TRAIN STATION SYSTEM
Composition Tree

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Plato's Advice

" First the taking in of scattered particulars under one idea so that everyone understands what is being talked about … second the separation of the idea into parts, by dividing it at its joints, …"

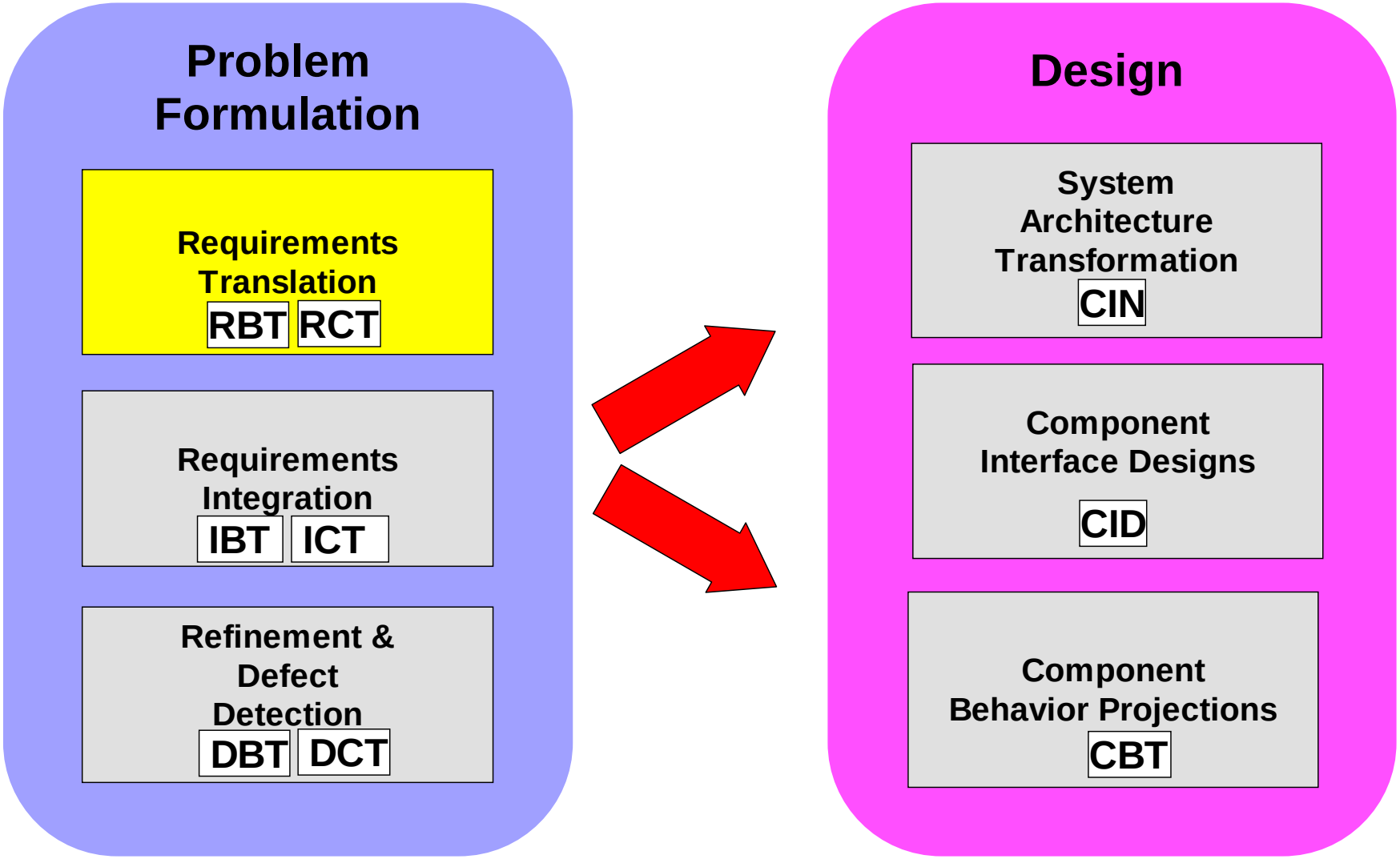
" The beginning is the most important part of the work"

Purpose of this Case Study

- The Train Station case study is used as the first translation exercise to introduce people to the process of translating functional requirements into Composition Tree fragments (RCTs).

- The exercise is also used to illustrate requirements integration of RCTs to produce an integrated composition tree (ICT).

Genetic Software Engineering



TRAIN-STATION PROBLEM (Sherwood Station)

Develop a system to model the behavior of a Train-Station. You need to model a train entering the station from the north and then leaving the station to the south. A crossing with boom gates and flashing red lights is located just south of the station. There is a signal to the north of the station that only allows a train to enter when the station is not occupied, that is, when the north signal is green. There is also an exit signal light that ensures the train can only leave the station when the boom gates are down. There is also a north detector that can detect the train approaching the station region from the north. And, there is an exit detector that detects when a train leaves to the south.

1. Initially the station is not occupied. The north signal turns green whenever the station is not occupied. Whenever the north signal is green a train may approach from the north. When approaching from the north a train is detected, by the north detector, which causes the north signal to turn red.

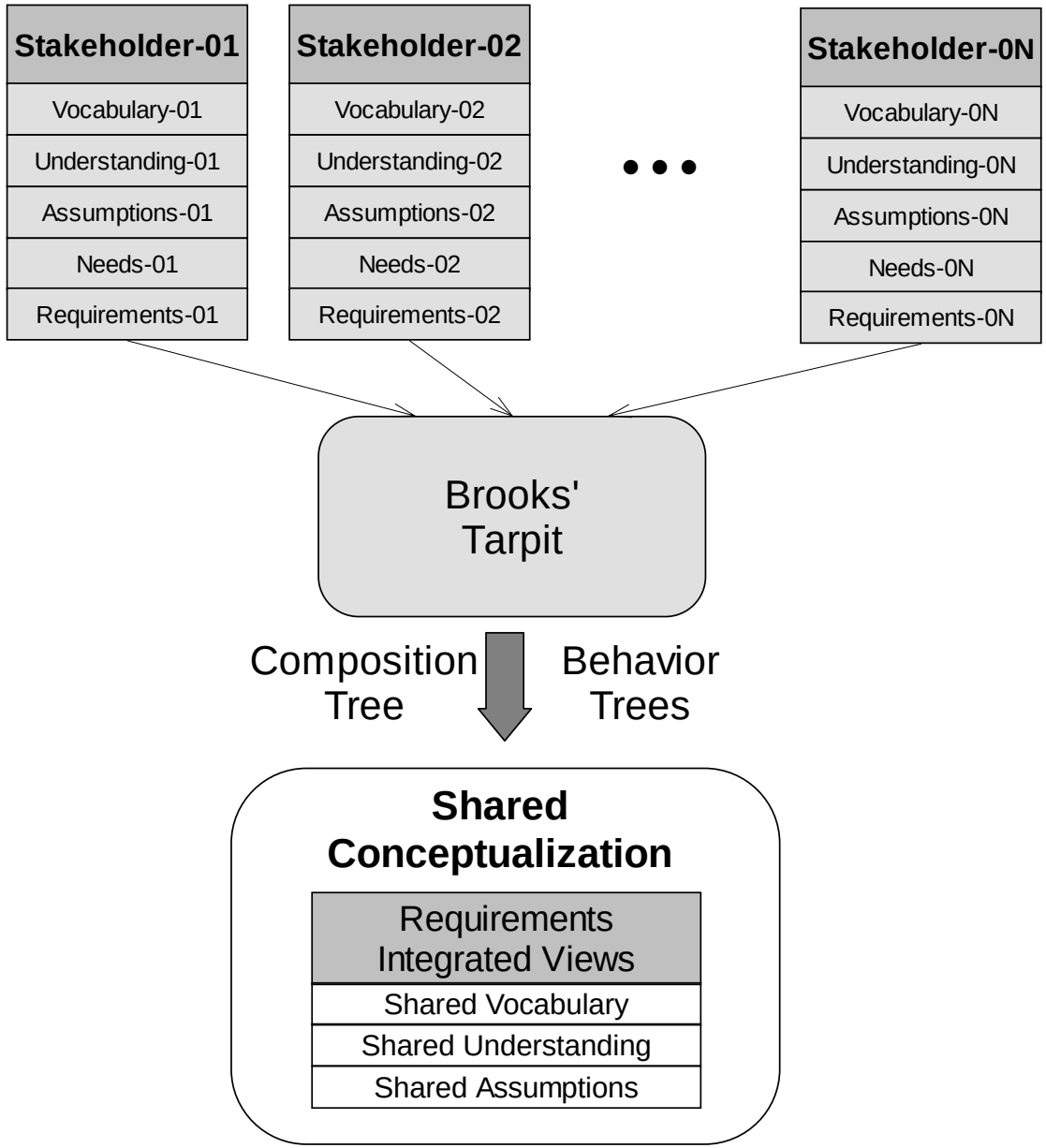
2. When the north detector detects a train it causes the crossing lights to start flashing red. At the same time, a timer starts timing and when it times out it causes the boom gates to be lowered after which the exit light turns green.

