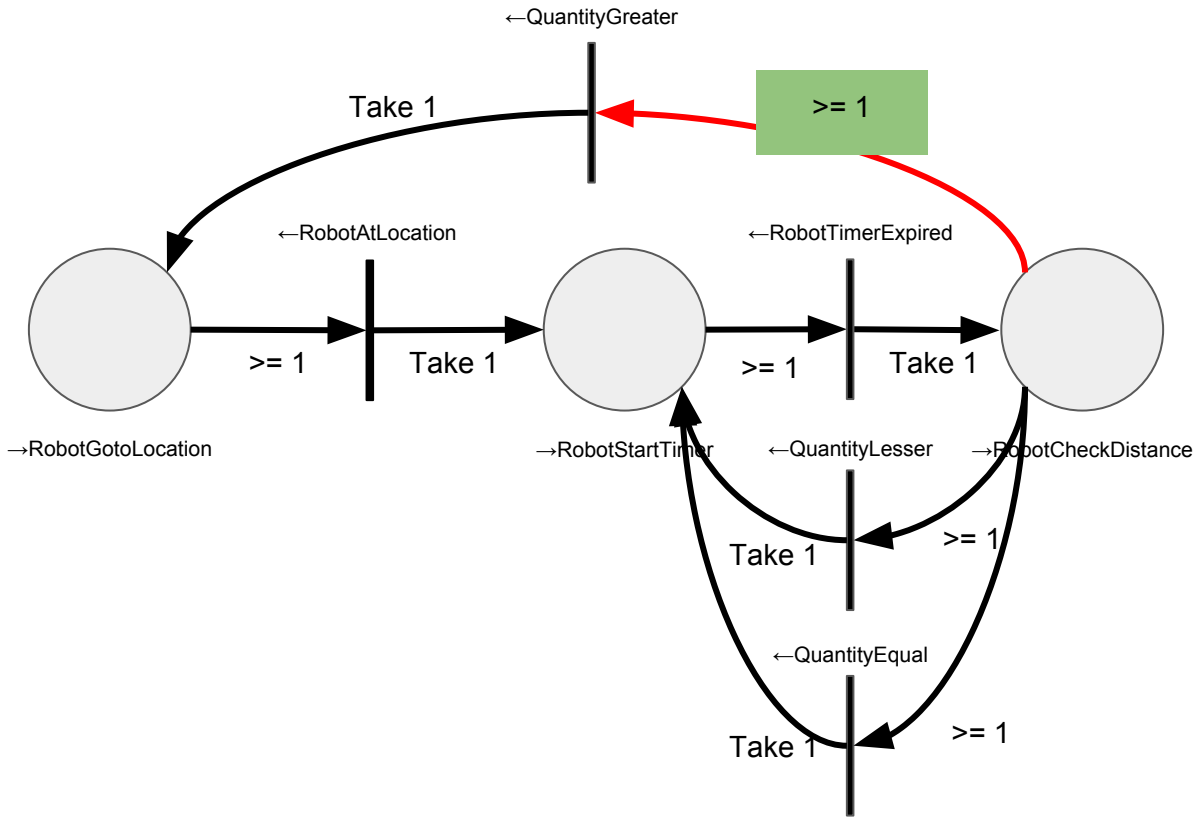
Quiz 5-20 Solution

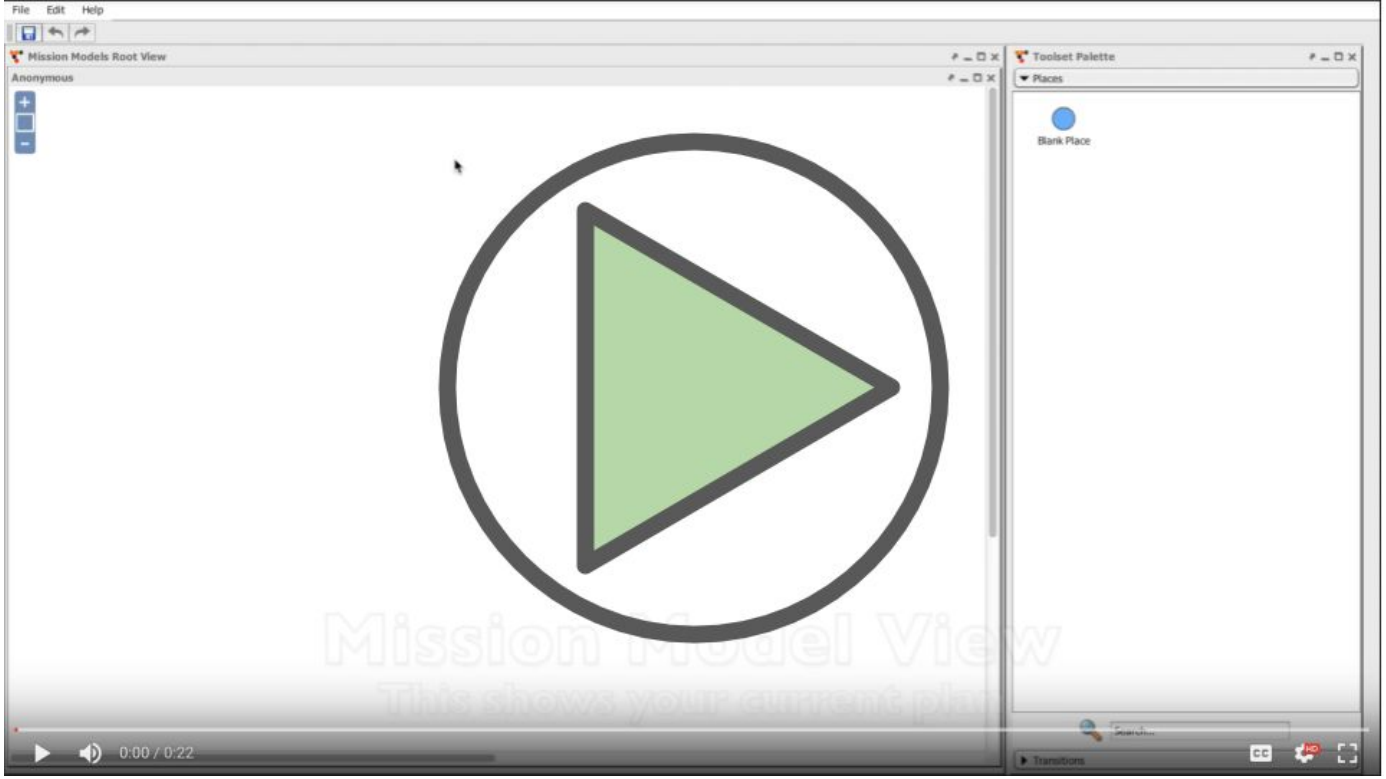


Quiz 5-21: Choose the requirement for the in edge



