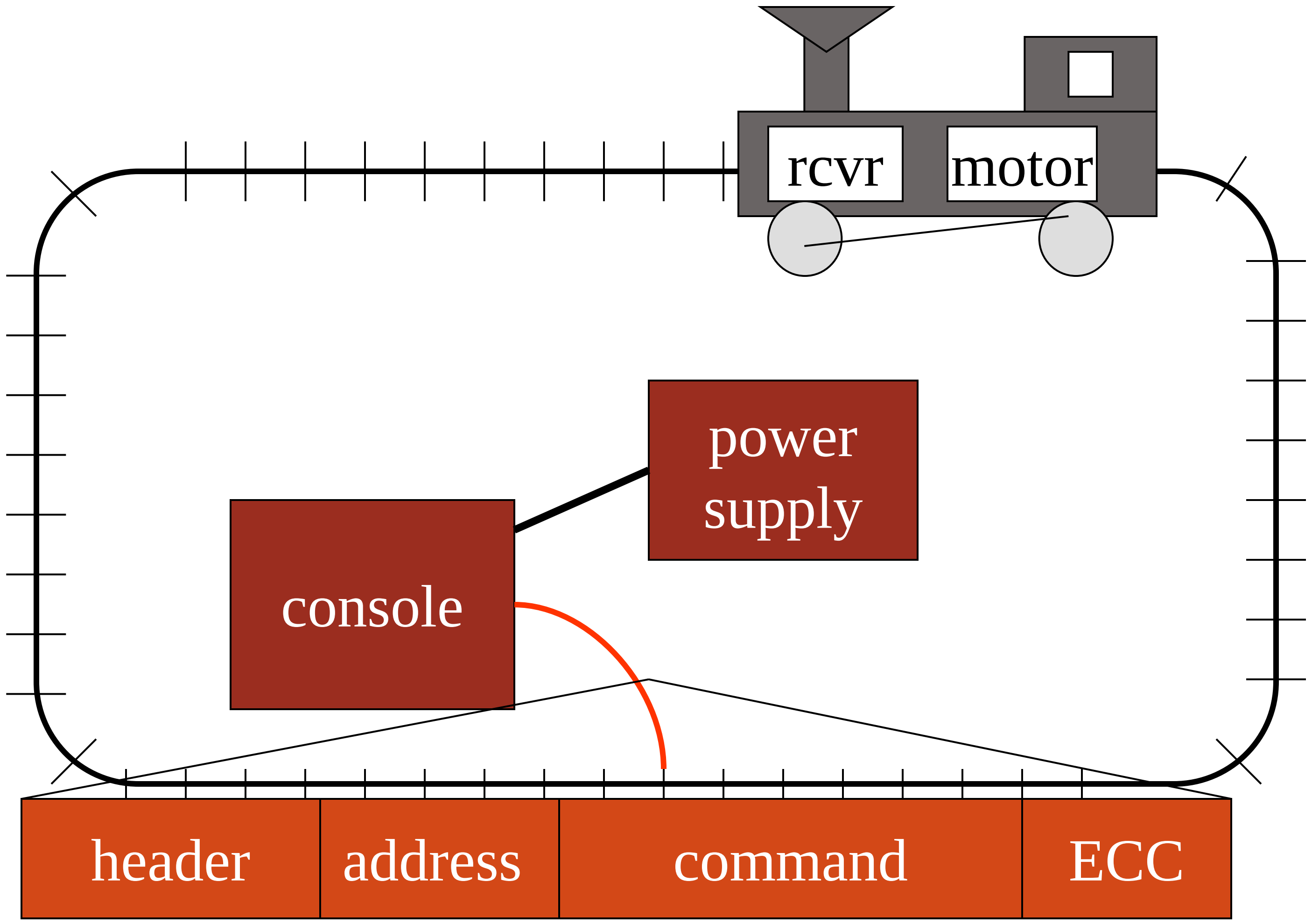
Example: Model Train Controller

Purposes of example:

Follow a design through several levels of abstraction.

Gain experience with UML.

Model train setup



Requirements

- Console can control 8 trains on 1 track.
- Throttle has at least 63 levels.
- Inertia control adjusts responsiveness with at least 8 levels.
- Emergency stop button.
- Error detection scheme on messages.

Requirements form

name	model train controller
purpose	control speed of <= 8 model trains
inputs	throttle, inertia, emergency stop, train #
outputs	train control signals
functions	set engine speed w. inertia; emergency stop
performance	can update train speed at least 10 times/sec
manufacturing cost	$50
power	wall powered
physical size/weight	console comfortable for 2 hands; < 2 lbs.

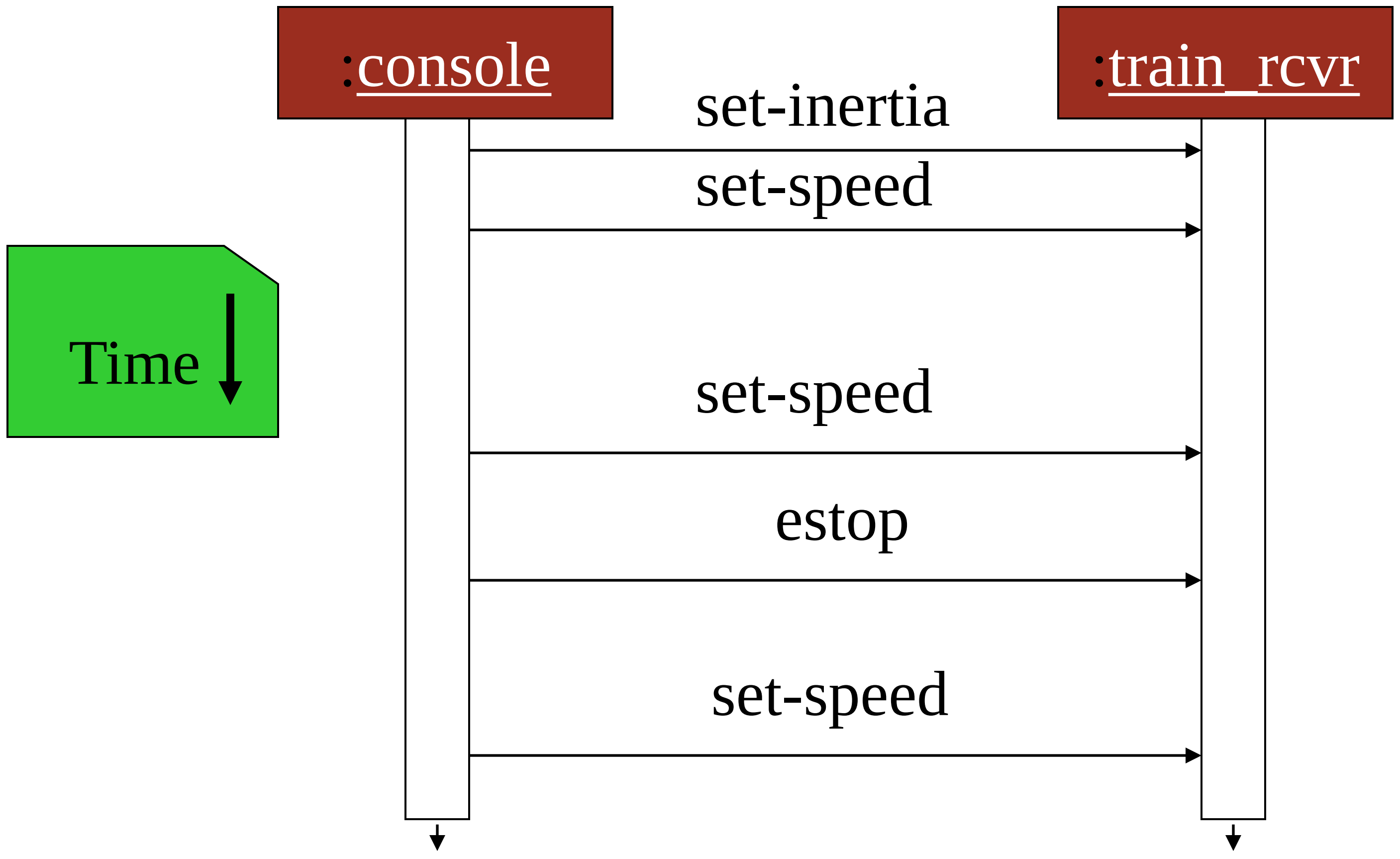
Conceptual specification

- Before we create a detailed specification, we will make an initial, simplified specification.
  - Gives us practice in specification and UML.
  - Good idea in general to identify potential problems before investing too much effort in detail.

