CLeaRSY
Safety Solutions Designer

AIX
LYON
PARIS
STRASBOURG
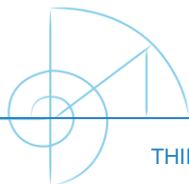
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Subject

Block Occupancy

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R&D Director

PART II

Block Occupancy

▶ This exercise is an example of how B can be used to develop a piece of software.

▶ It is based on a real example, although it has been simplified to fit the size of an exercise.

▶ Abstract iterators are used to simplify the modelling and implementations

Introduction: Train Movement Authority

▶ A train obtains permission to move forward in unoccupied sectors

▶ Based on the knowledge about the track occupancy

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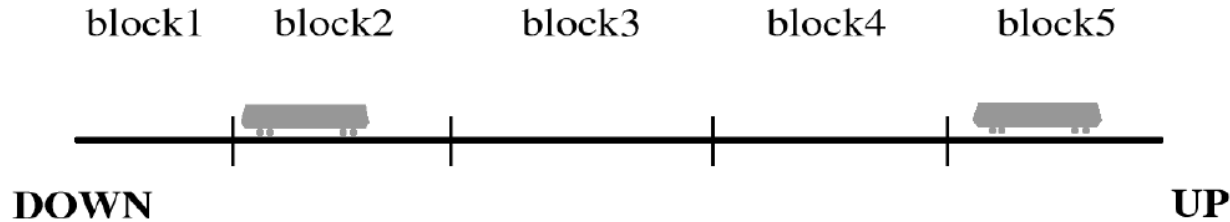
► This software controls a railroad line, divided into fixed blocks.

► The purpose of the functionality developed here is to manage safely block occupancy by trains, only by "sensing their presence"

▷ There is no direct communication with trains, no GPS.

Hackathon

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block1　　block2　　block3　　block4　　block5

DOWN　　　　　　　　　　　　　　　　　　　**UP**
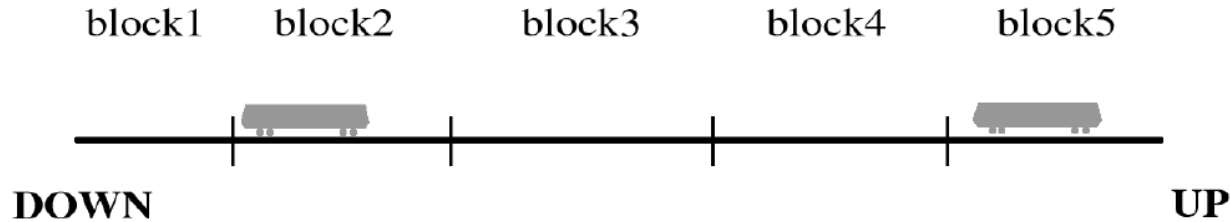
▶ A railroad line has two directions 'up' and 'down'.

▶ Each block may only be connected to one upward block and to one downward block. So the line is quite simple, since it has no switch.

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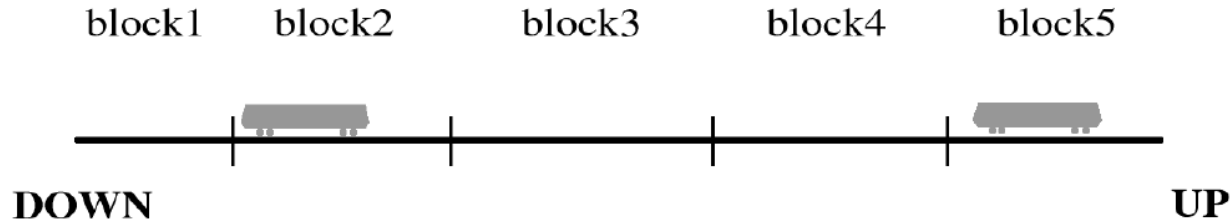
► The purpose of the functionality developed in this exercise is to establish safely, from the software point of view, which blocks are occupied by a train and which are free

