Example: Model Train Controller

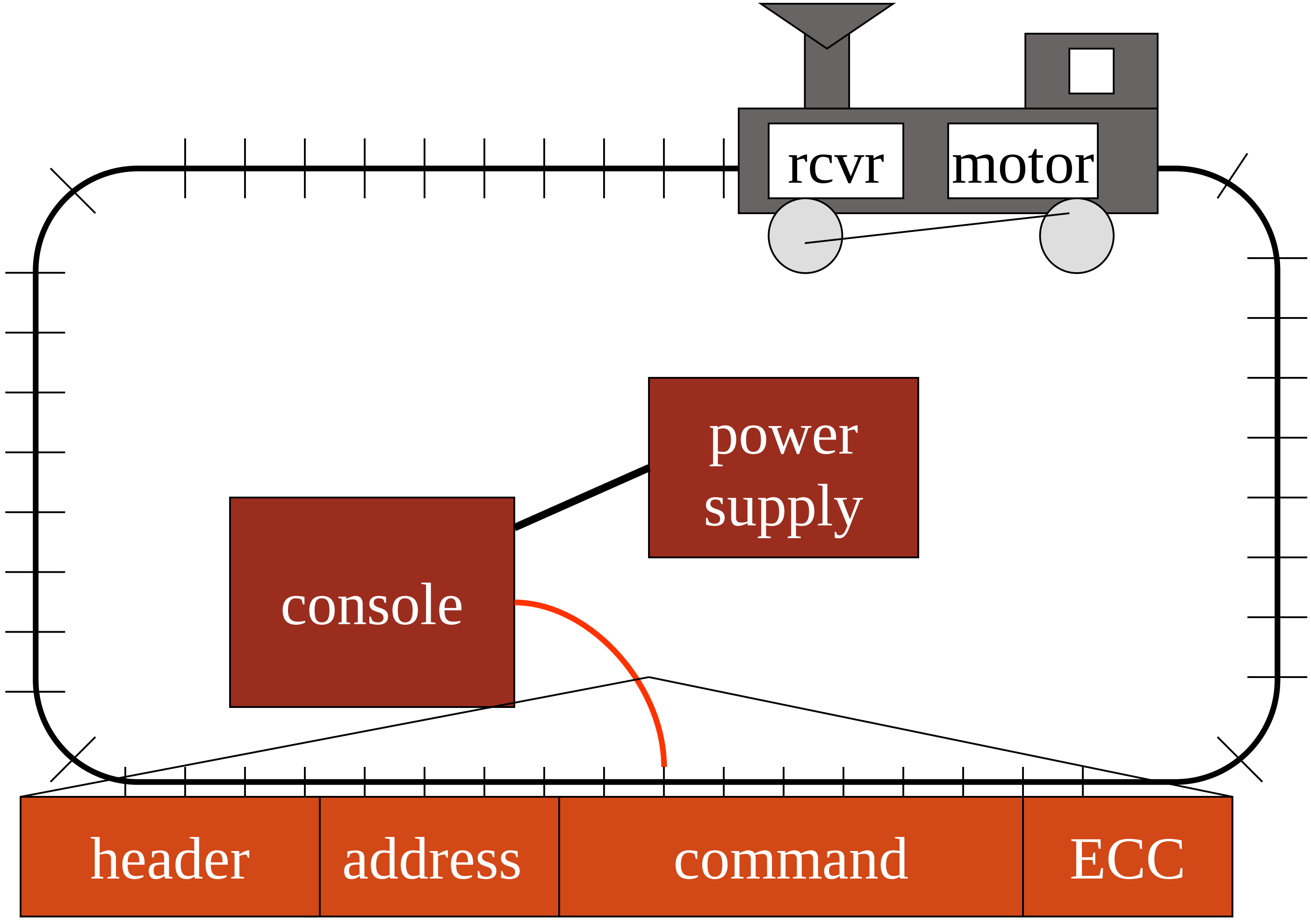
Purposes of example:

Follow a design through several levels of abstraction.

Gain experience with UML.

Text: Section 1.4

Model train setup



Requirements

- Console controls up to 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.
  - Ignore erroneous 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.