3. After the train is detected the north detector, it subsequently arrives at the station, the doors open, the people disembark, and then the doors close.

4. After the doors close the train may leave the station only when and if the exit light is green. When the train leaves the station, heading south, it is detected by the exit detector which means the station is again not occupied. This causes the north signal to turn green and the exit light to turn red. When the exit detector detects the train leaving, it also causes the boom gates to be raised and then the crossing lights to stop flashing red.

For the purposes of the exercise ignore trains approaching the station from the south. This additional requirement can be integrated later as a separate exercise. Also ignore situations where the train does not stop at the station - this too requires some refinements to the design.

The Biggest Challenge

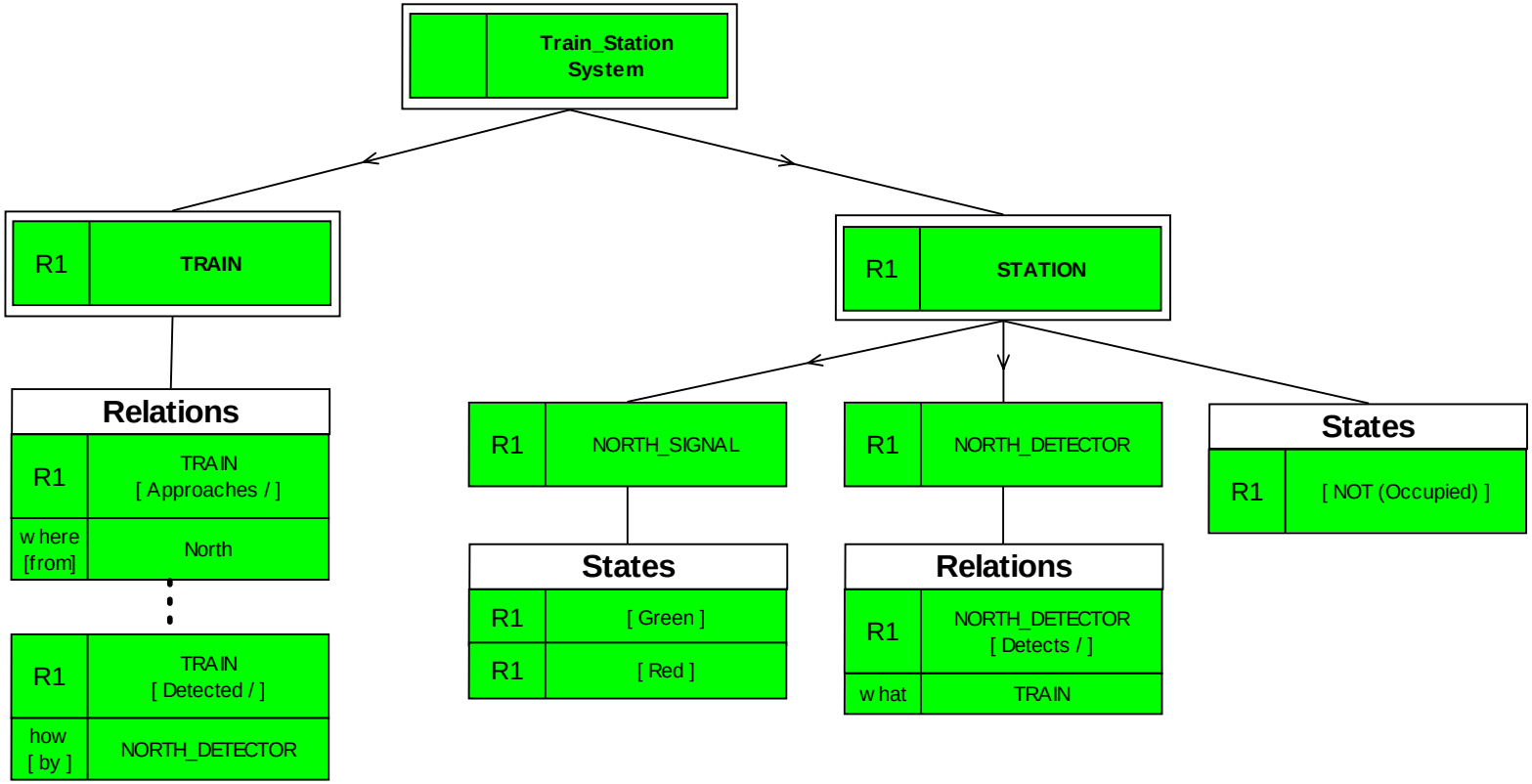


Translation to Composition Trees

REQUIREMENT-R1

Initially the station is not occupied. The north signal turns green whenever the station is not occupied. Whenever the north signal is green a train may approach from the north. When approaching from the north, a train is detected by the north detector, which causes the north signal to turn red.

Composition Tree - R1

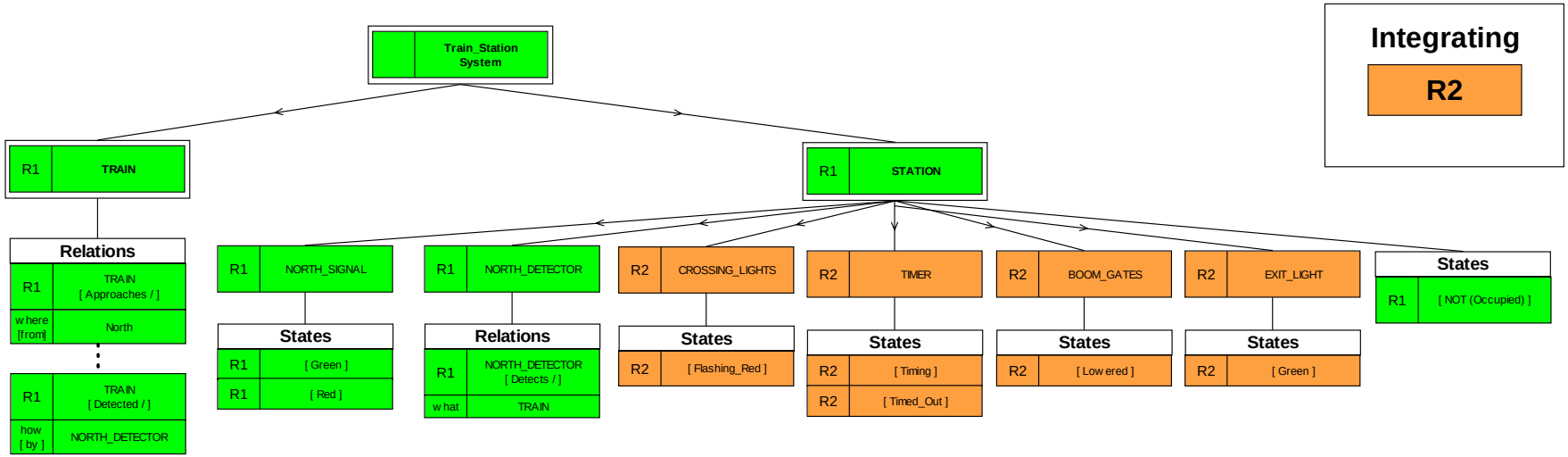


Composition Tree – Integrating R2

REQUIREMENT-R2

When the north detector detects a train it causes the crossing lights to start flashing red. At the same time a timer starts timing and when it times out, it causes the boom gates to be lowered, after which the exit light turns green.