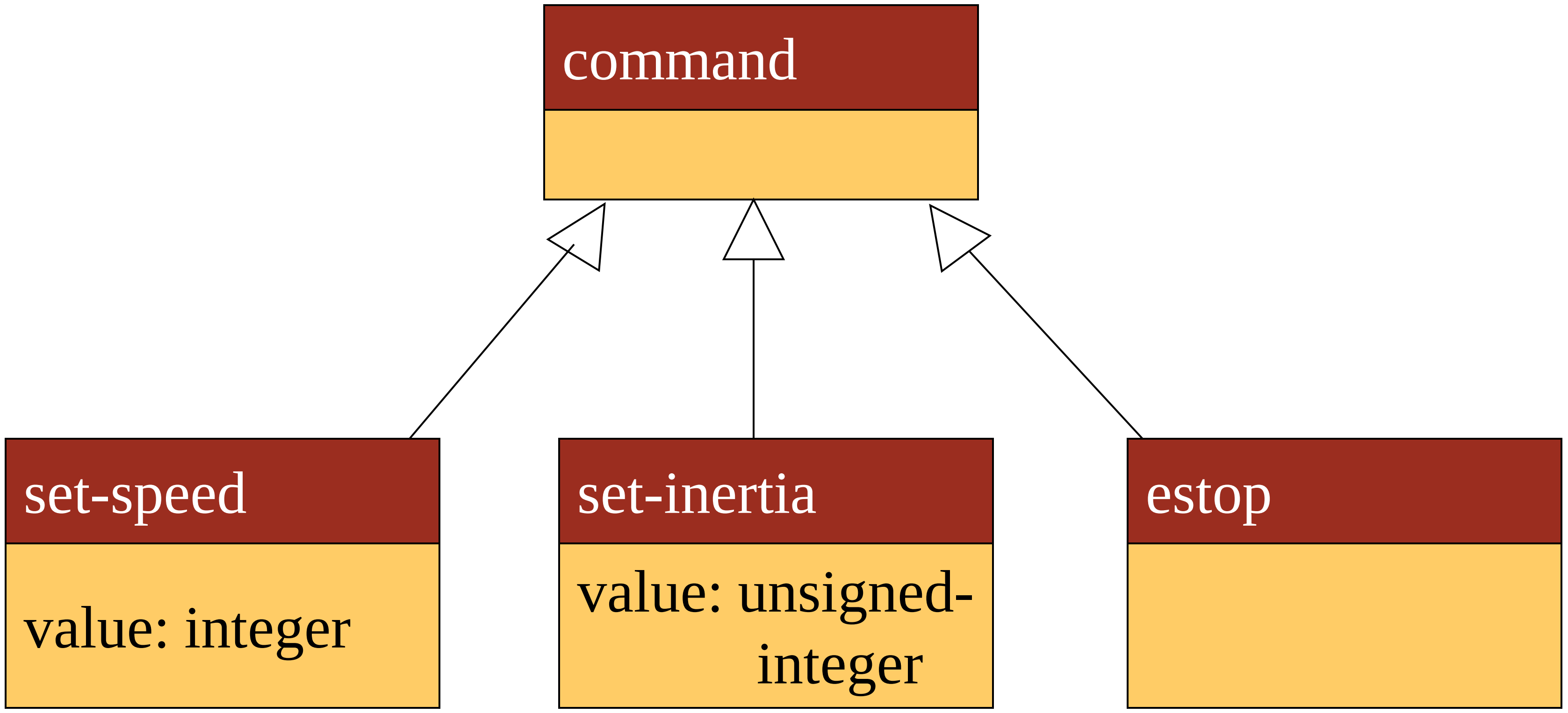
Basic system commands

command name	parameters
set-speed	speed (positive/negative)
set-inertia	inertia-value (non-negative)
estop	none

Typical control sequence



Message classes



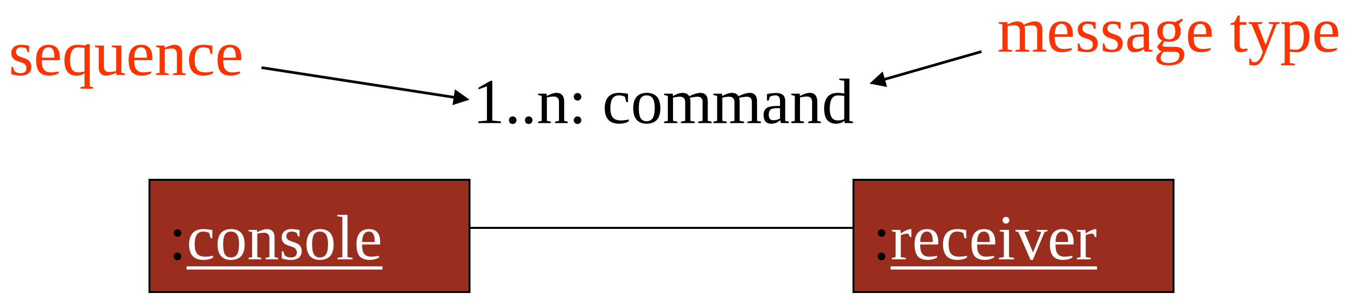
Roles of message classes

- Implemented message classes derived from message class.
  - Attributes and operations will be filled in for detailed specification.
- Implemented message classes specify message type by their class.
  - May have to add type as parameter to data structure in implementation.

Subsystem collaboration diagram

Shows relationship between console and receiver

(ignores role of track):



System structure modeling

- Some classes define non-computer components.
  - Denote by *name.
- Choose important systems at this point to show basic relationships.