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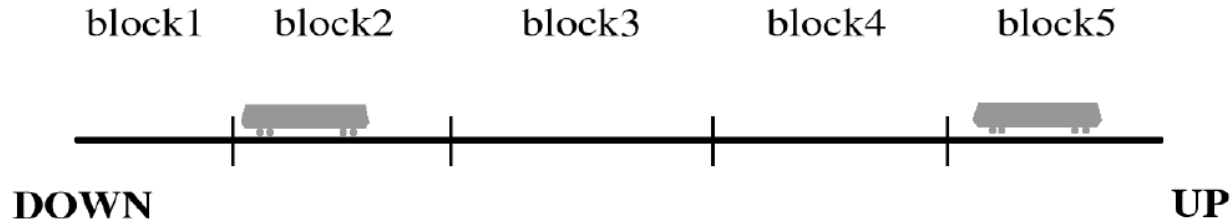
► Here are the basic principles given by the system analysis:

▷ For each block a detector located along the track called Trackside Detector (TD) is used to detect trains. It has the size of the track. It does not return the exact position of the train

▷ A train is equipped with an antenna located below the coach.

▷ When the antenna is above a trackside detector, a signal inside the detector is produced, so the train presence may be detected.

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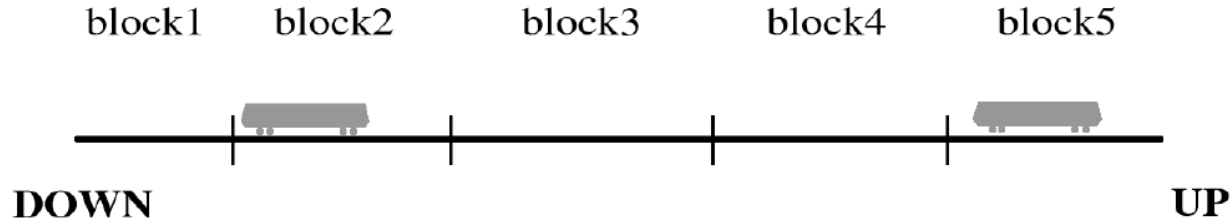
► Now building the software appears to be easy, since we just need to read for each block the state of its trackside detector.

► However, this solution raises two issues, both related with safety:
  ▷ The information given by a trackside detector is not accurate enough on the border of detectors.
  ▷ Trackside detectors (or antennas) may be faulty.

Subject: software development

down exit detector | down border detector | block | up border detector | up exit detector

Trackside Detector
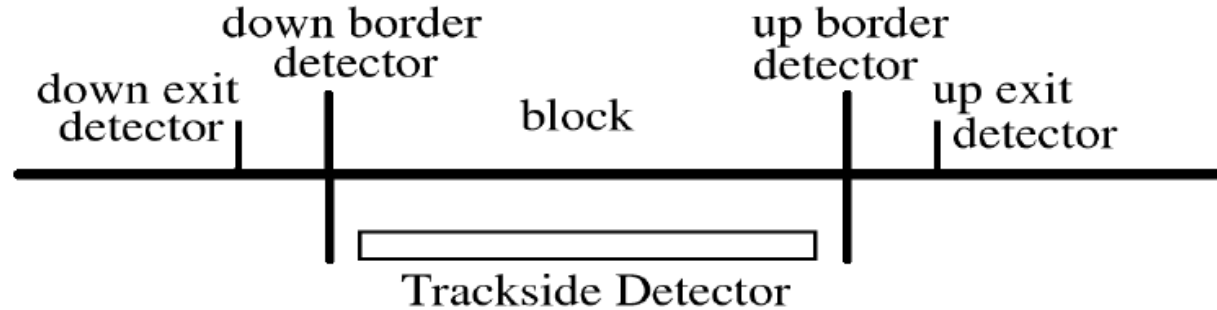
► To overcome those issues, the following elements are added to the system specification.