Composition Tree – Integrating R2

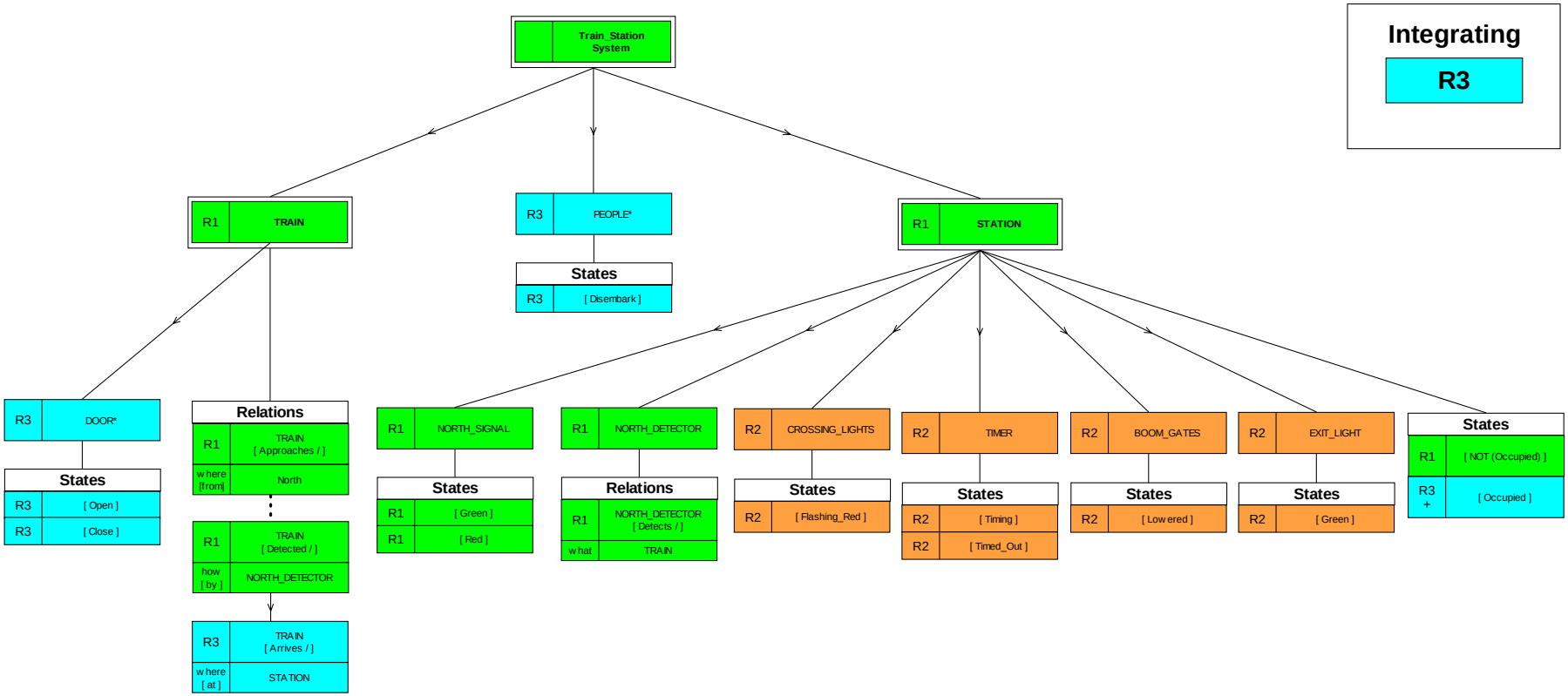


Composition Tree – Integrating R3

REQUIREMENT-R3

After the train is detected by the north detector, it subsequently arrives at the station, the doors open, the people disembark, and then the doors close.