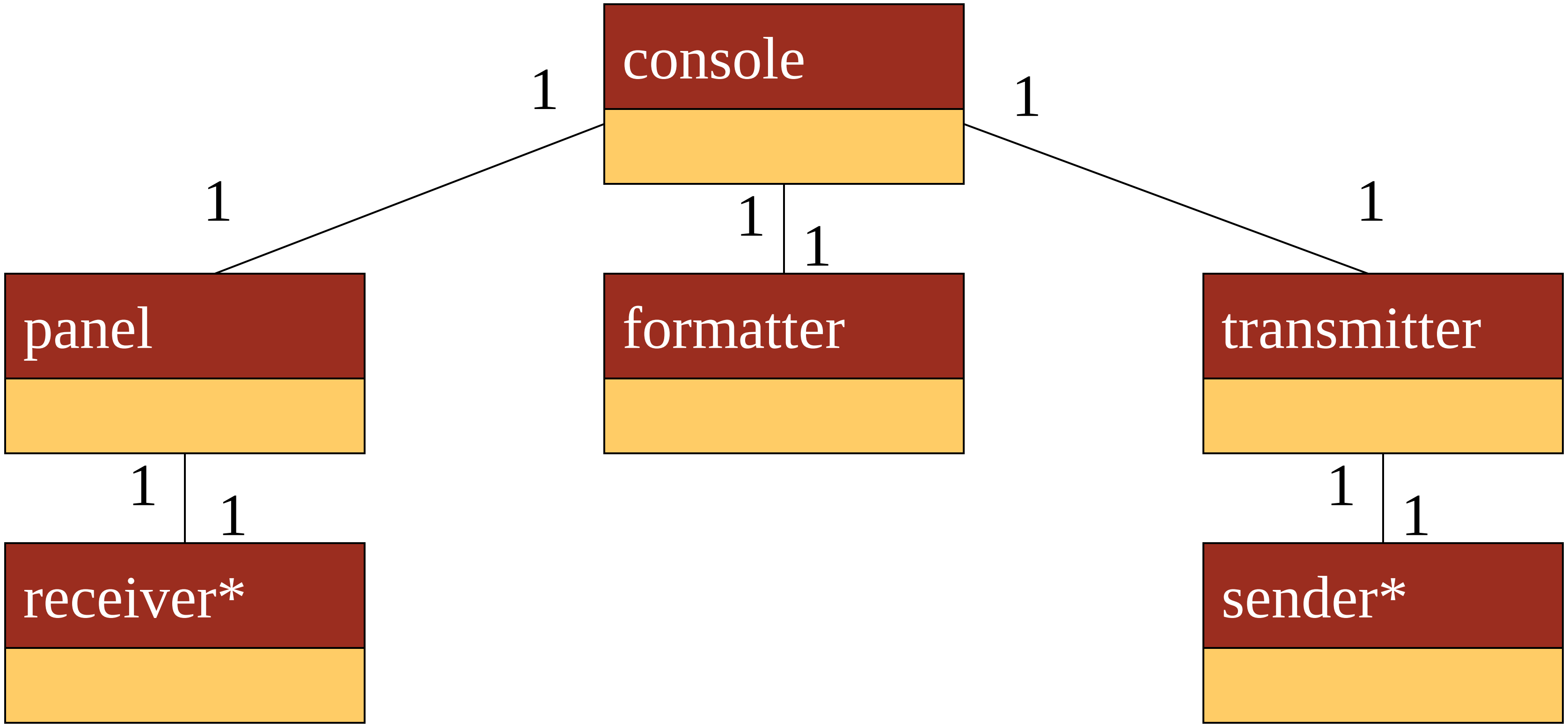
Major subsystem roles

- Console:
  - read state of front panel;
  - format messages;
  - transmit messages.
- Train:
  - receive message;
  - interpret message;
  - control the train.

Console class roles

- panel: describes analog knobs and interface hardware.
- formatter: turns knob settings into bit streams.
- transmitter: sends data on track.

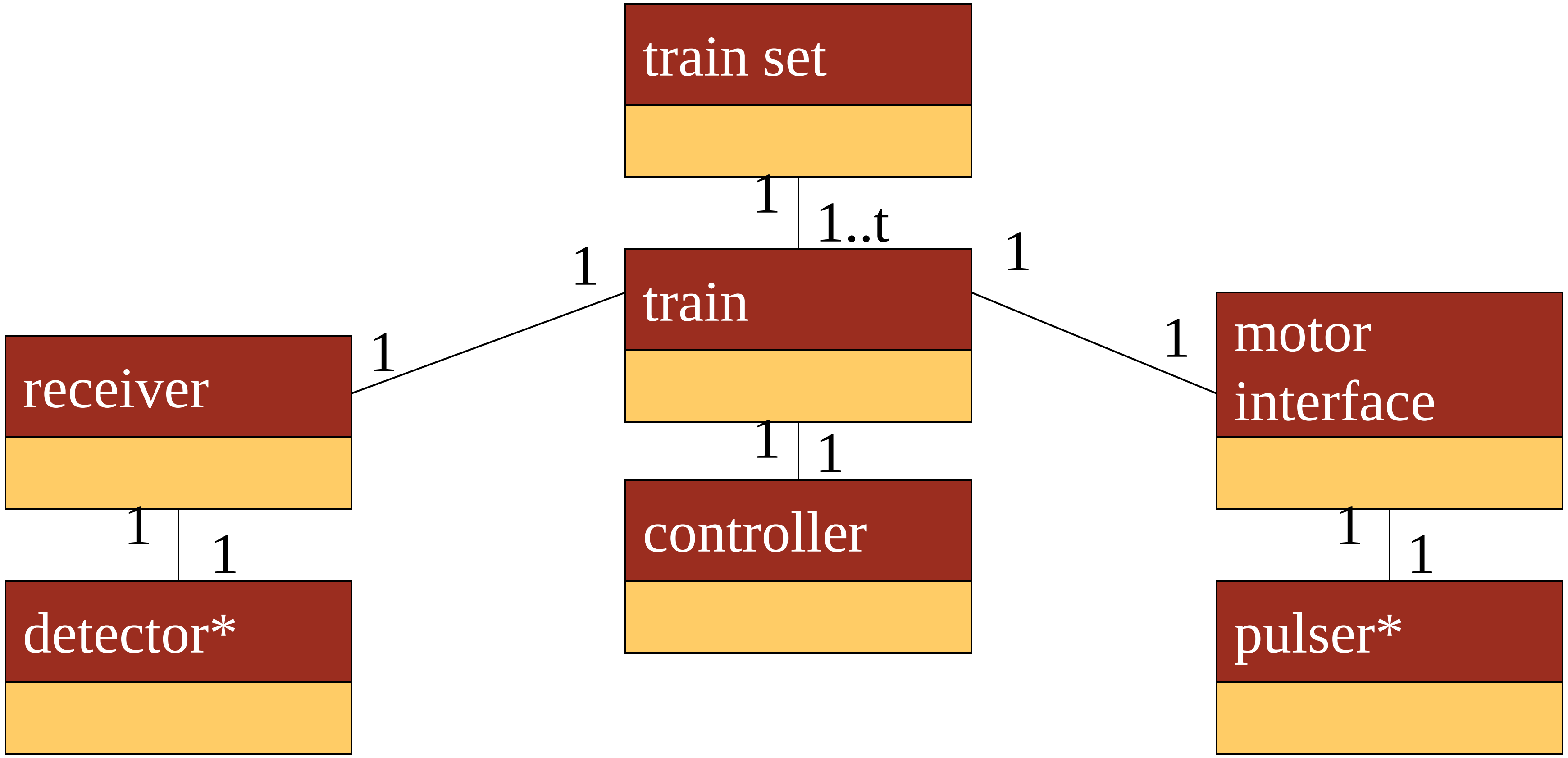
Console system classes



Train class roles

- receiver: digitizes signal from track.
- controller: interprets received commands and makes control decisions.
- motor interface: generates signals required by motor.