▷ A Border Detector (BD)

▷ Exit Detectors (ED)

▷ The Trackside Detector Loss (TDL) alarm

Hackathon

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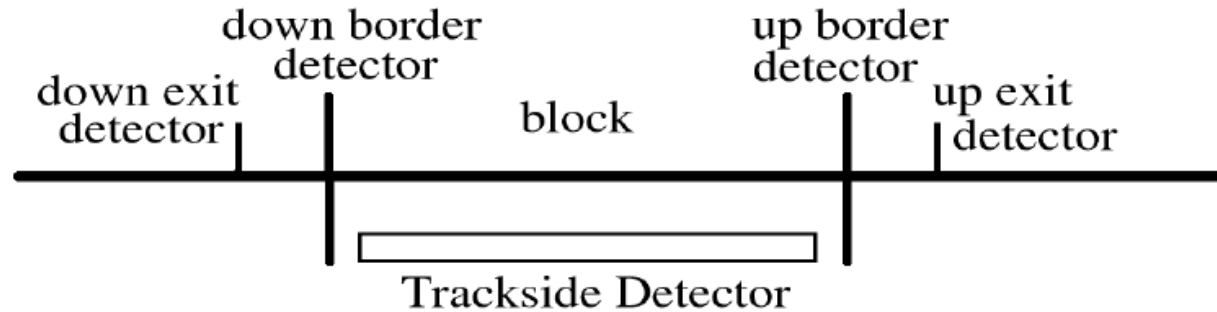
► A Border Detector (BD) – detect absence/presence

▷ used at each borderline between two blocks to achieve accurate block occupancy detection.

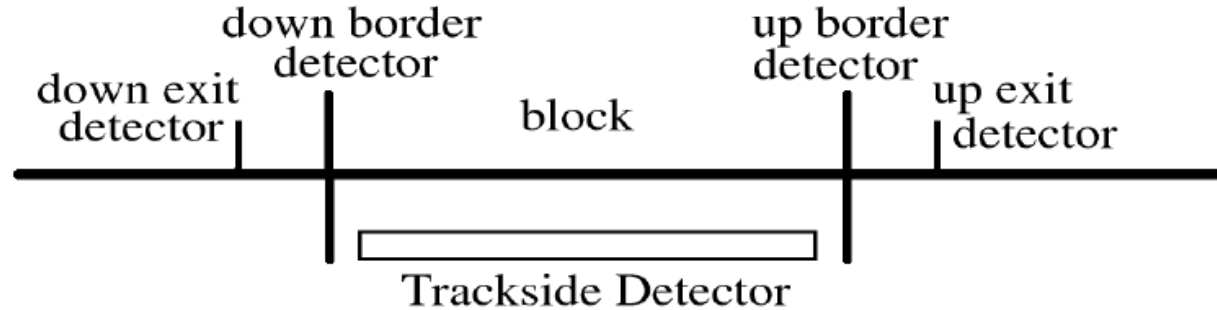▷ When a block trackside detector or border detector is occupied, then the block is considered to be occupied.

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down exit detector — down border detector — block — up border detector — up exit detector

Trackside Detector
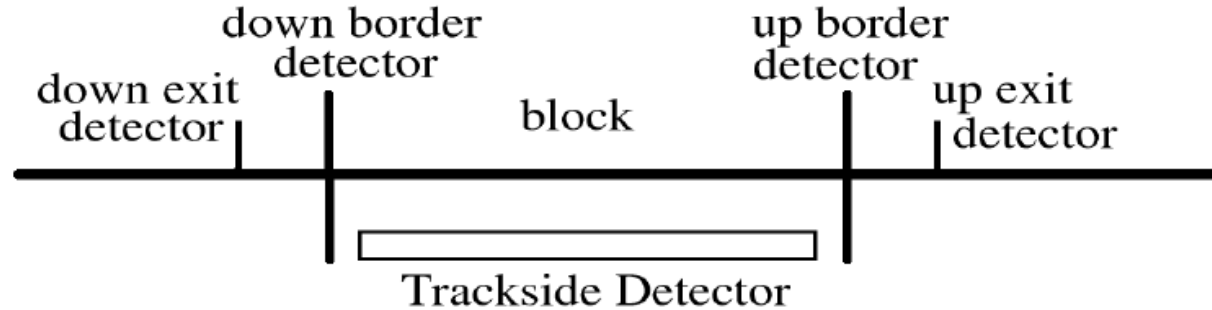
▶ **Exit Detectors (ED)** – detect absence/presence