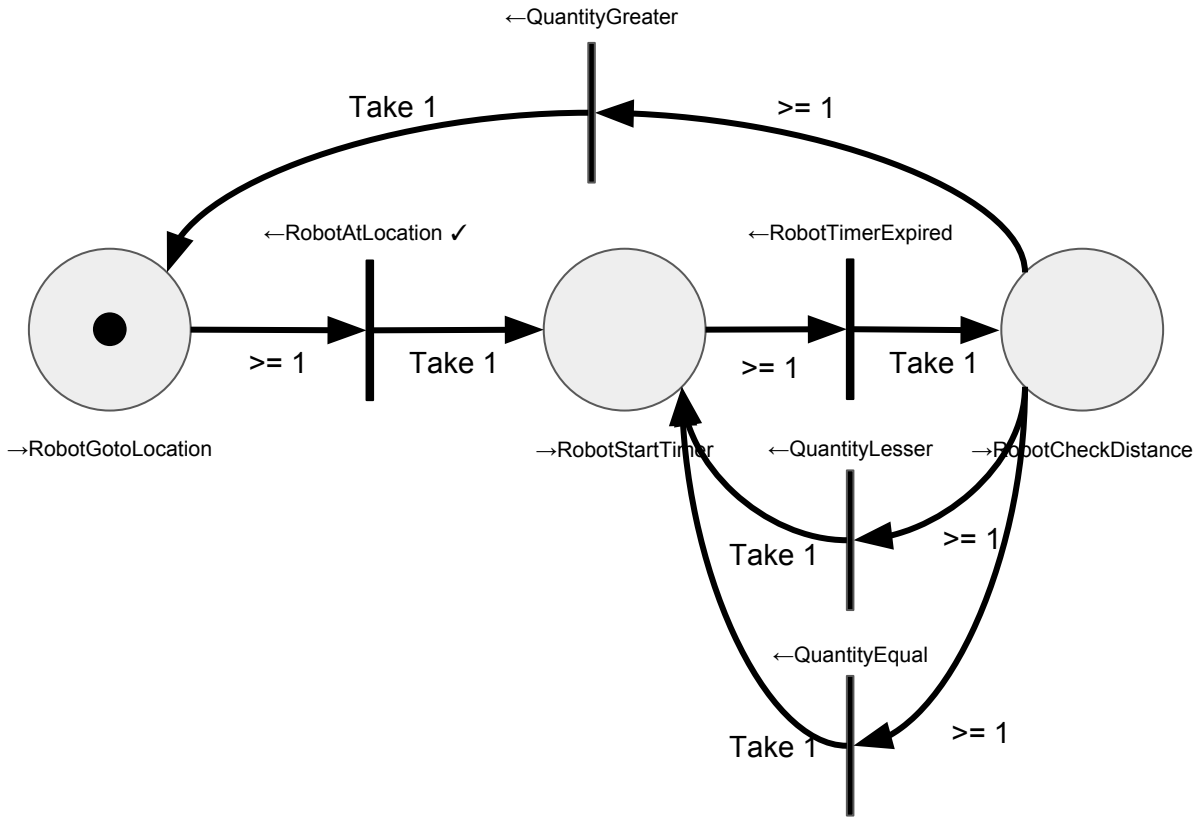
Quiz 5-21 Solution



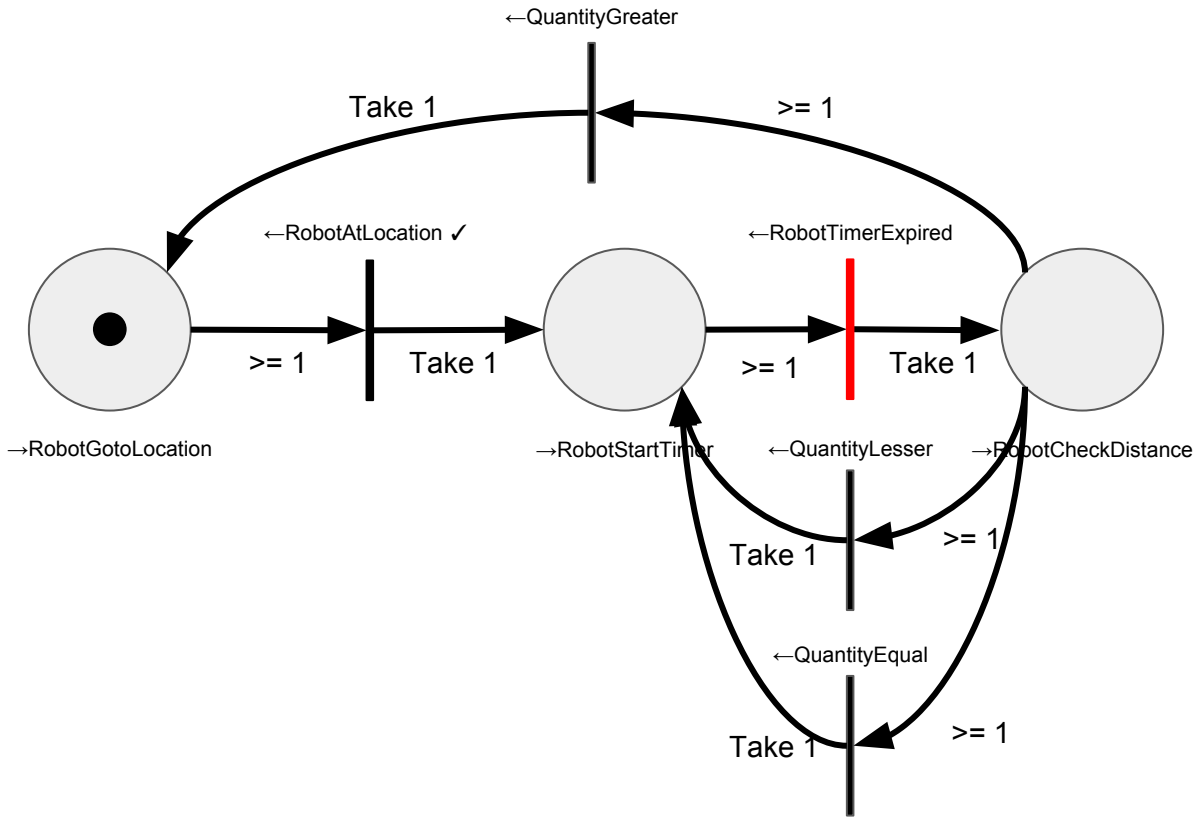


Watch “Input Requirements”: This video will show you how to add in edge requirements.