Train system classes

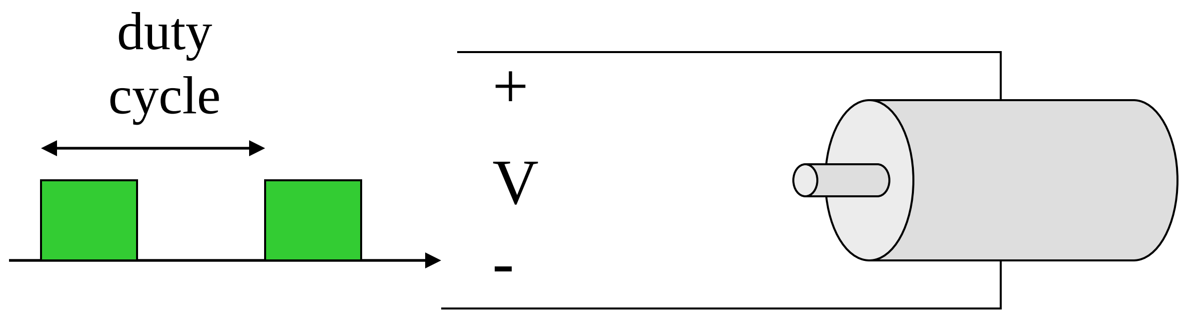


Detailed specification

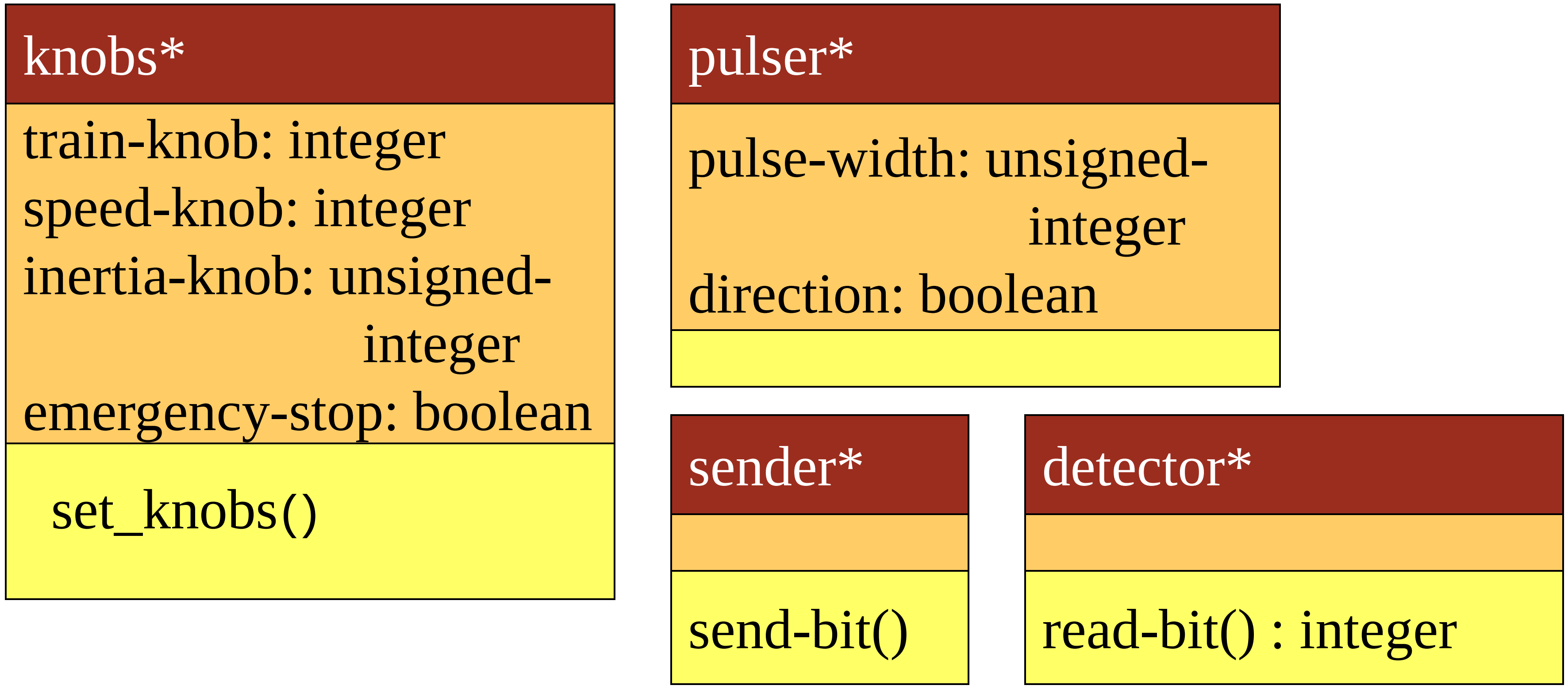
- We can now fill in the details of the conceptual specification:
  - more classes;
  - behaviors.
- Sketching out the spec first helps us understand the basic relationships in the system.

Train speed control

- Motor controlled by pulse width modulation:



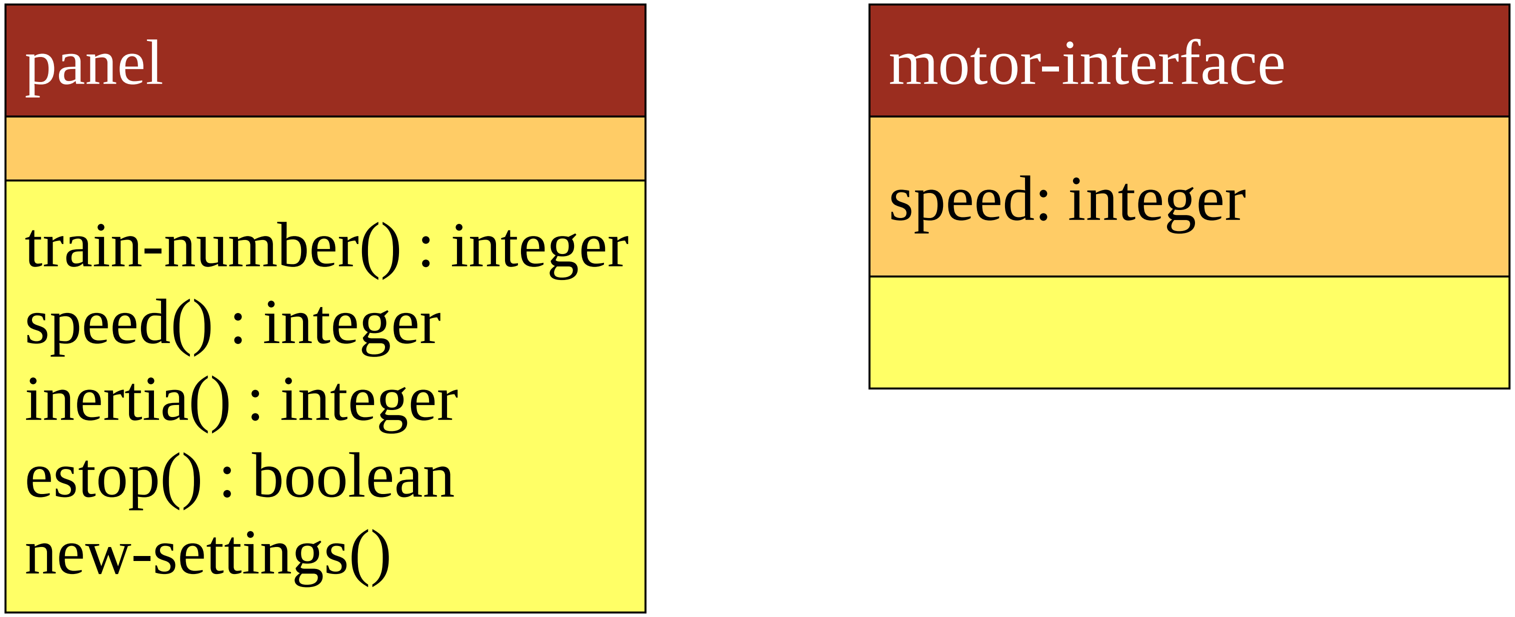
Train system analog physical object classes



Class descriptions

- panel class defines the controls.
  - new-settings() behavior reads the controls.
- motor-interface class defines the motor speed held as state.