Composition Tree – Integrating R3

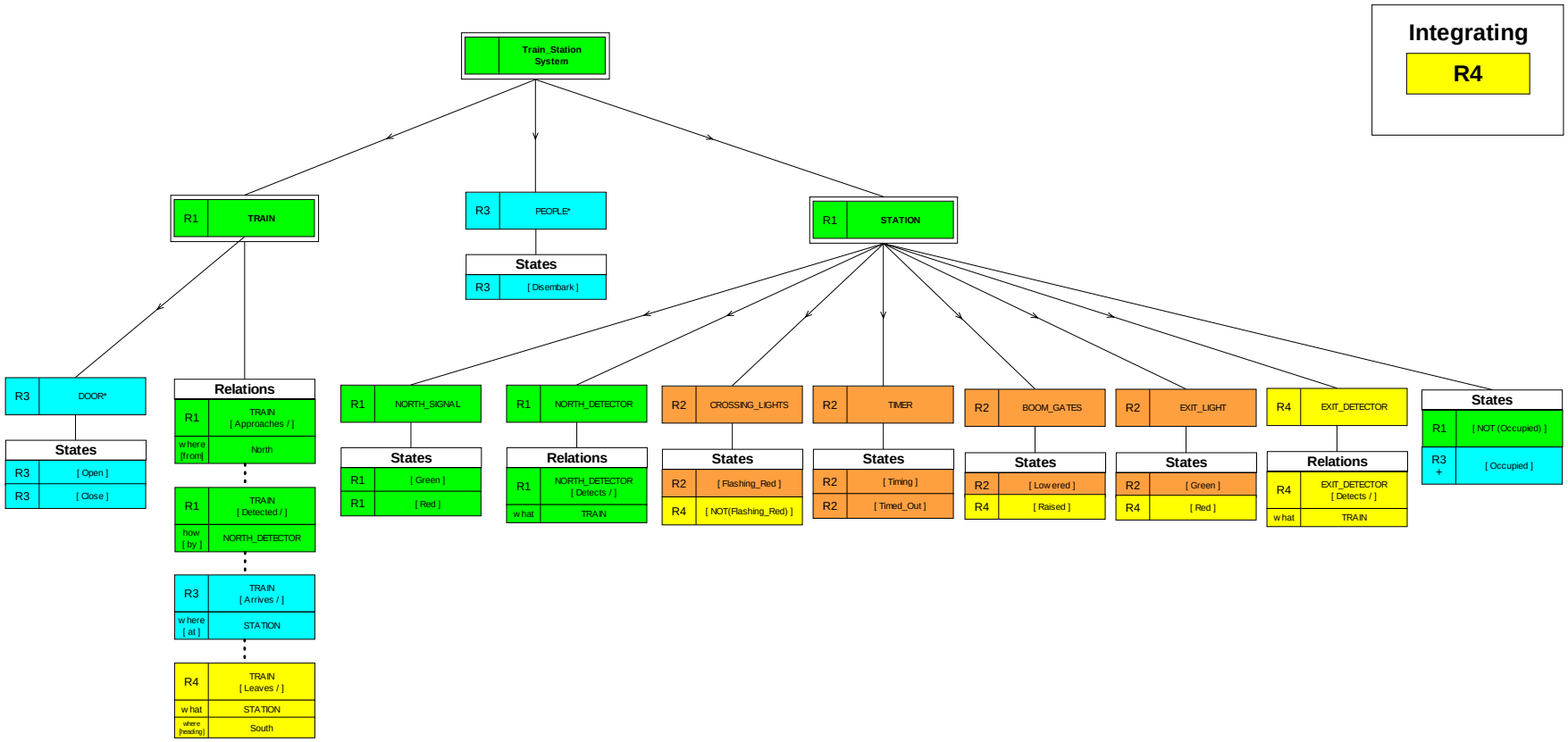


Composition Tree – Integrating R4

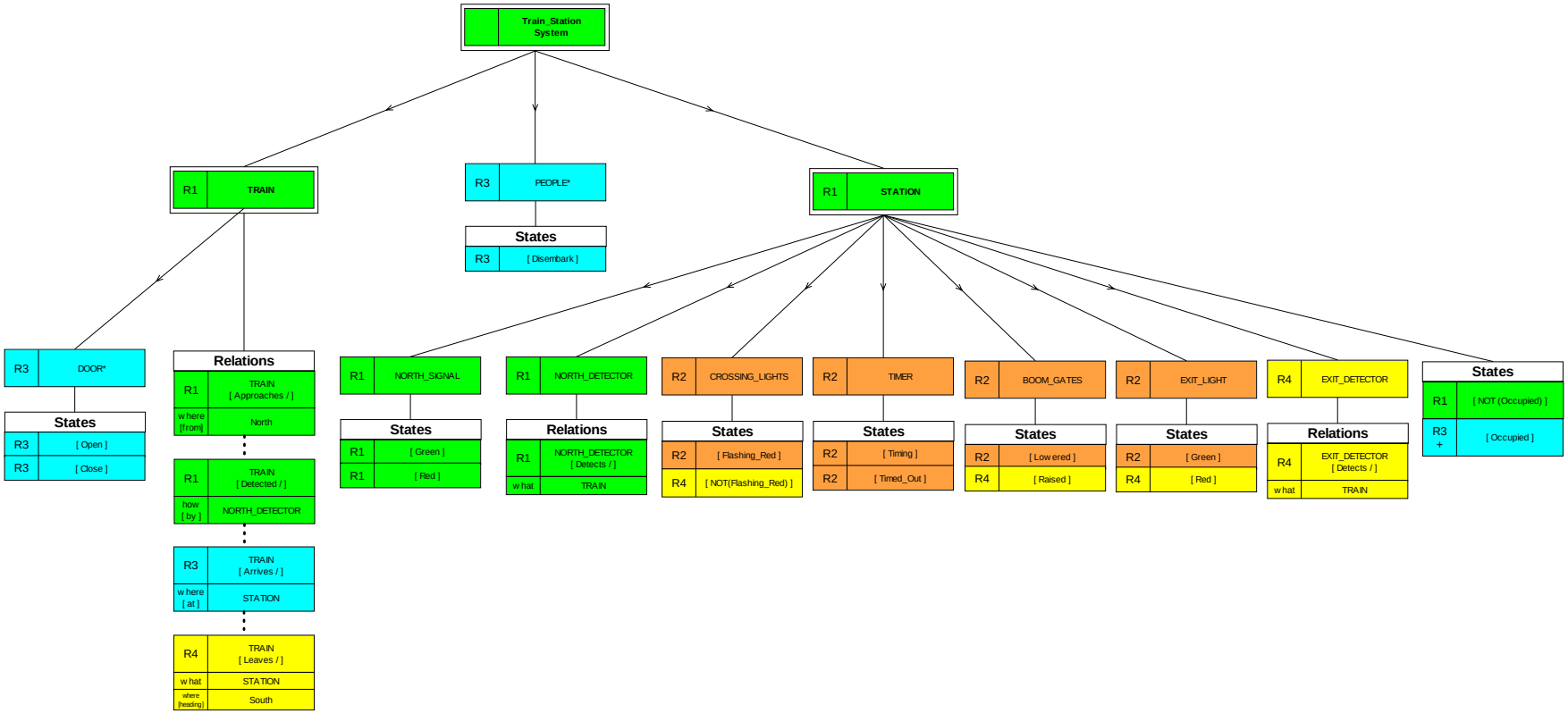
REQUIREMENT-R4

After the doors close the train may leave the station provided the exit light is green. When the train leaves the station, heading south, it is detected by the exit detector, which means the station is again not occupied. This causes the north signal to turn green and the exit light to turn red. When the exit detector detects the train , it also causes the boom gates to be raised and then the crossing lights to stop flashing red.