Job 5-2: Add the in edge requirements



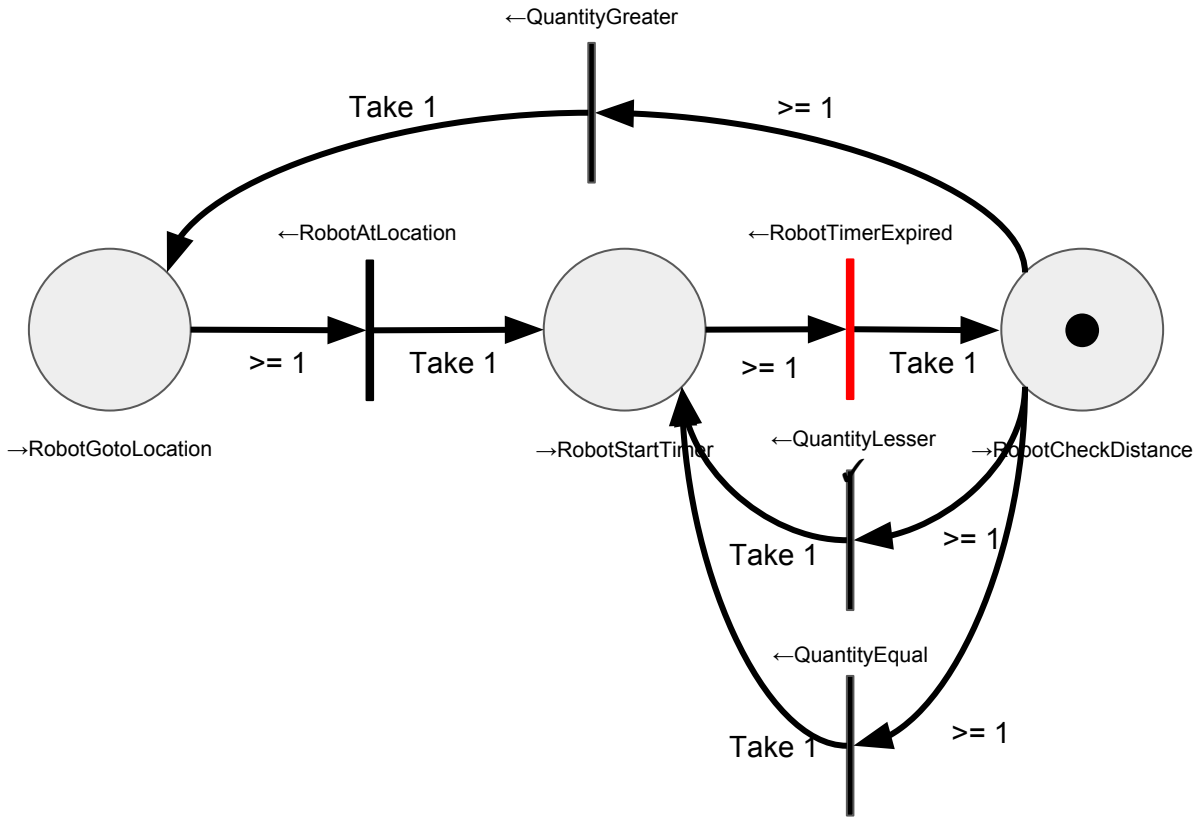
Quiz 5-22: Does the transition fire?



Quiz 5-22 Solution

No: ←RobotTimerExpired has not been received and the in edge requirement is not satisfied (→RobotStartTimer place has 0 tokens and would need at least 1 token)

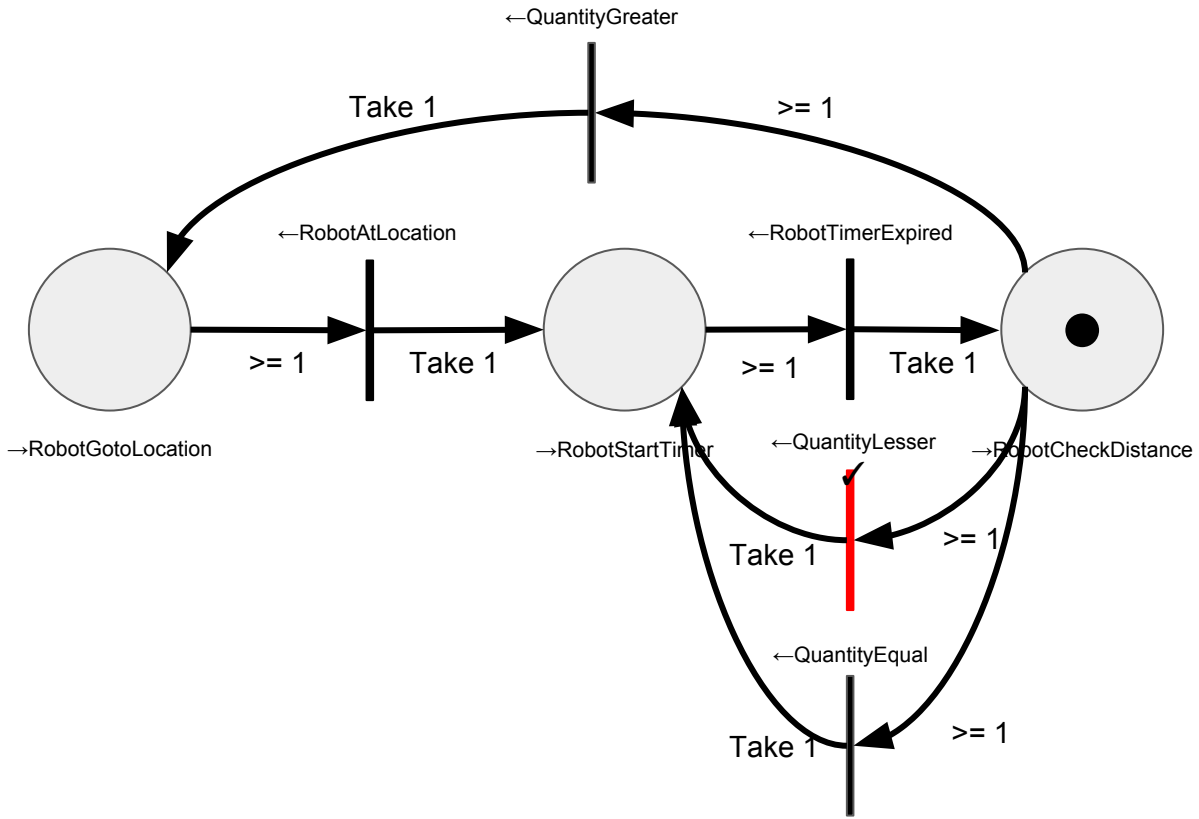
Quiz 5-23: Does the transition fire?