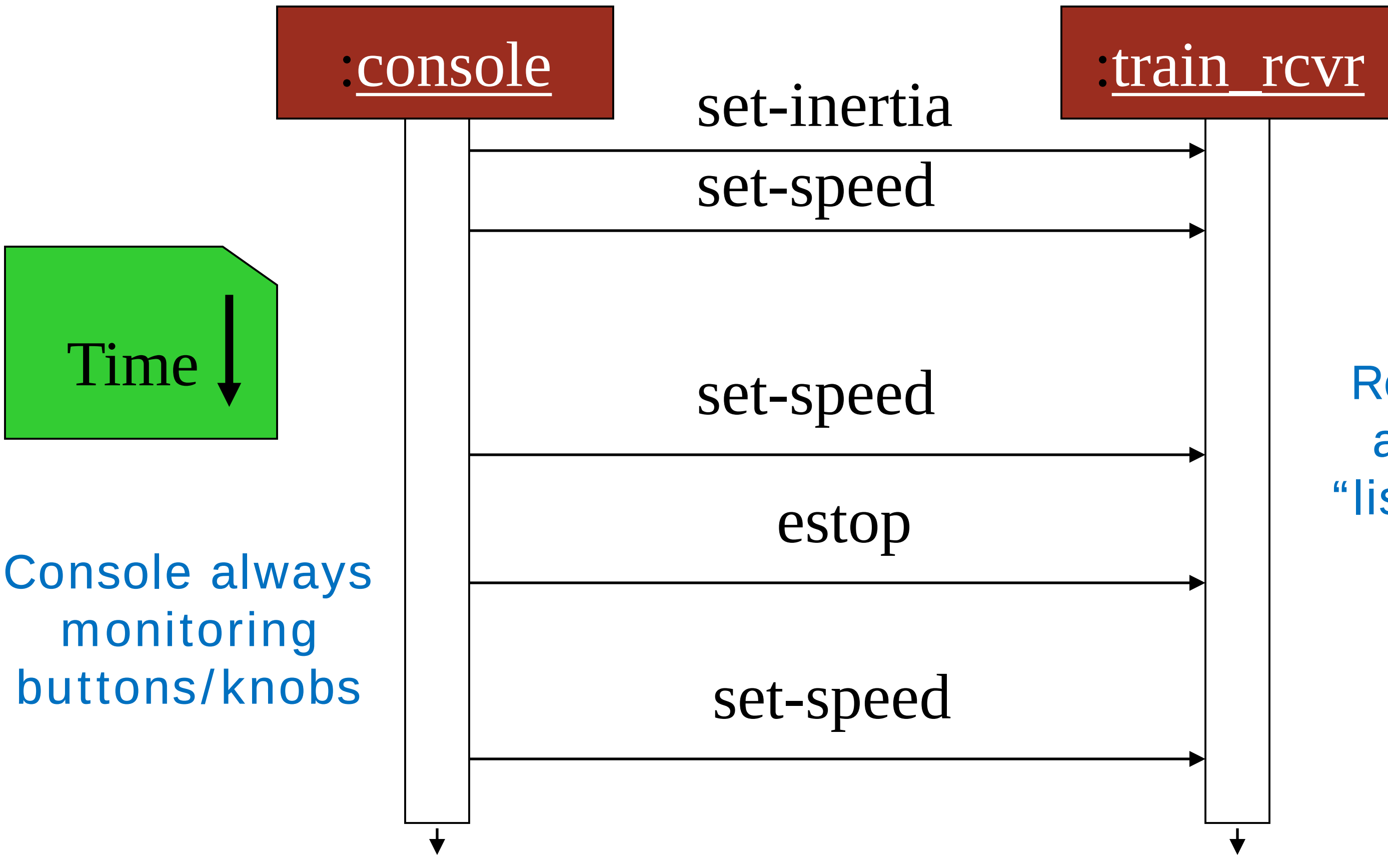
Conceptual specification

- 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

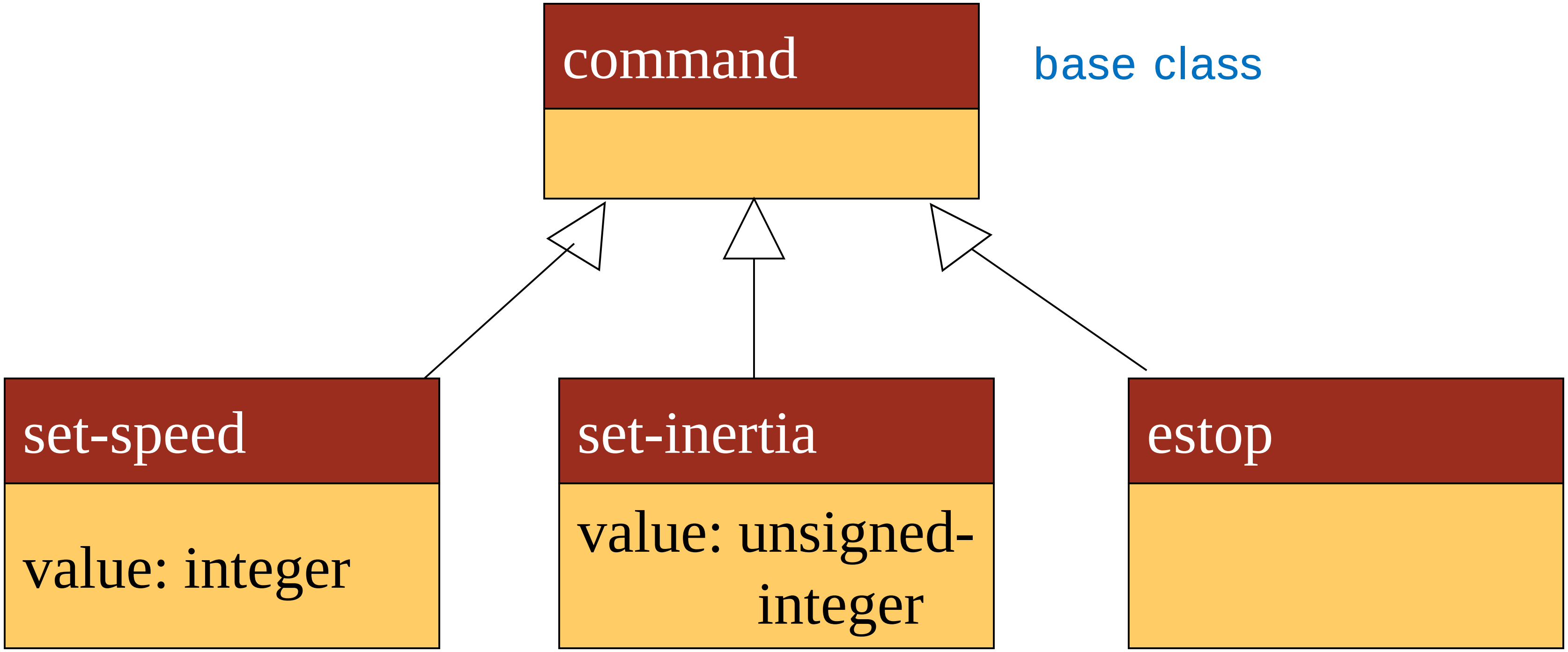
Typical control sequence



Console always monitoring buttons/knobs

Receiver always "listening"

Message classes