▷ located after a block border (in the upward block or in the downward block)

▷ used to detect trains leaving the block.

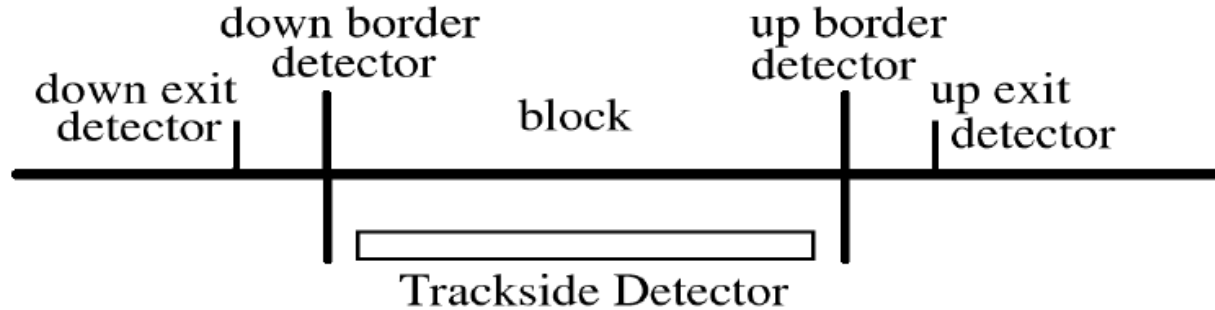▷ A block is released on the falling edge of one of its exit detector.

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down exit detector • down border detector • up border detector • up exit detector • block • Trackside Detector

▶ **The Trackside Detector Loss (TDL) alarm**

▷ set for a block when a trackside detector inconsistency happens.

▷ Such an inconsistency happens when a block trackside detector is free although it should be occupied.

▷ When a TDL alarm is set, the procedure to release it requires that an operator at the command center send back an alarm acknowledgement.

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down exit detector — down border detector — block — up border detector — up exit detector — Trackside Detector

► To avoid unjustified TDL alarm due to the lack of accuracy of trackside detectors, blocks may be masked for TDL alarm when trains are located near a block border.

Models

hackathon-2024 / **block** /

TProver adding block

Name	Last commit message
..	
block_occupancy.mch	adding block
block_occupancy.pmm	adding block
block_occupancy_seq.mch	adding block
block_occupancy_seq_i.imp	adding block
block_occupancy_seq_i.pmm	adding block
configuration.mch	adding block
inputs.mch	adding block
main.mch	adding block
main_i.imp	adding block