Quiz 5-23 Solution

No: ←RobotTimerExpired has not been received and the in edge requirement is not satisfied (→RobotStartTimer place has 0 tokens and would need at least 1 token)

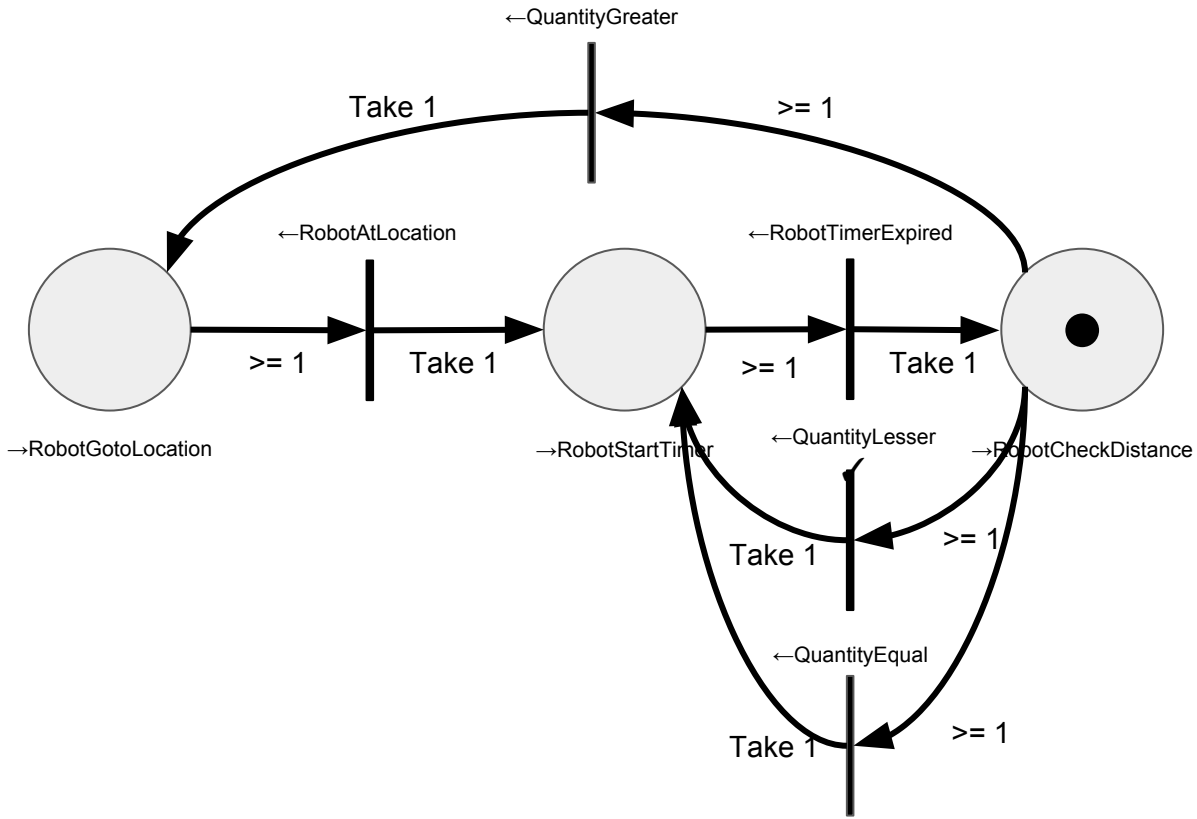
Quiz 5-24: Does the transition fire?



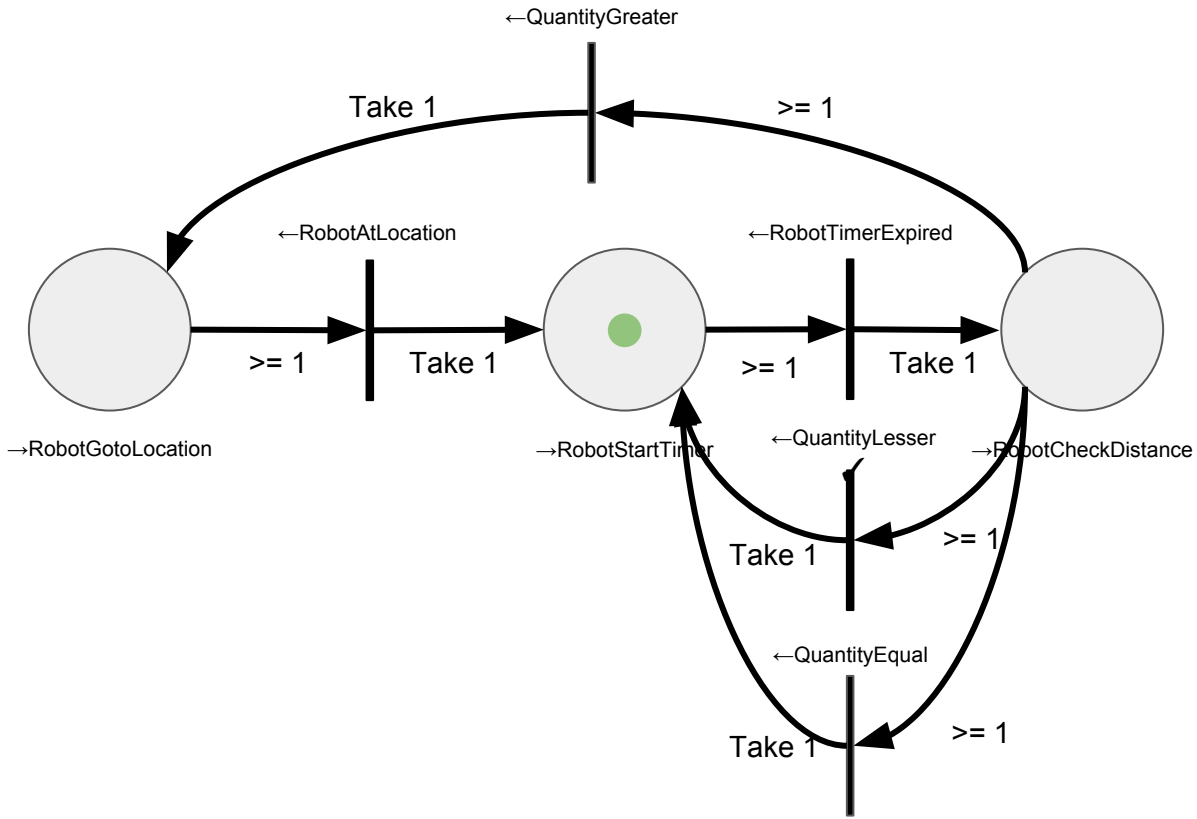
Quiz 5-24 Solution

Yes: ←QuantityLesser has been received and the in edge requirement is satisfied (→RobotCheckDistance place has one token)