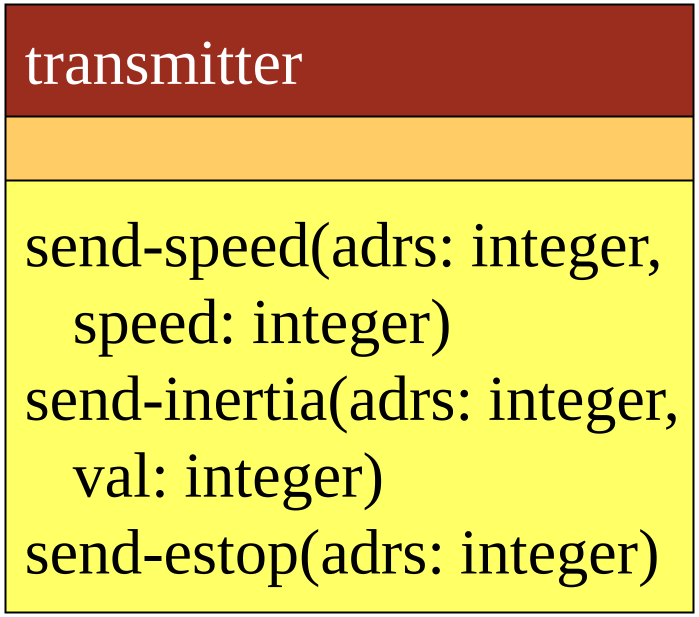
Panel and motor interface classes



Class descriptions

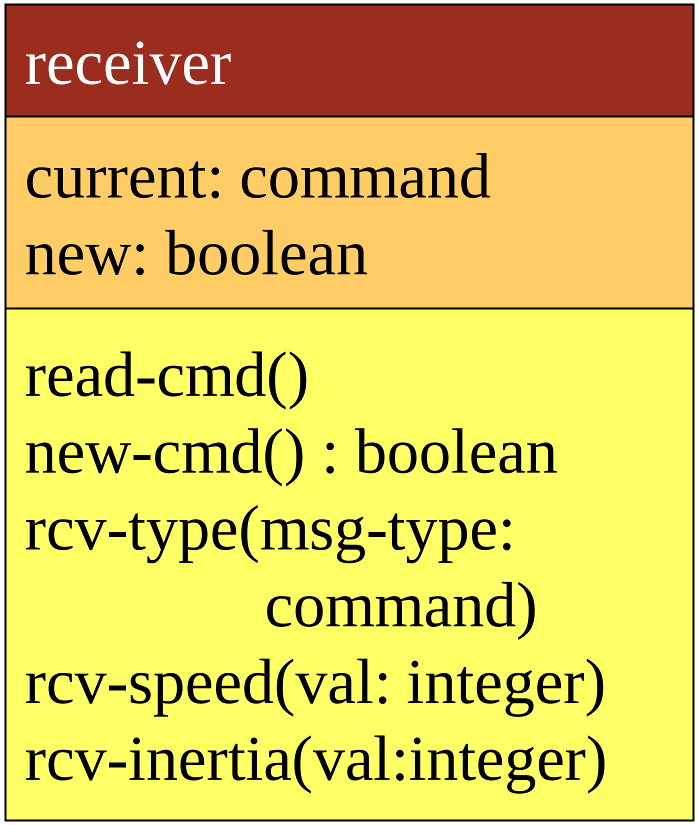
- transmitter class has one behavior for each type of message sent.
- receiver function provides methods to:
  - detect a new message;
  - determine its type;
  - read its parameters (estop has no parameters).

Transmitter and receiver classes



```
transmitter

send-speed(adrs: integer,
   speed: integer)
send-inertia(adrs: integer,
   val: integer)
send-estop(adrs: integer)
```



```
receiver
current: command
new: boolean
read-cmd()
new-cmd() : boolean
rcv-type(msg-type:
                command)
rcv-speed(val: integer)
rcv-inertia(val:integer)
```

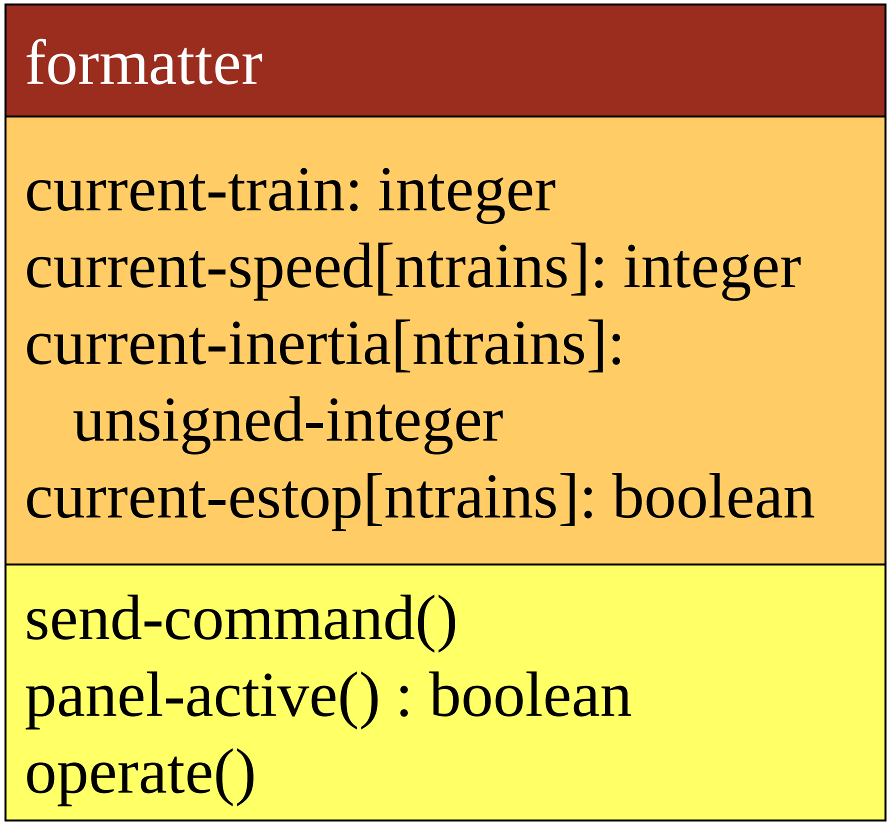
Formatter class description

- Formatter class holds state for each train, setting for current train.
- The operate() operation performs the basic formatting task.

Control input cases

- Use a soft panel to show current panel settings for each train.
- Changing train number:
  - must change soft panel settings to reflect current train’s speed, etc.
- Controlling throttle/inertia/estop:
  - read panel, check for changes, perform command.