https://github.com/CLEARSY/hackathon-2024

B Project Architecture

configuration

main — ob, tdla, obd, otd
main_i

obd, otd — inputs

block_occupancy_seq — ob, tdla
block_occupancy_seq_i

block_occupancy — ob, mb, tdla

B Project Architecture

configuration

TO COMPLETE
main — ob, tdla, obd, otd
main_i

obd, otd — inputs

TO COMPLETE
block_occupancy_seq — ob, tdla
block_occupancy_seq_i
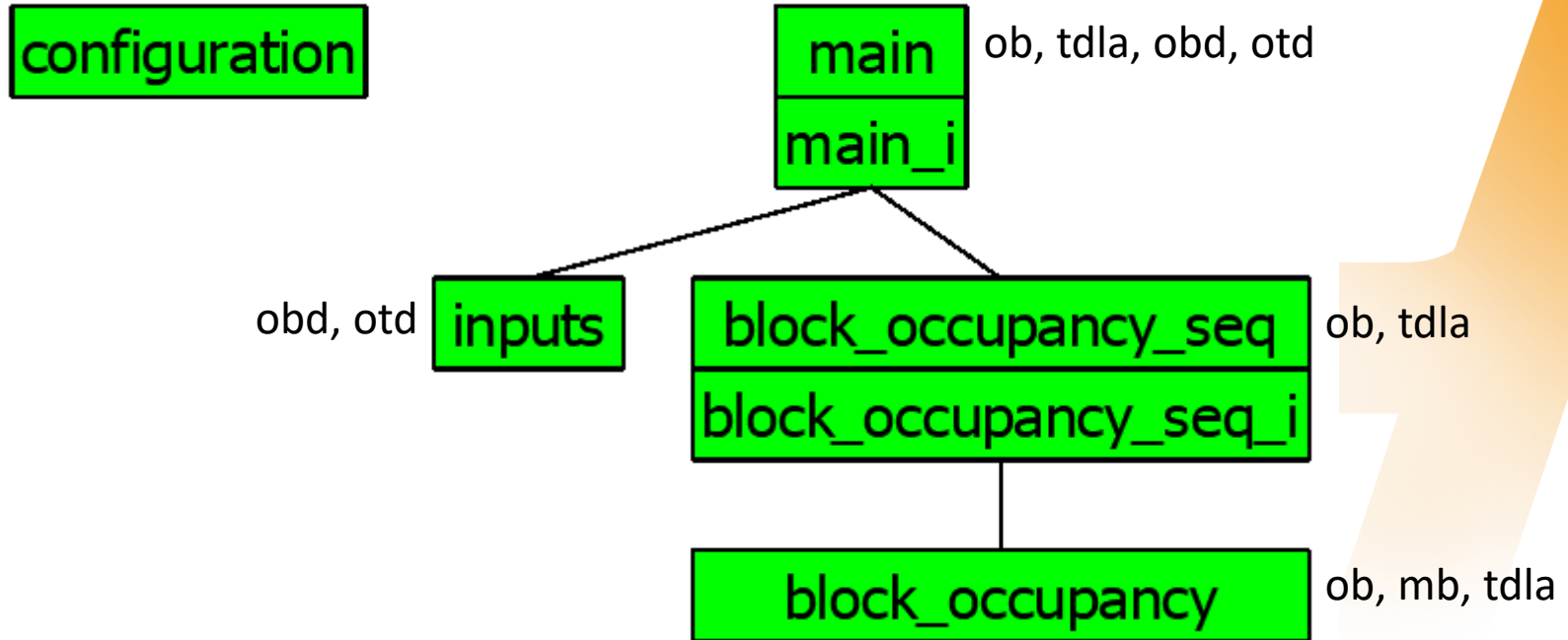
TO SPECIFY
block_occupancy — ob, mb, tdla
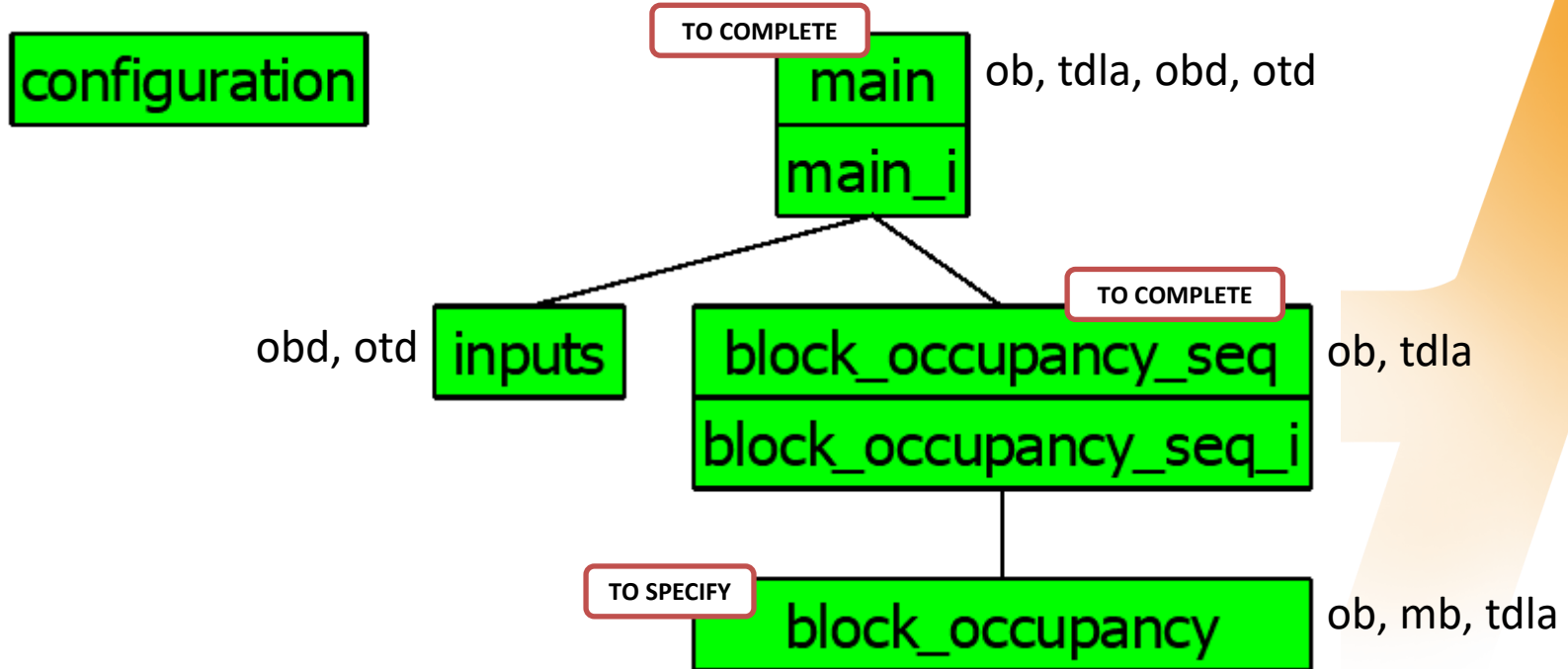
Activities