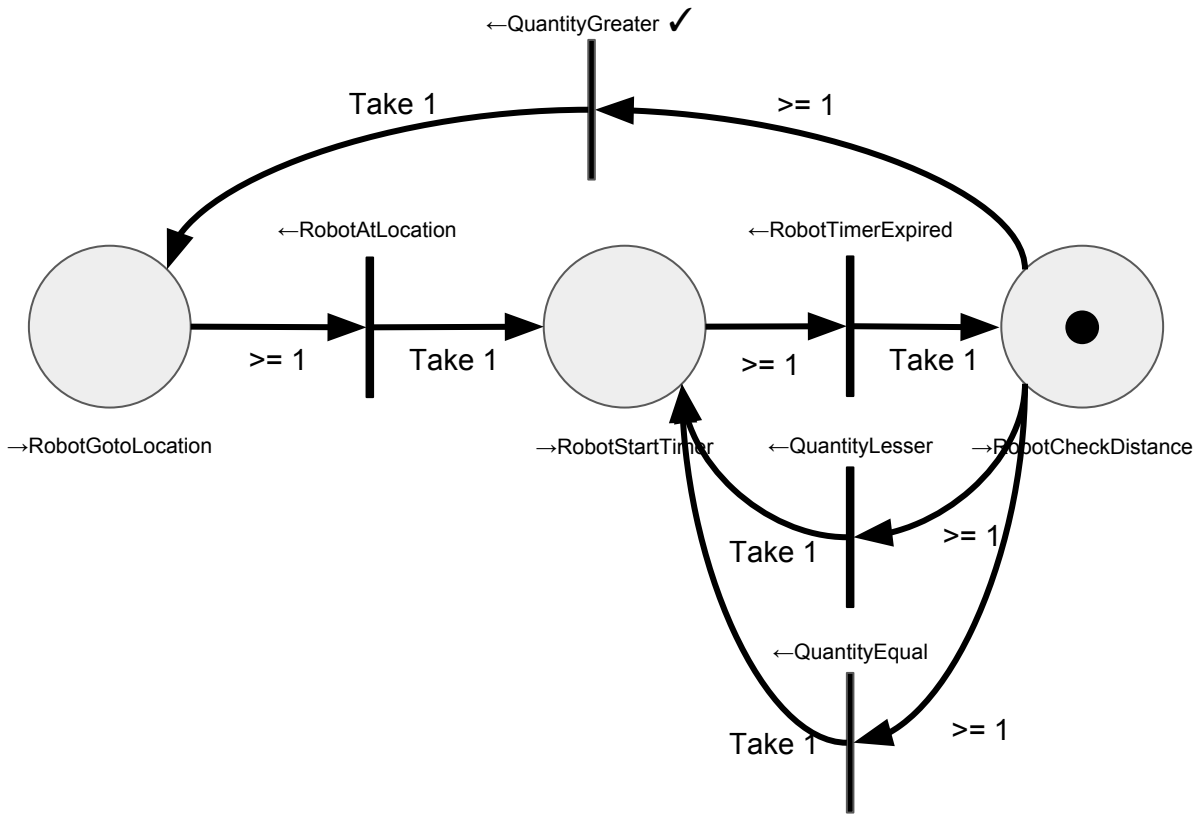
Quiz 5-25: Draw the tokens after all eligible transitions fire