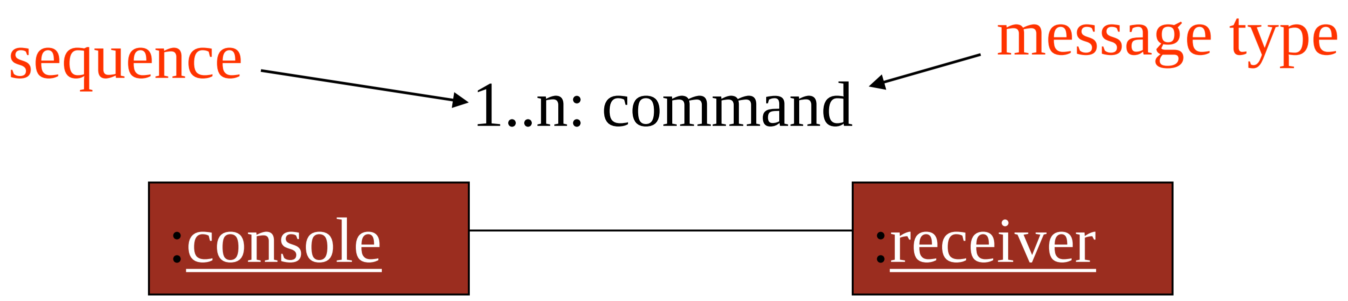


- Implemented message classes derived from message class.
  - Attributes and operations will be filled in for detailed specification.
- Implemented message classes specify message type by their class.
  - May have to add type as parameter to data structure in implementation.