▶ Complete main.mch

▶ Complete block_occupancy_seq & block_occupancy_seq_i

▶ In block_occupancy

▷ specify unmask blocks

▷ specify release_tdl_alarm

▷ specify set_tdl_alarm

▷ specify mask_blocks

▷ specify release_blocks

▷ specify occupy_blocks

Ranking

Block occupancy		24
	complete main	2
	complete block_occupancy_seq	2
	specify unmask blocks	4
	specify release_tdl_alarm	2
	specify set_tdl_alarm	2
	specify mask_blocks	2
	specify release_blocks	4
	specify occupy_blocks	2
	model TC, POG, PR, B0	2
	explanation	2

occupy_blocks

► This function manages occupied blocks.

► Blocks which do not become occupied remain unchanged.

► A block is occupied when

▷ one of its border detector is occupied

▷ or when its trackside detector is occupied.

$$ob := ob \cup d\_bd2b[obd] \cup otd$$

release_tdl_alarm

► This function releases Trackside Detector Loss (TDL) alarm.

► When a TDL alarm acknowledgment is received from the Control Center, then TDL alarm is released for all blocks.

► If no TDL alarm acknowledgment is received then TDL alarm remains unchanged.

```
IF  cc_tdl_ack = TRUE
THEN
        tdla := {}
END
```