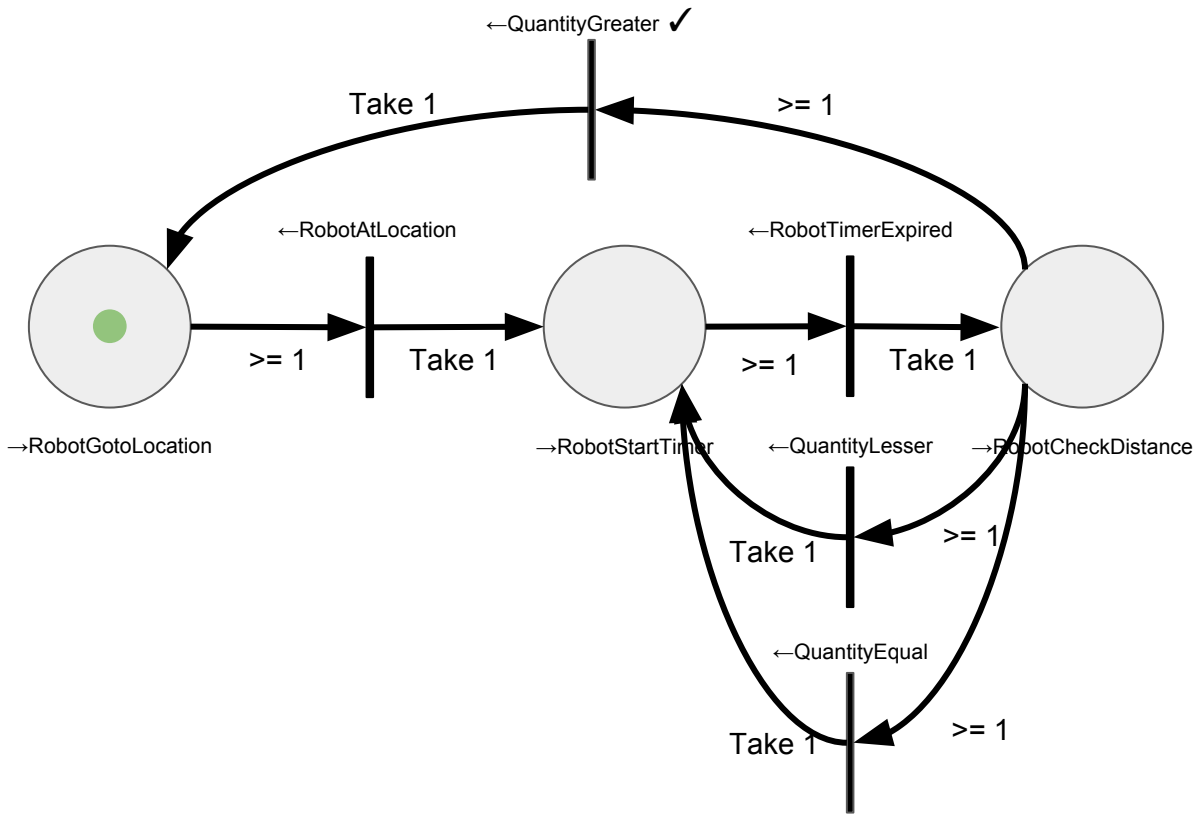
Quiz 5-25 Solution



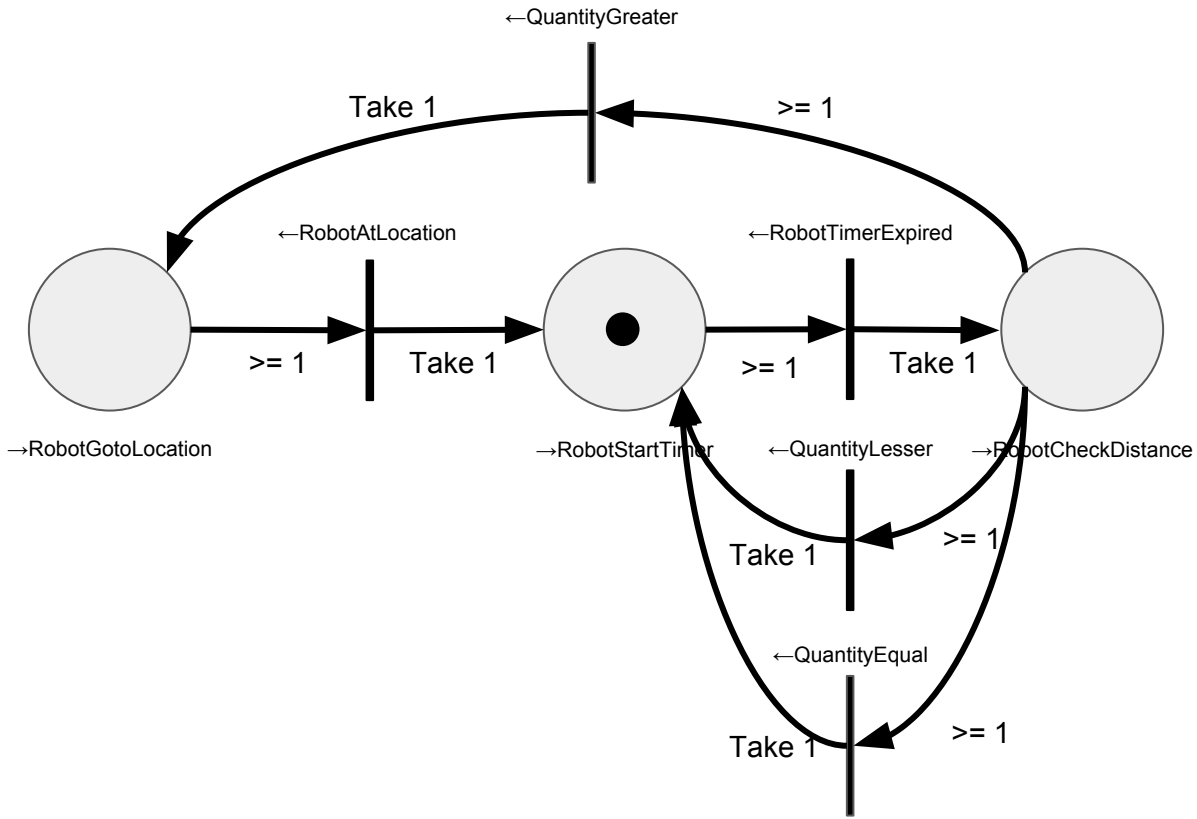
Quiz 5-26: Draw the tokens after all eligible transitions fire