Composition Tree – Integrating R4



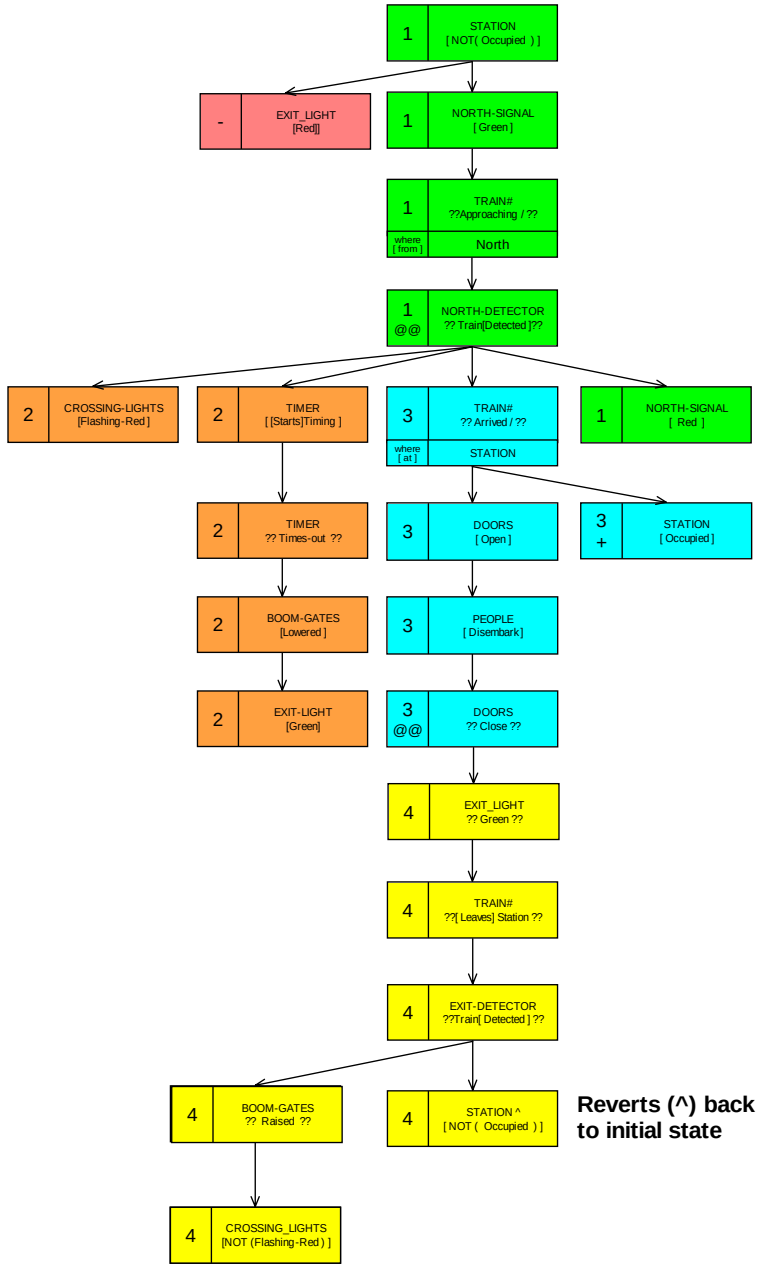
Composition Tree – ICT



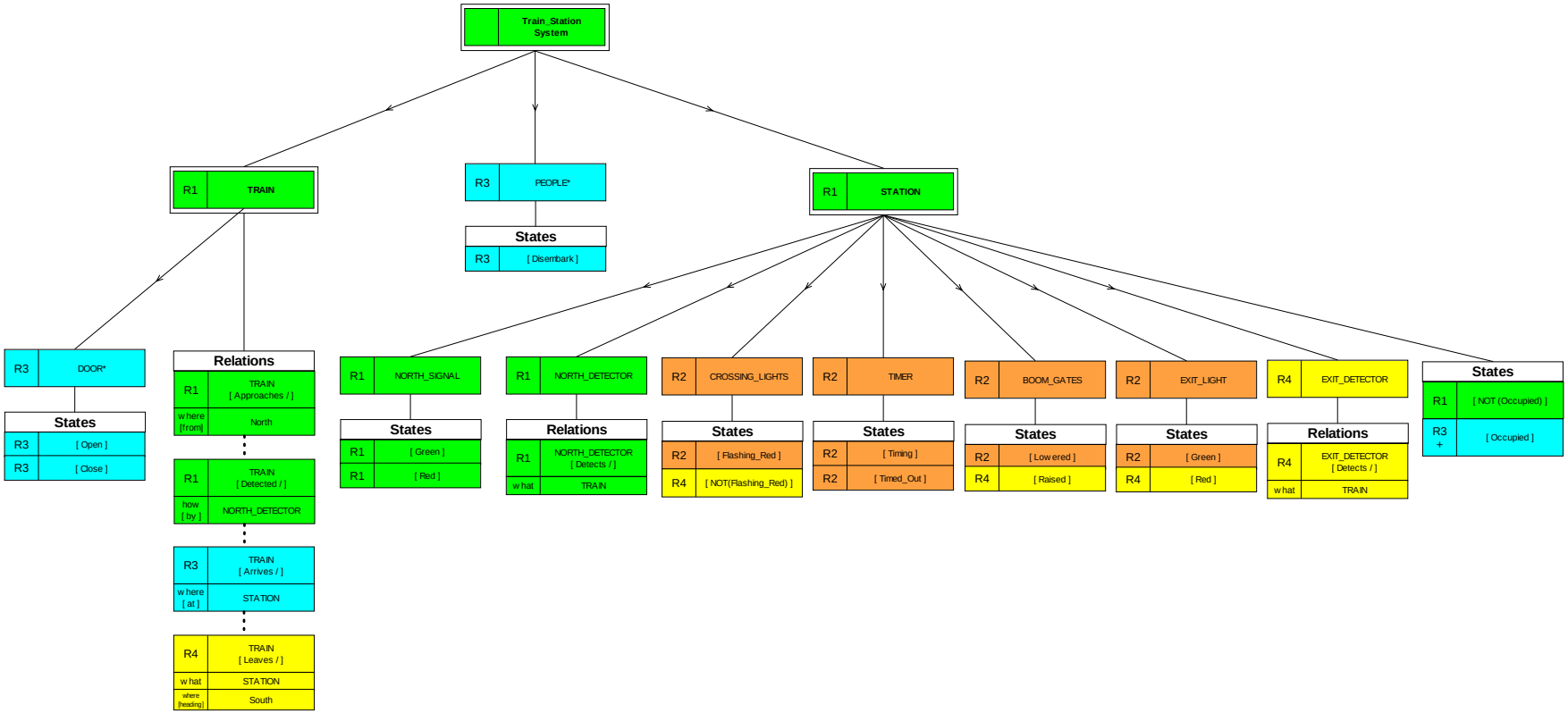
Comparison – IBT Versus ICT

Integrated Behavior Trees
versus
Integrated Composition Trees

Functional Requirements → IBT → DBT



Functional Requirements → ICT → DCT



Goal of Requirements Translation

- The goal of requirements translation is to formalize ALL the useful information in a set of requirements.

- Behavior Trees and Composition Trees usually go a long way towards achieving this goal.

- However behavior sometimes takes place on a “structure” – we use Structure Trees to formalize this info.

Structure Tree – Train Station System

- When we examine the behavior of the Train in the Train Station System we see that there is an implicit structure that the behavior is taking place on.

- The implicit fixed structural relationships between the entities in the system is not captured by the composition tree.

- We use a Structure Tree to capture this information.

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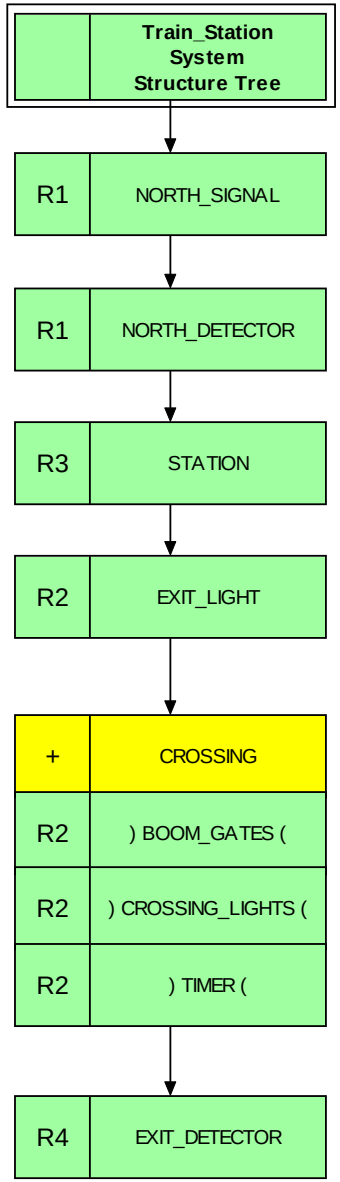
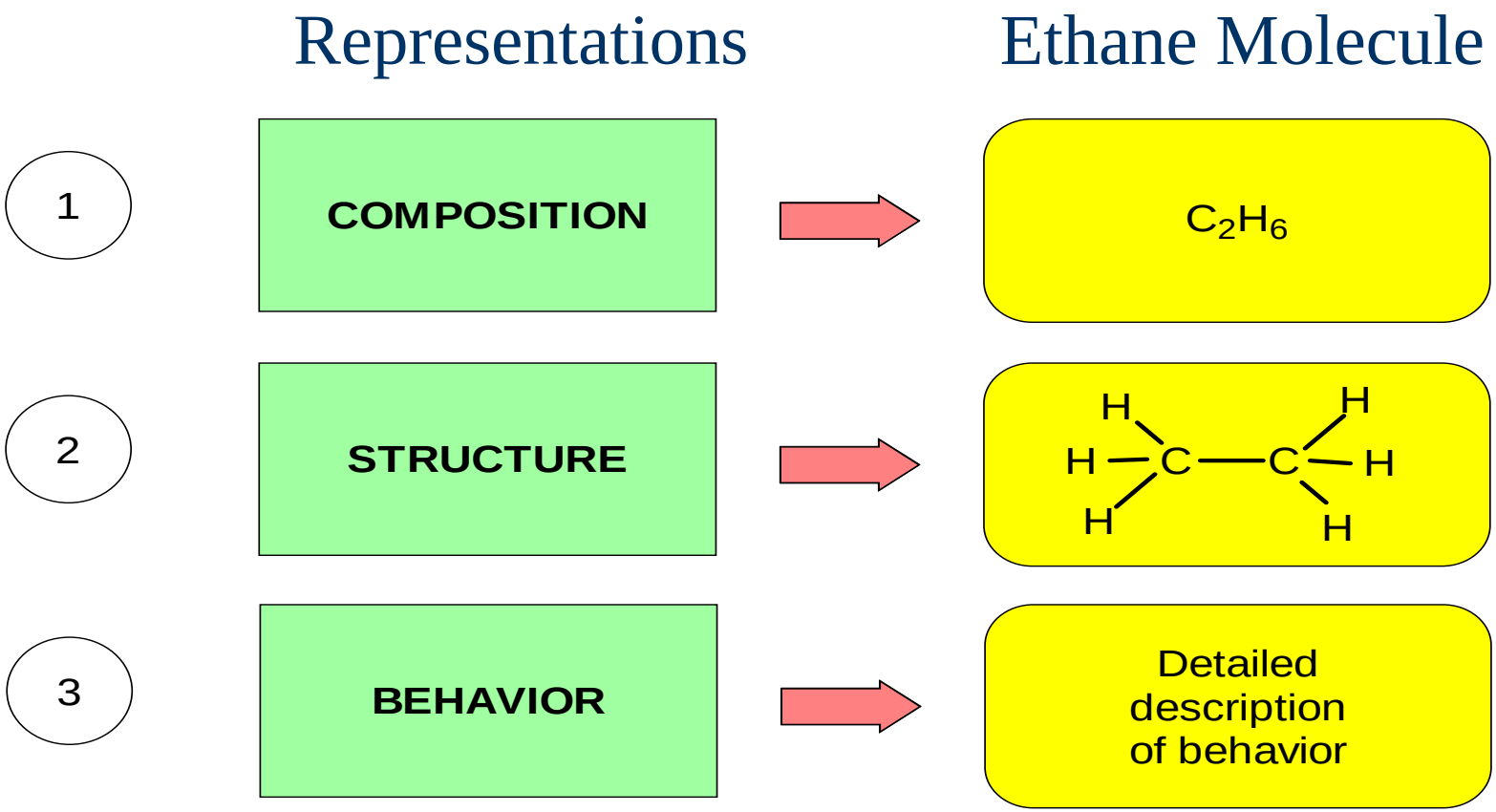
Integrated Structure Tree – IST