Formatter class

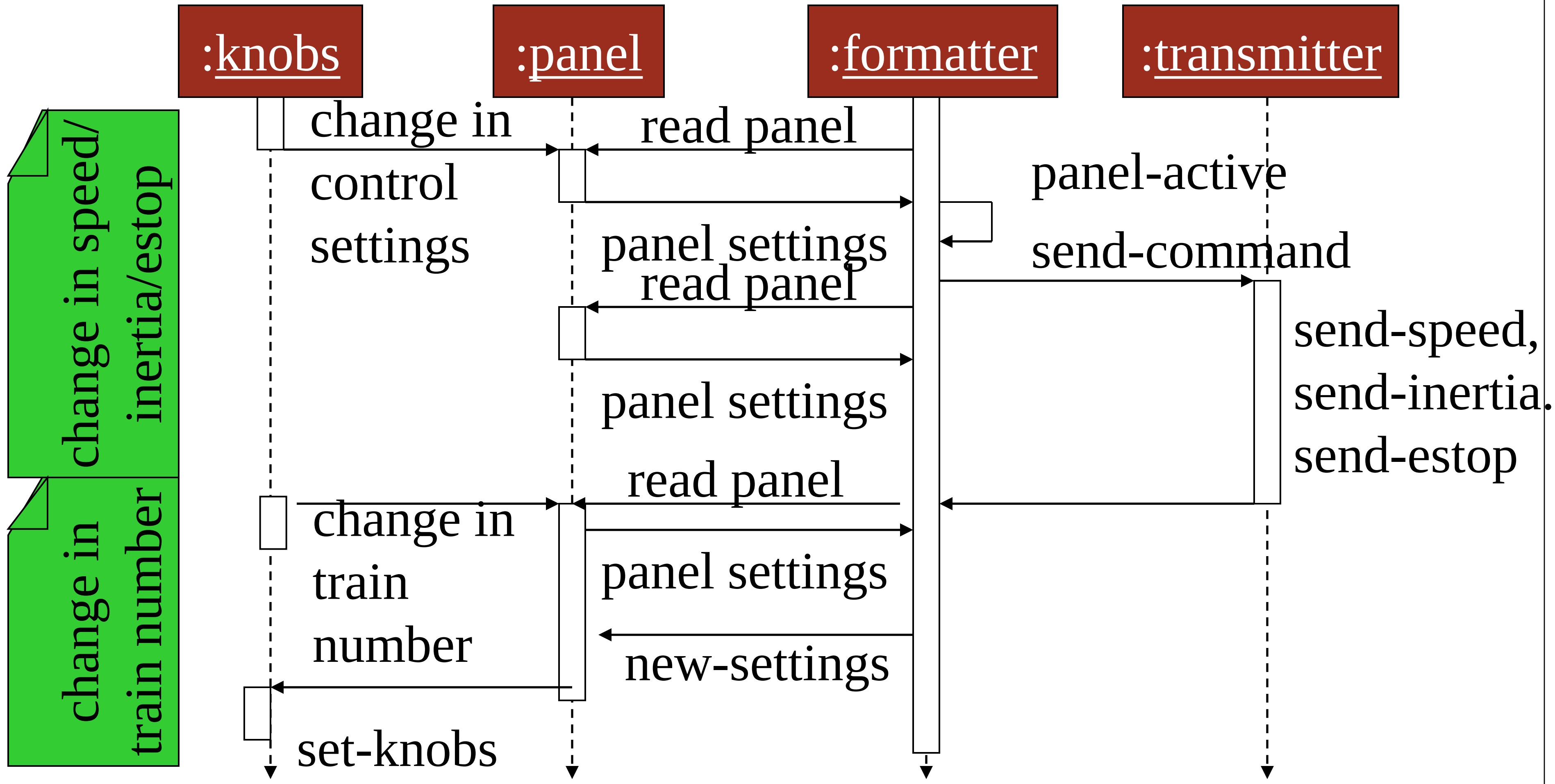


formatter

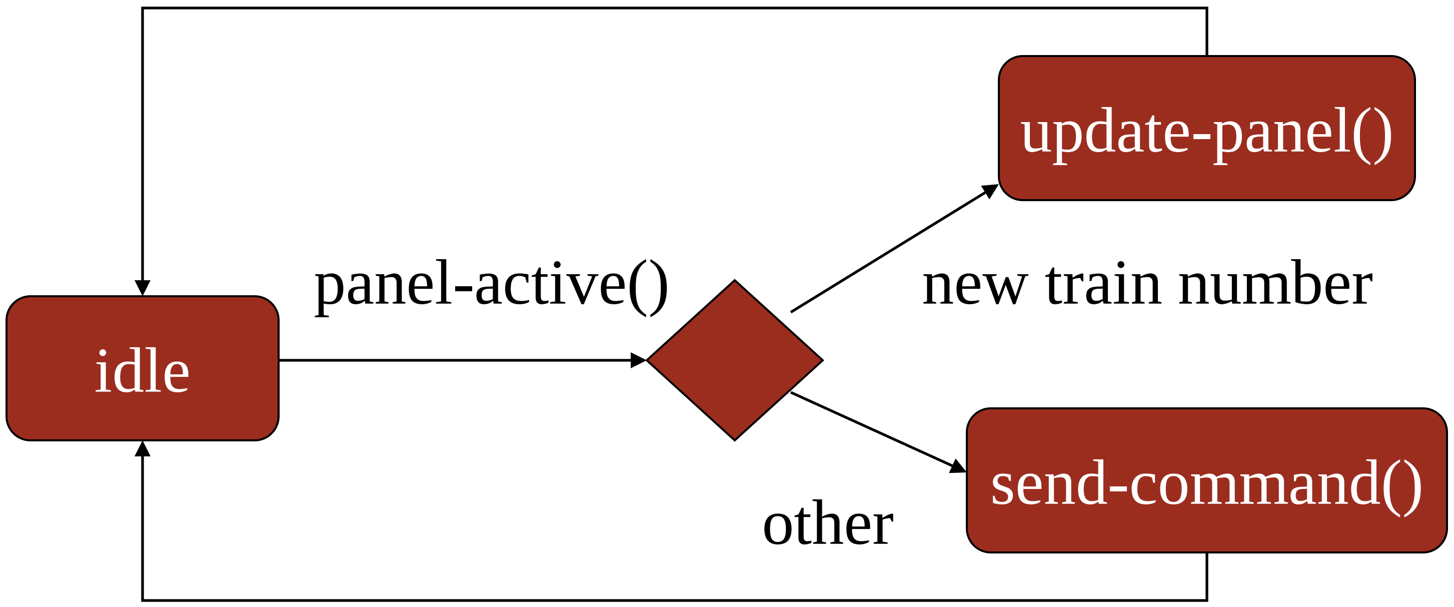
current-train: integer
current-speed[ntrains]: integer
current-inertia[ntrains]:
   unsigned-integer
current-estop[ntrains]: boolean

send-command()
panel-active() : boolean
operate()