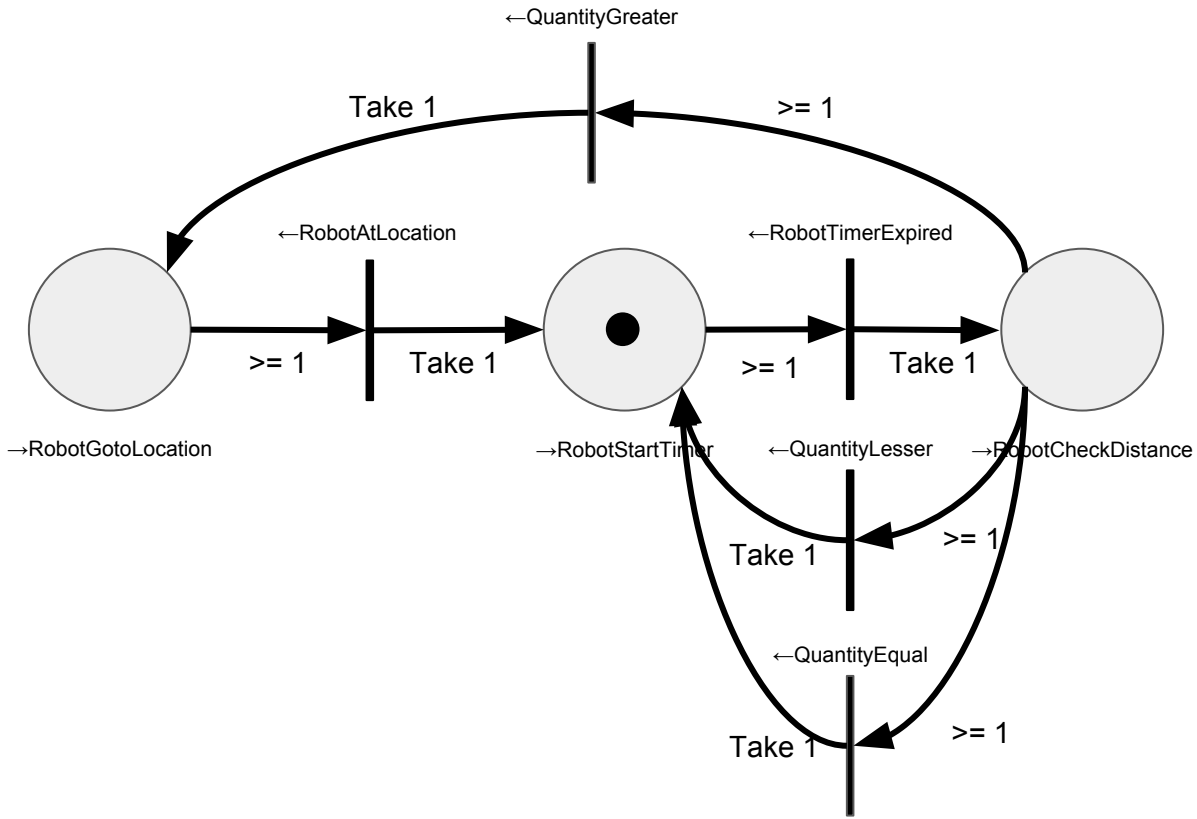
Quiz 5-26 Solution



Quiz 5-27: Draw the tokens after all eligible transitions fire



Quiz 5-27 Solution

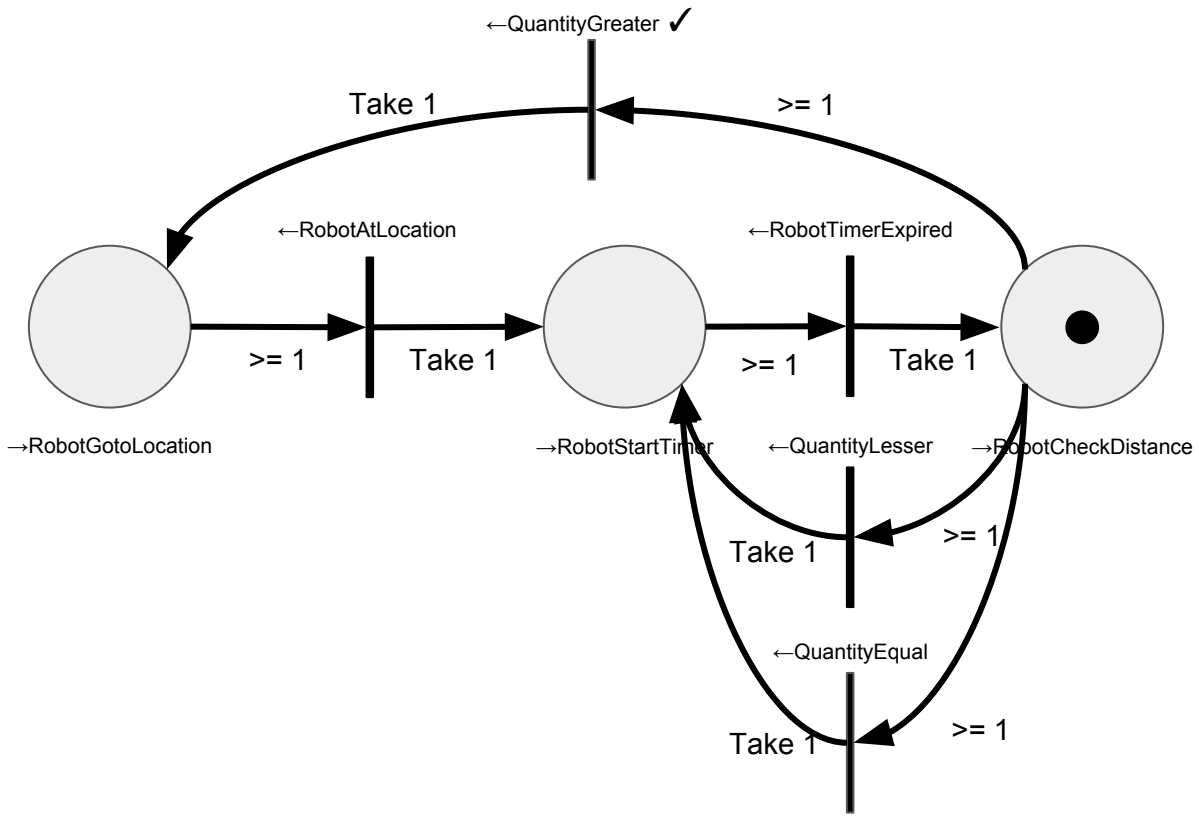


In addition to manipulating tokens, when a transition fires it also resets the receipt status of each of its input events to “not received” The transition firing means that the information received in the input event is being acted on, so the transition should not fire again in the future unless that information is received again.

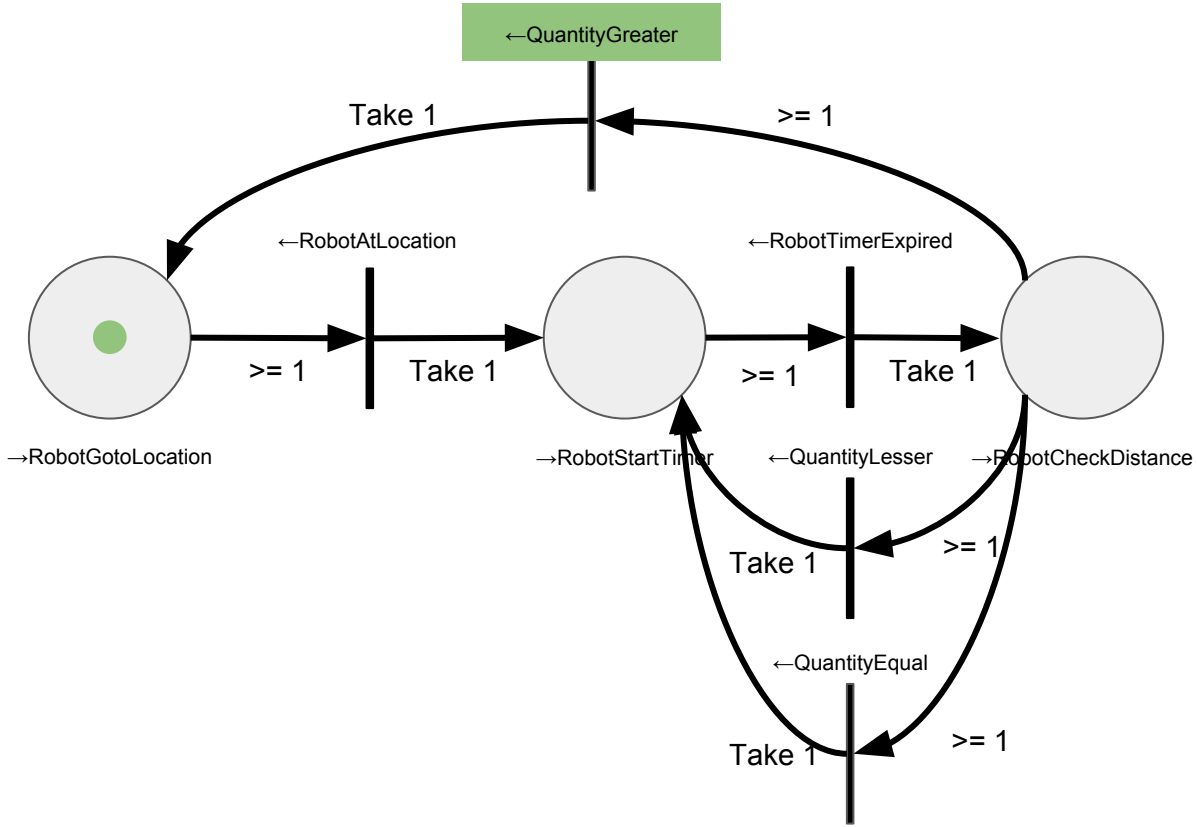
Once a firing transition manipulates tokens according to the its out edge requirements and its input events have been marked as “not received,” other transitions are allowed to check if they should fire.

Note that, if an input event is received, but the transition does not fire, it remains “received” until the transition does fire.