Subsystem collaboration diagram

Shows relationship between console and receiver

(ignores role of track): interaction via commands



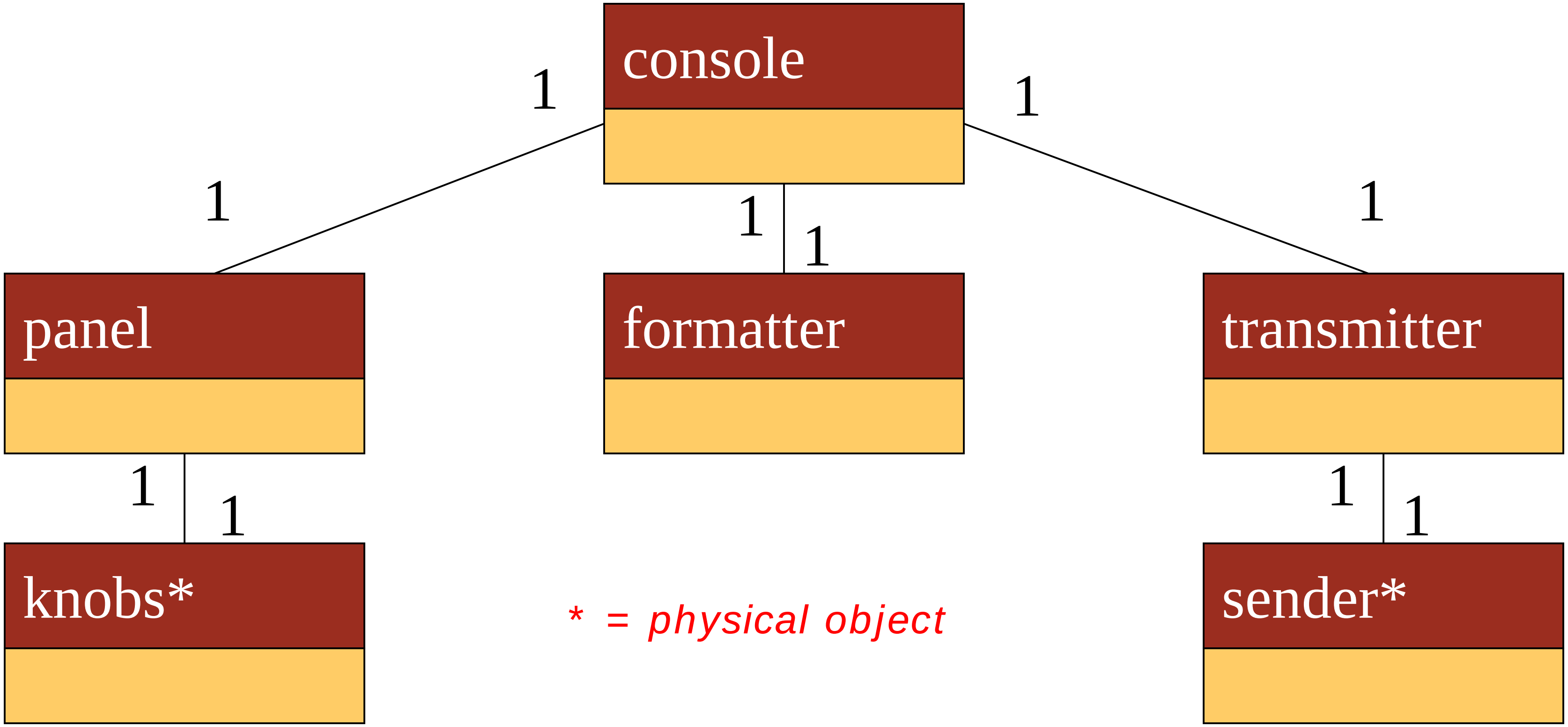
System structure modeling

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