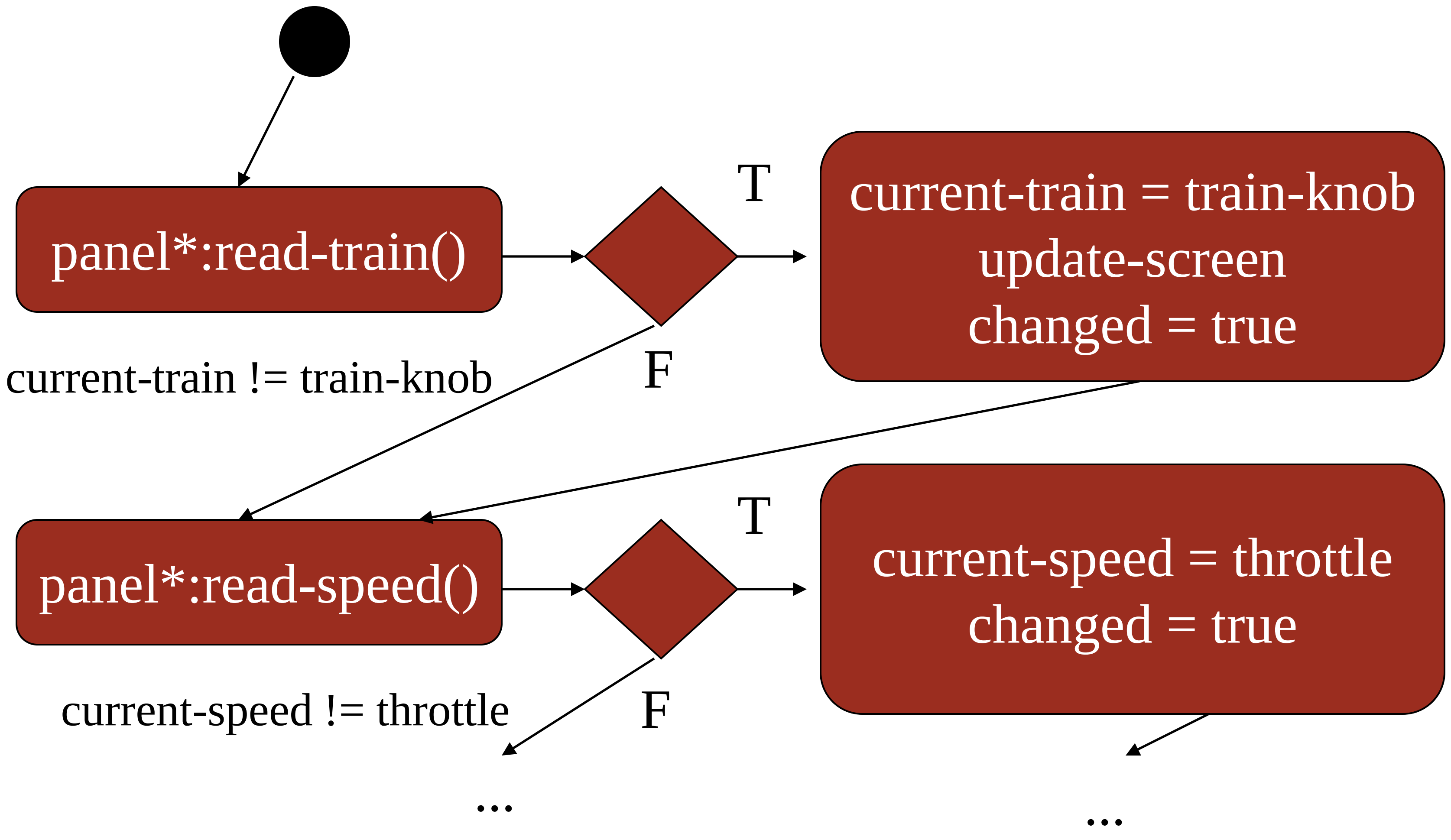
Control input sequence diagram



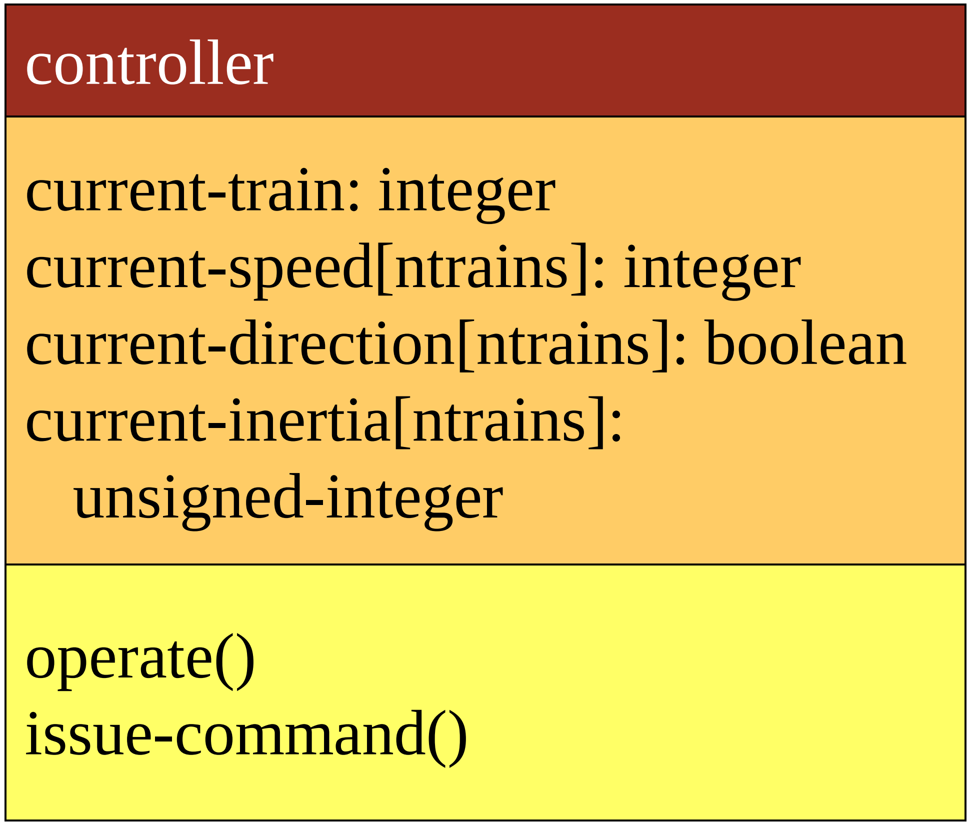
Formatter operate behavior
(in the formatter class)



Panel-active behavior
(in the formatter class)



Train controller class



controller

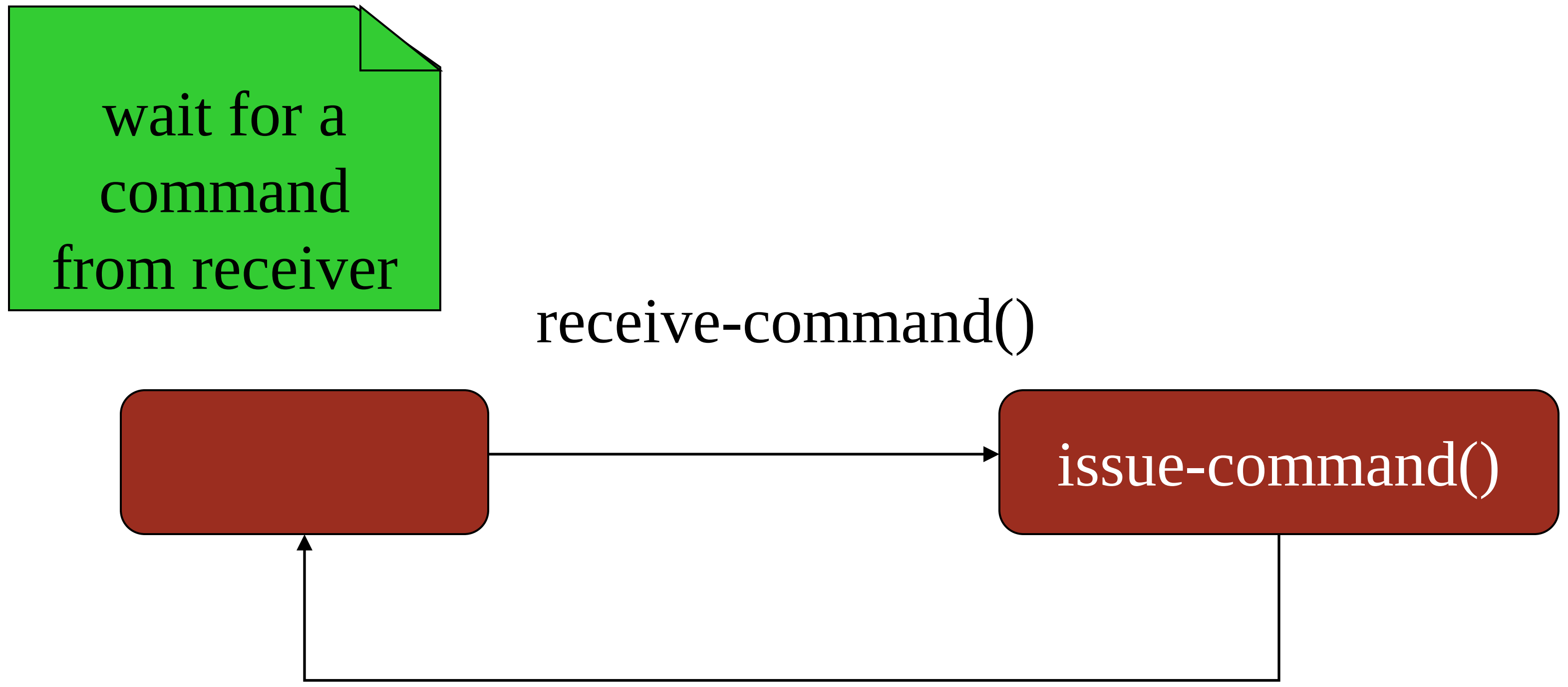
current-train: integer
current-speed[ntrains]: integer
current-direction[ntrains]: boolean
current-inertia[ntrains]:
  unsigned-integer

operate()
issue-command()