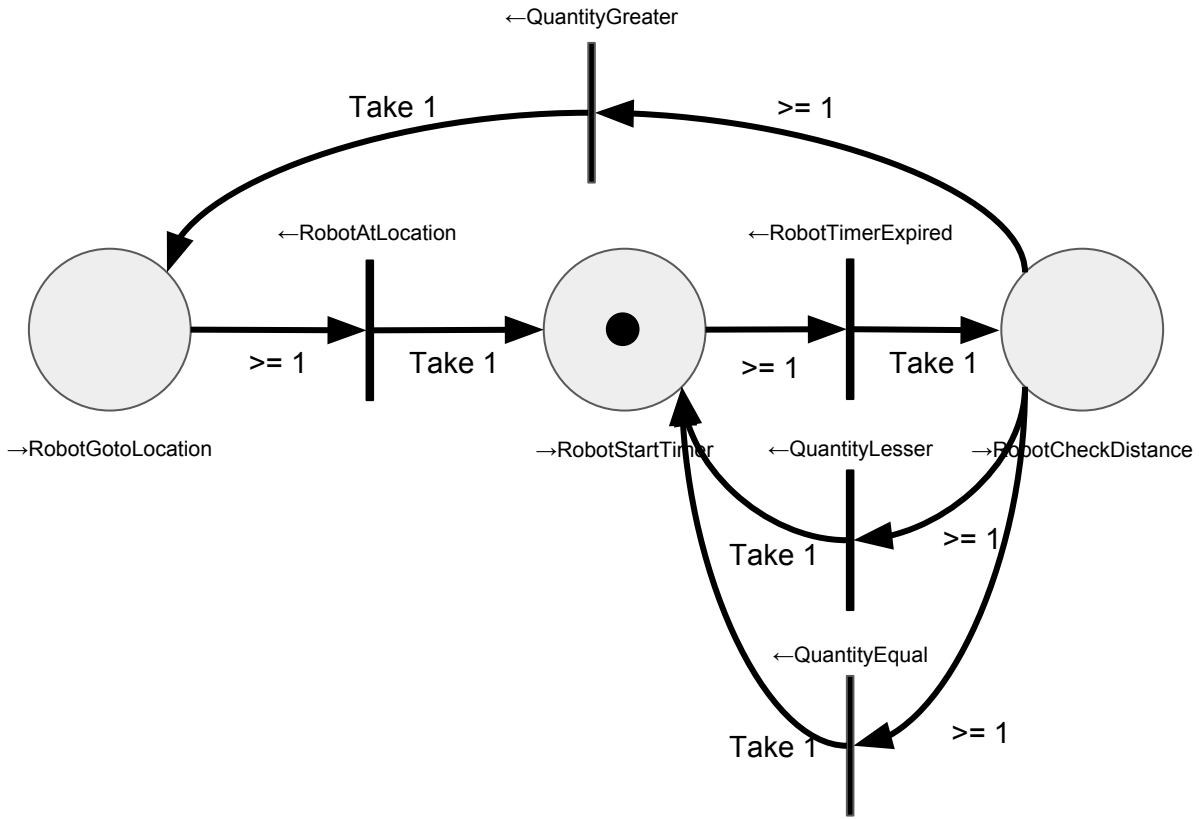
Quiz 5-28: Draw the tokens and update the input event receipt status after all eligible transitions fire



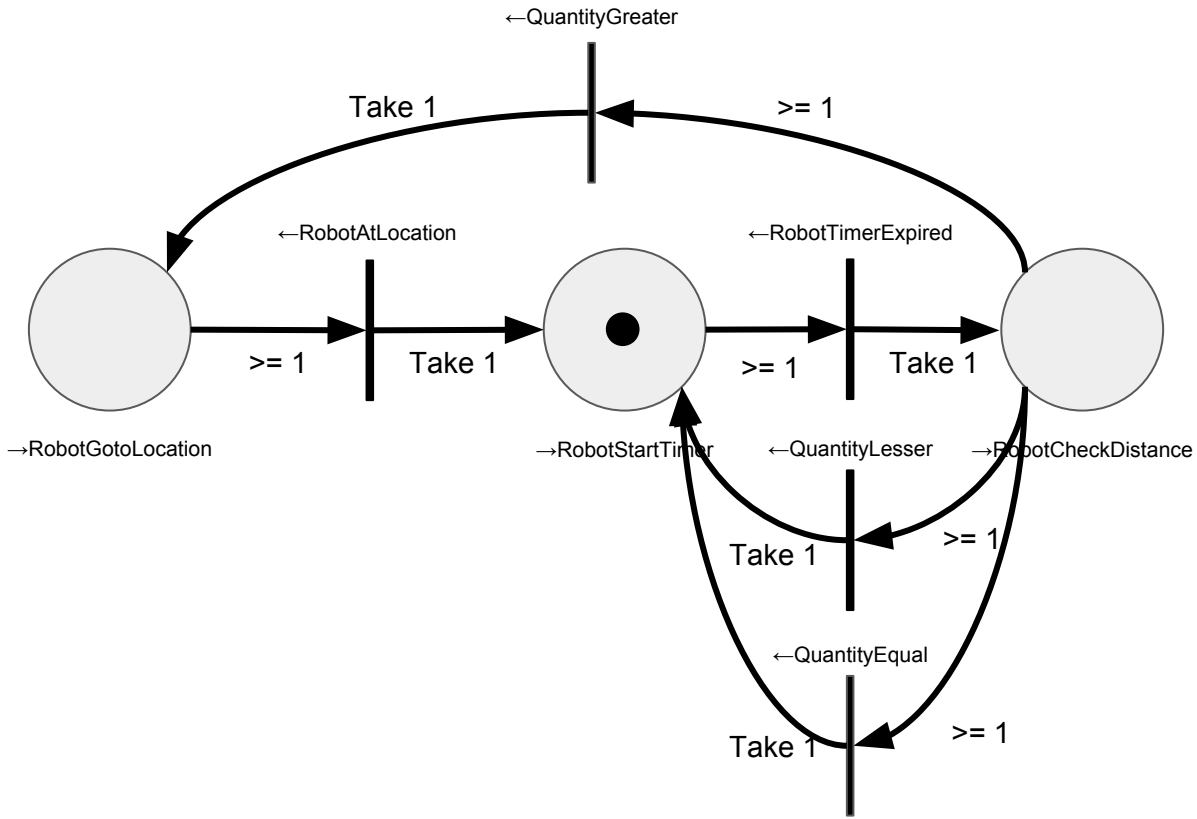
Quiz 5-28 Solution



Quiz 5-29: Draw the tokens and update the input event receipt status after all eligible transitions fire



Quiz 5-29 Solution



We have now addressed when to fire a transition and what to do with tokens when a transition fires. However, the current representation works only for a single robot.