Major subsystem roles

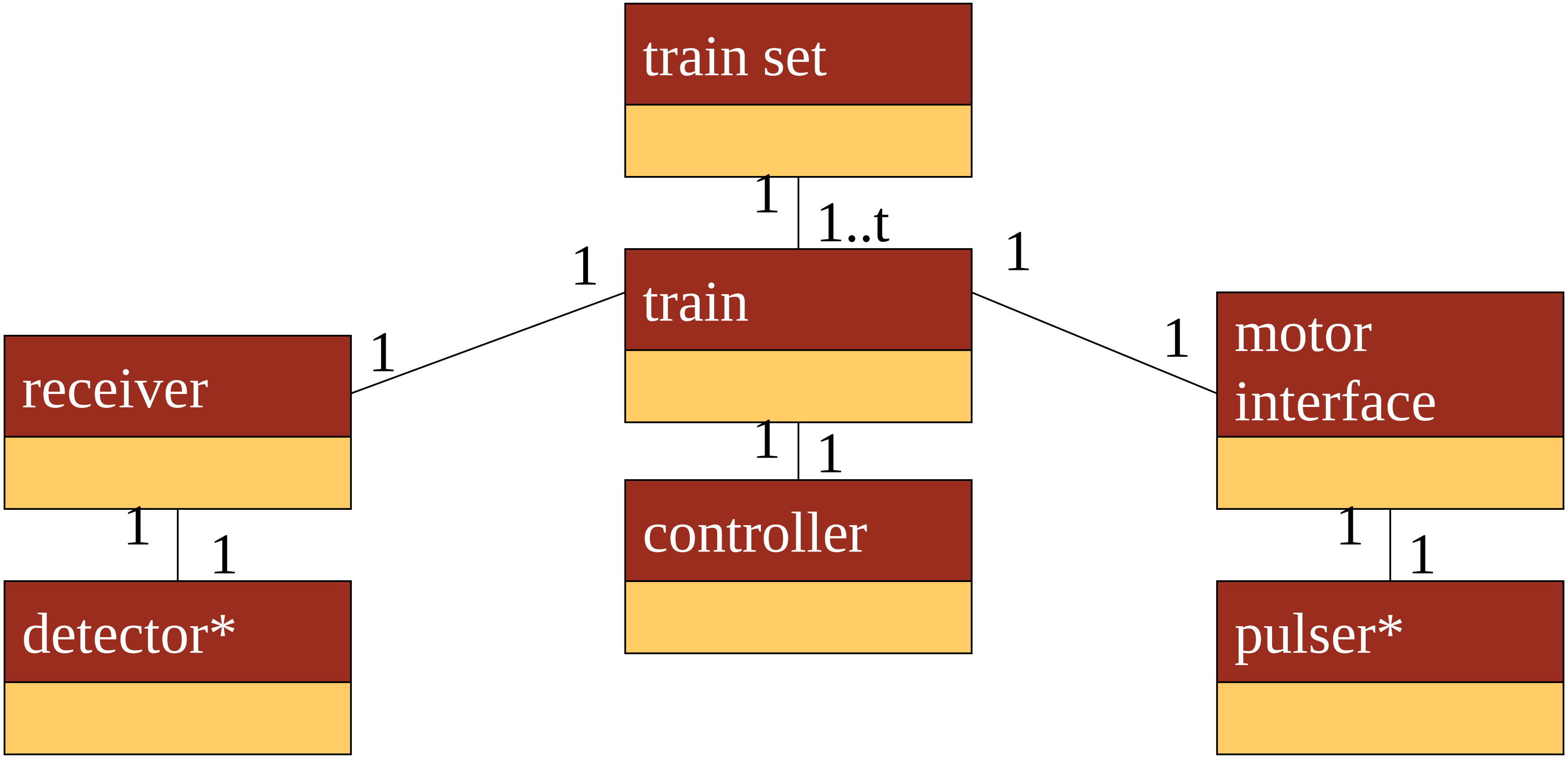
- Console:
  - read state of front panel;
  - format messages;
  - transmit messages.
- Train:
  - receive message;
  - interpret message;
  - control the train.