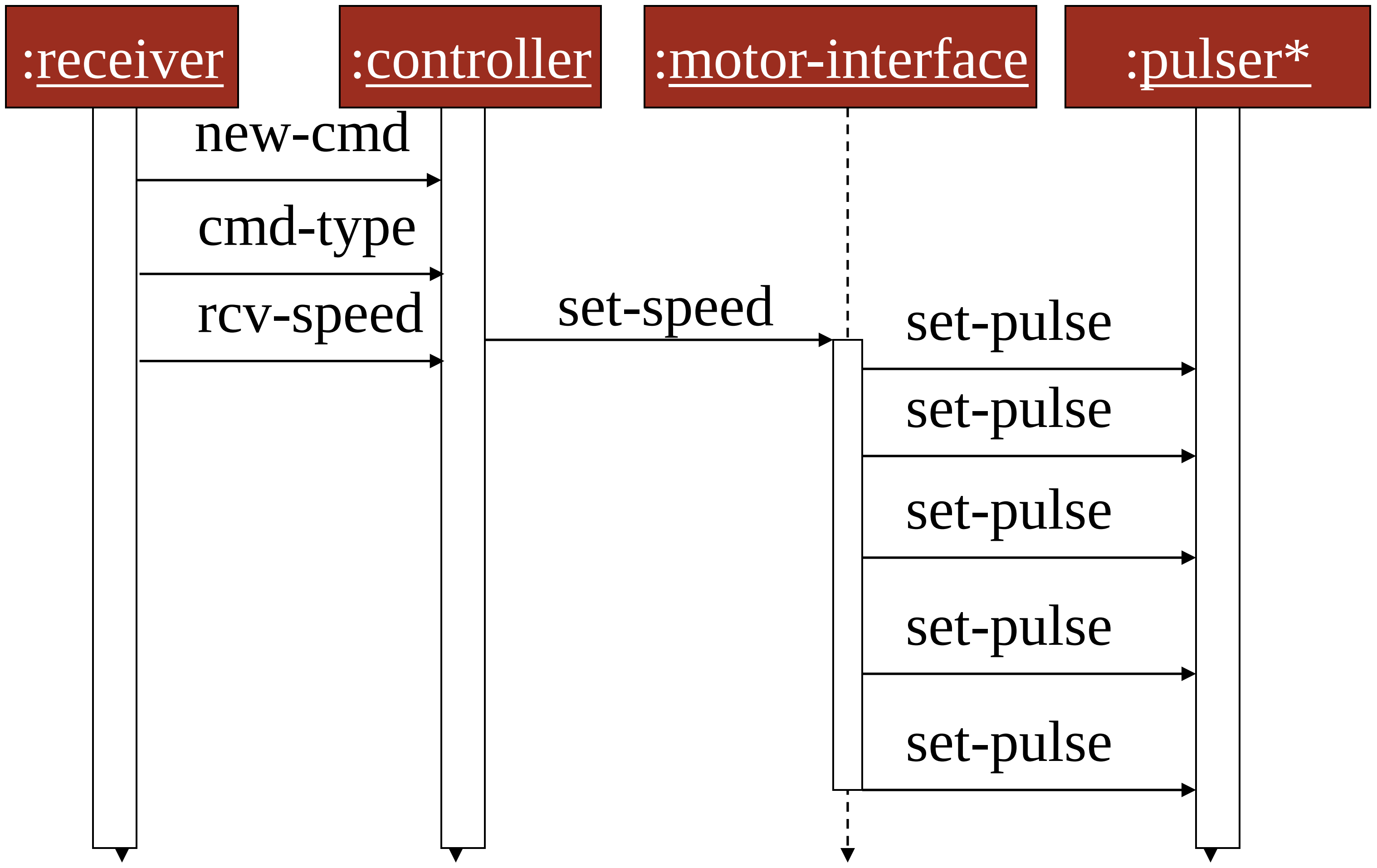
Setting the speed

- Don’t want to change speed instantaneously.
- Controller should change speed gradually by sending several commands.

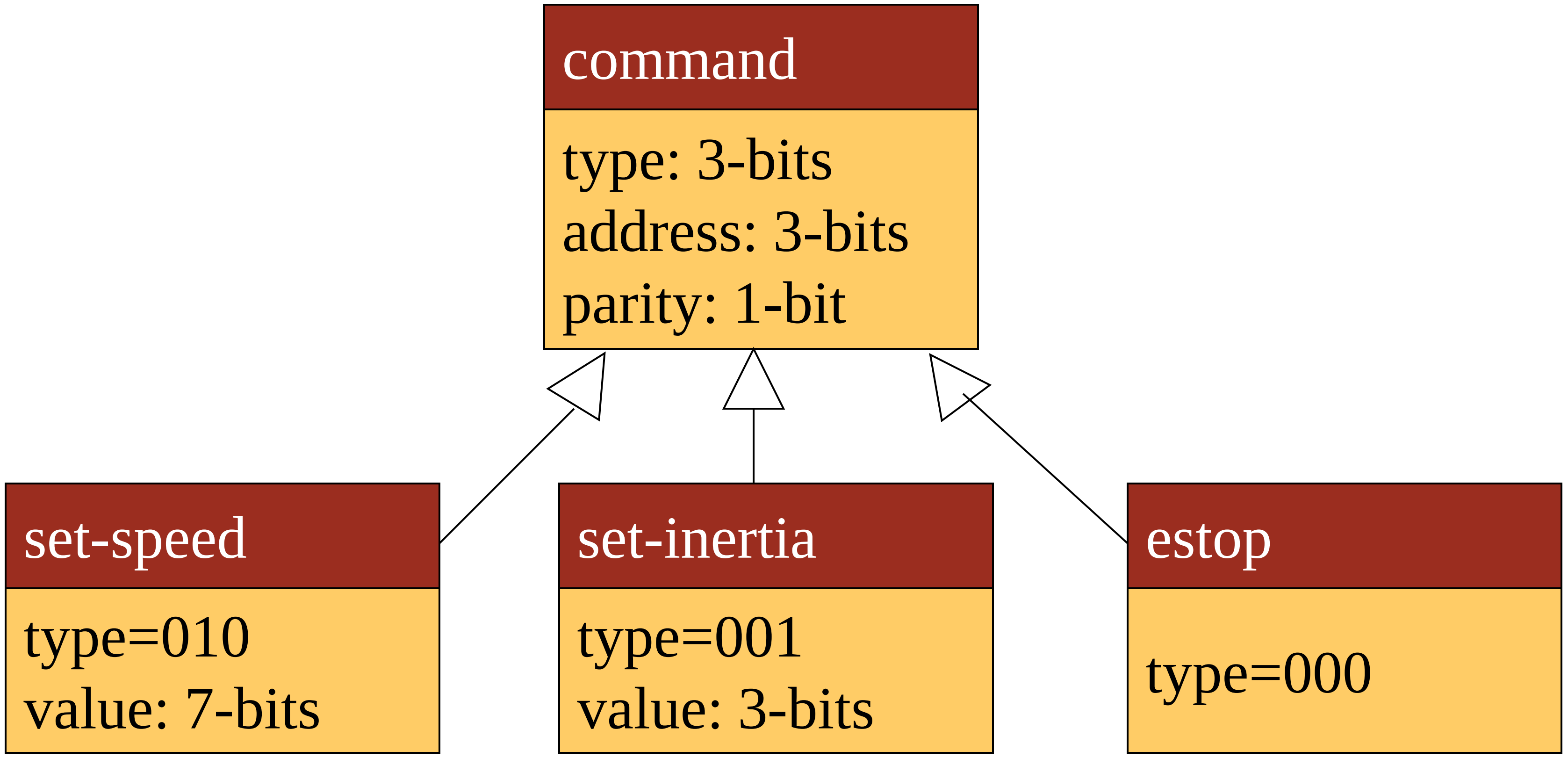
Controller operate behavior



Sequence diagram for set-speed command



Refined command classes



Summary

- Separate specification and programming.
  - Small mistakes are easier to fix in the spec.
  - Big mistakes in programming cost a lot of time.
- You can’t completely separate specification and architecture.
  - Make a few tasteful assumptions.