The Train as it traverses the structure of the system it encounters the entities in the system in the order specified in the integrated Structure Tree.

Recapping – Useful Information in Requirements

A Way to Look at Things - Chemistry



Revisiting Translation to Requirements Behavior Trees

R1 – Translated Behavior Tree

REQUIREMENT-R1

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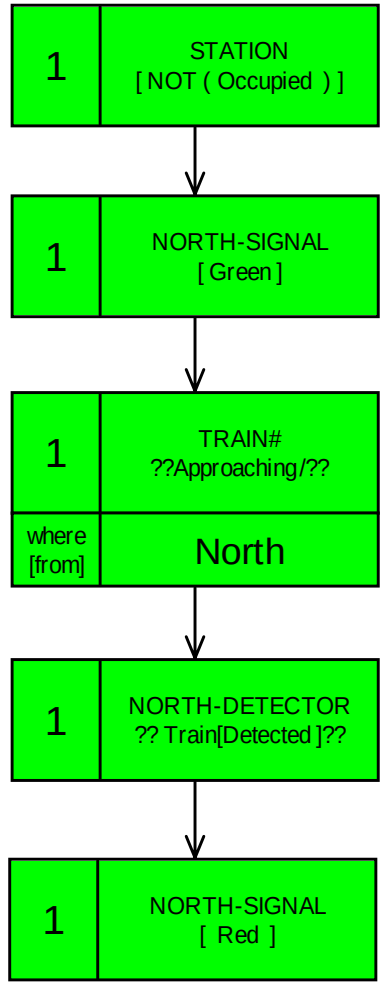
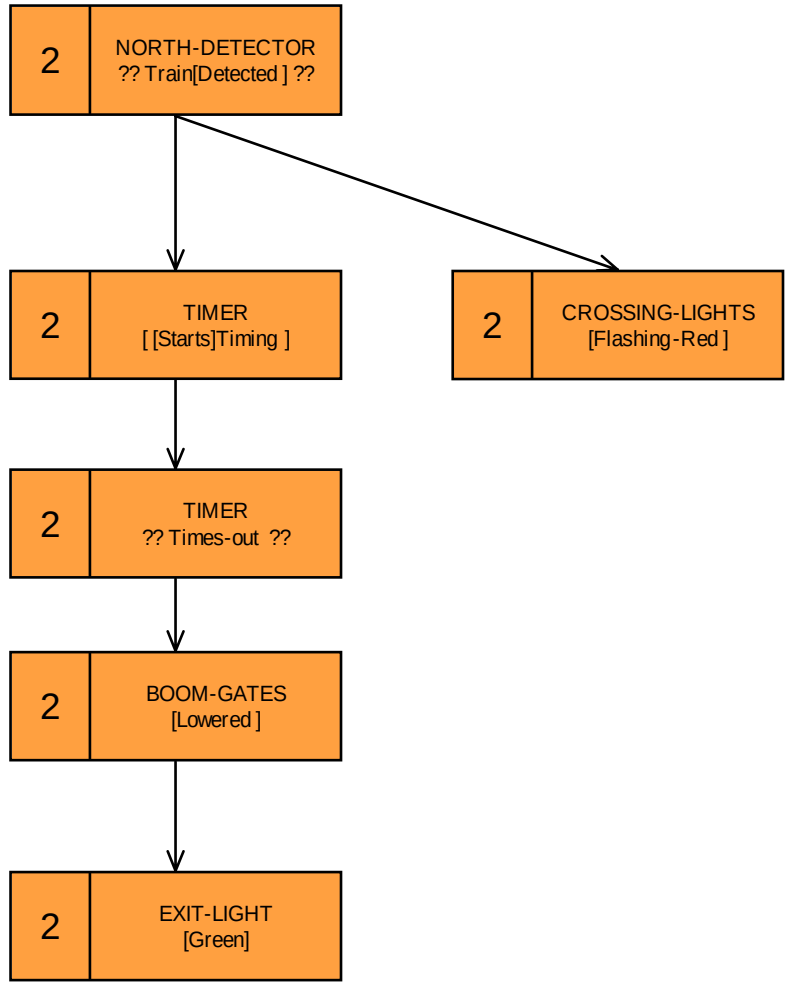