Console system class diagram



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

Train system class diagram



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

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 system analog physical object classes

knobs*

train-knob: integer
speed-knob: integer
inertia-knob: unsigned-integer
emergency-stop: boolean

set_knobs()

pulser*

pulse-width: unsigned-integer
direction: boolean

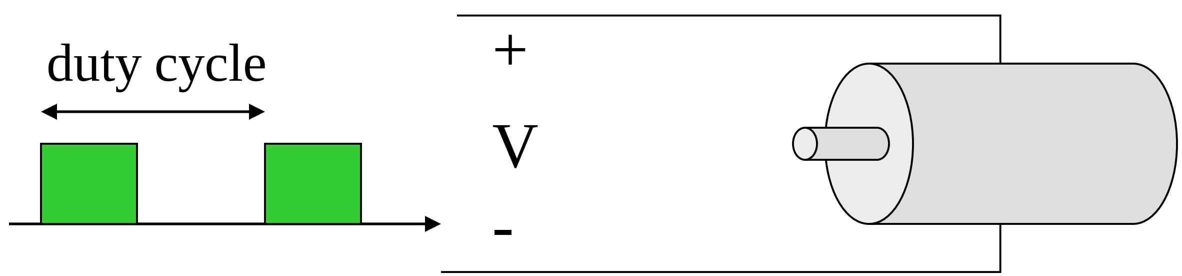
sender*

send-bit()

detector*

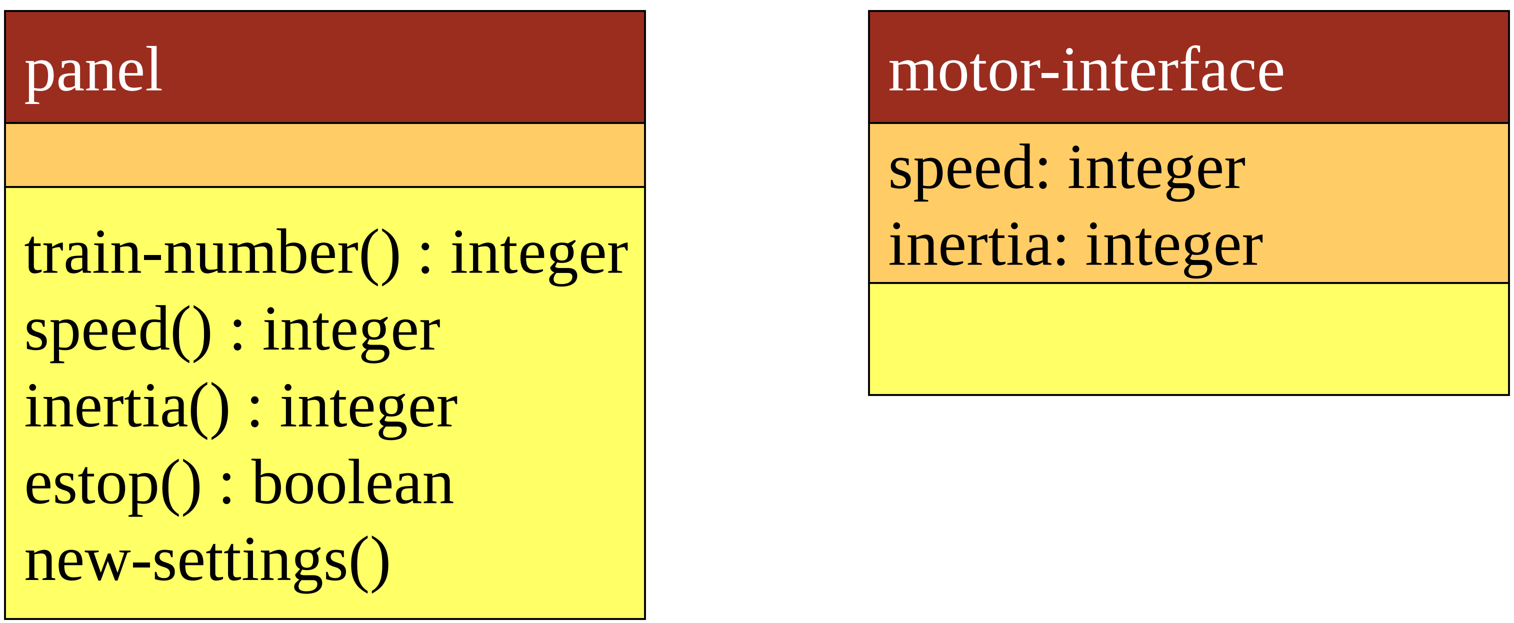
read-bit() : integer

Motor controlled by pulse width modulation:



Panel and motor interface classes

- panel class defines the controls.
  - new-settings() function reads the controls.
- motor-interface class defines the motor speed/inertia, held as state.