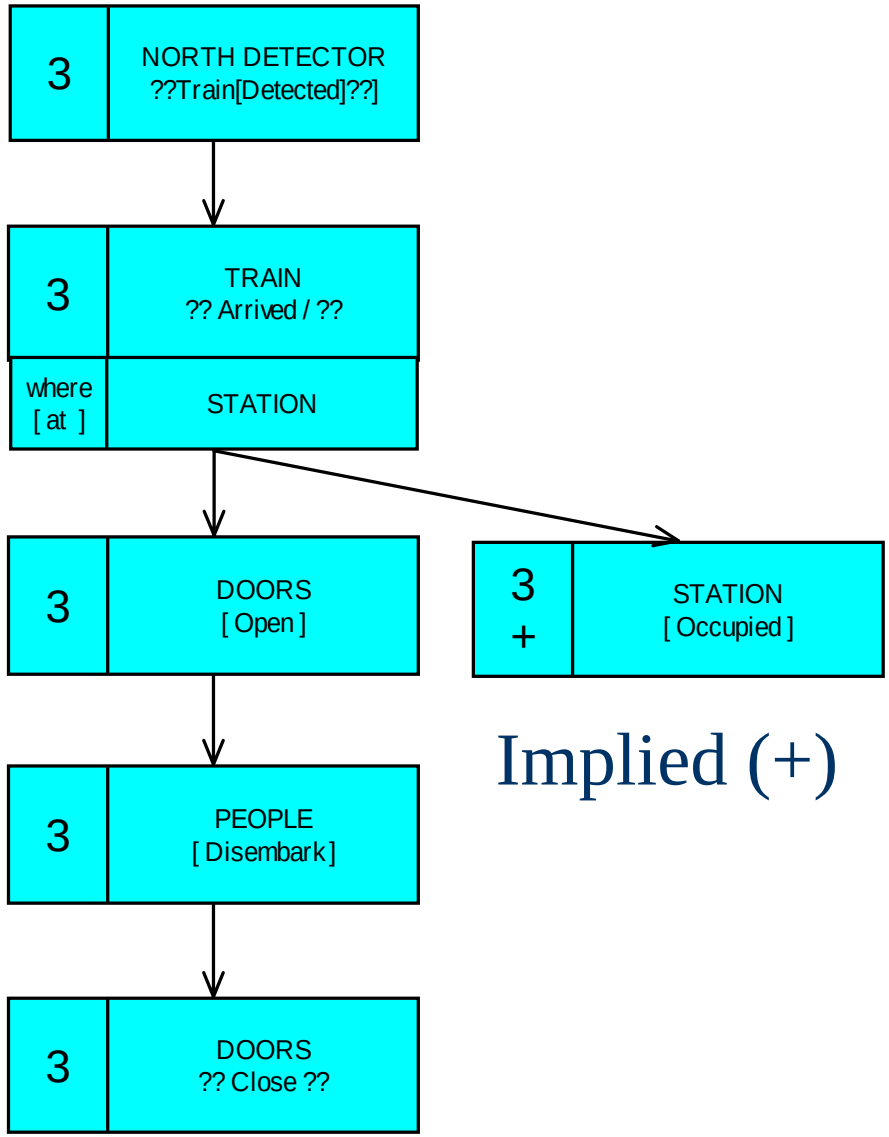
R2 – Translated Behavior Tree

REQUIREMENT-R2
When the north detector detects a train it causes the crossing lights to start flashing red. At the same time a timer starts timing and when it times out, it causes the boom gates to be lowered, after which the exit light turns green.



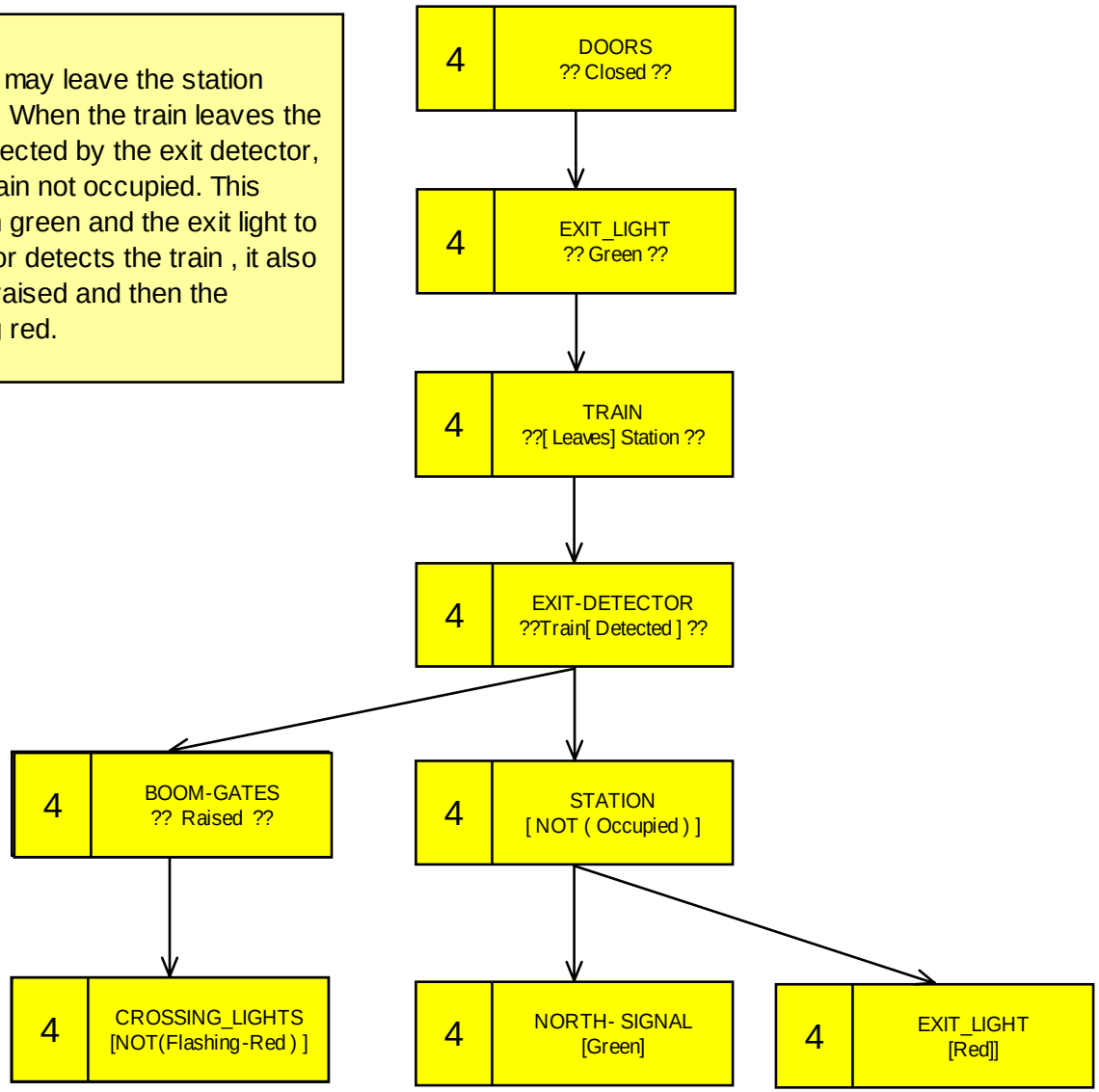
R3 – Translated Behavior Tree

REQUIREMENT-R3
After the train is detected by the north detector, it subsequently arrives at the station, the doors open, the people disembark, and then the doors close.



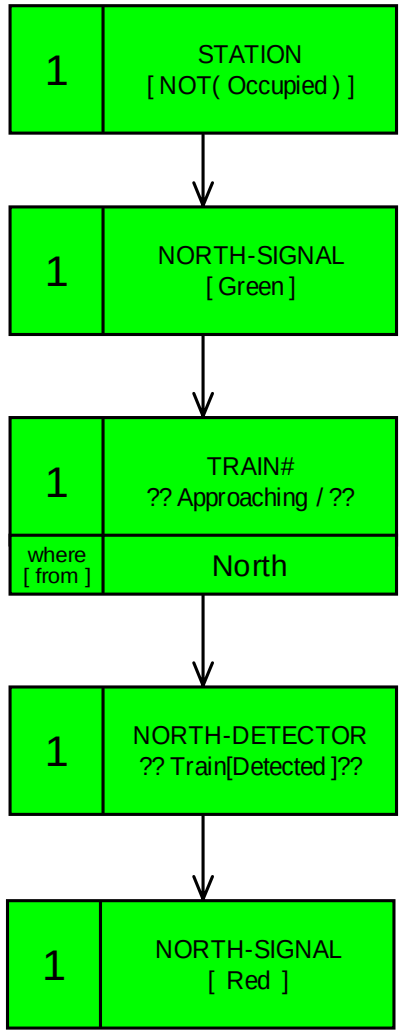
R4 – Translated Behavior Tree

REQUIREMENT-R4
After the doors close the train may leave the station provided the exit light is green. When the train leaves the station, heading south, it is detected by the exit detector, which means the station is again not occupied. This causes the north signal to turn green and the exit light to turn red. When the exit detector detects the train , it also causes the boom gates to be raised and then the crossing lights to stop flashing red.

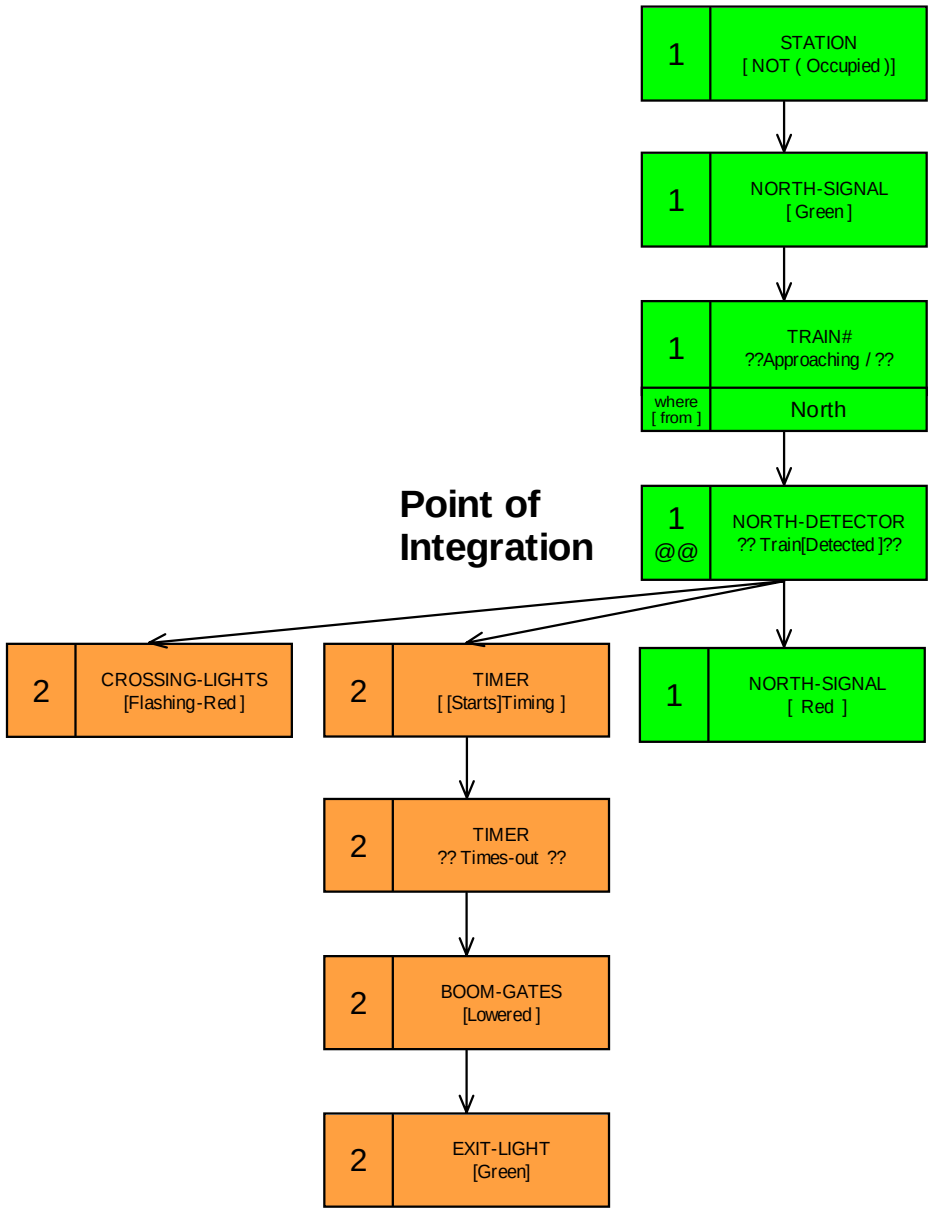


Integrating the Requirements Behavior Trees

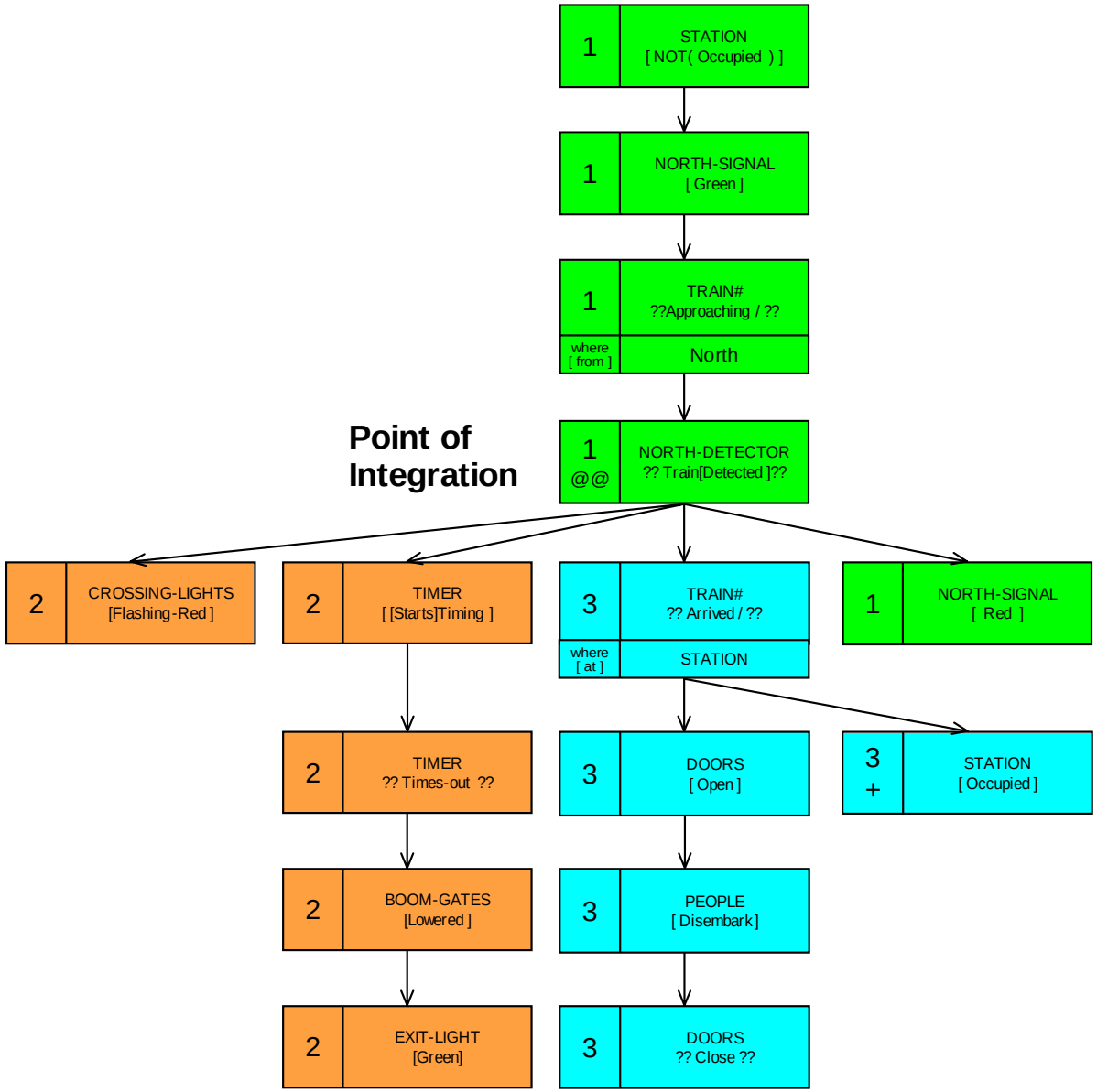
Integration – Base Case



Integration of R2 with R1



Integration of R3 into IBT



Integration of R4 into IBT