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.

Transmitter and receiver classes

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

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

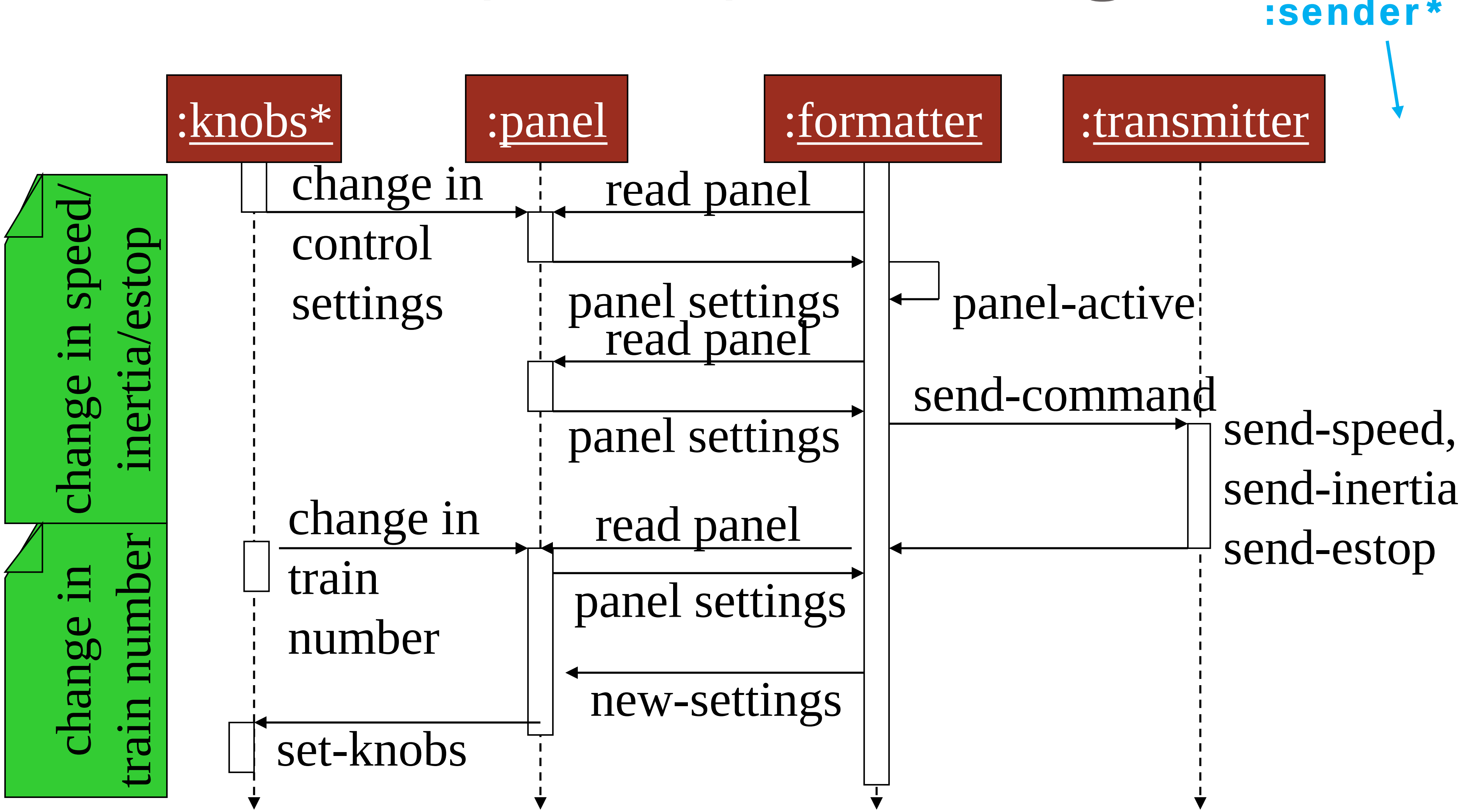
receiver
current: command new: boolean
read-cmd() new-cmd() : boolean rcv-type(msg-type: command) rcv-speed(val: integer) rcv-inertia(val:integer)

Formatter class

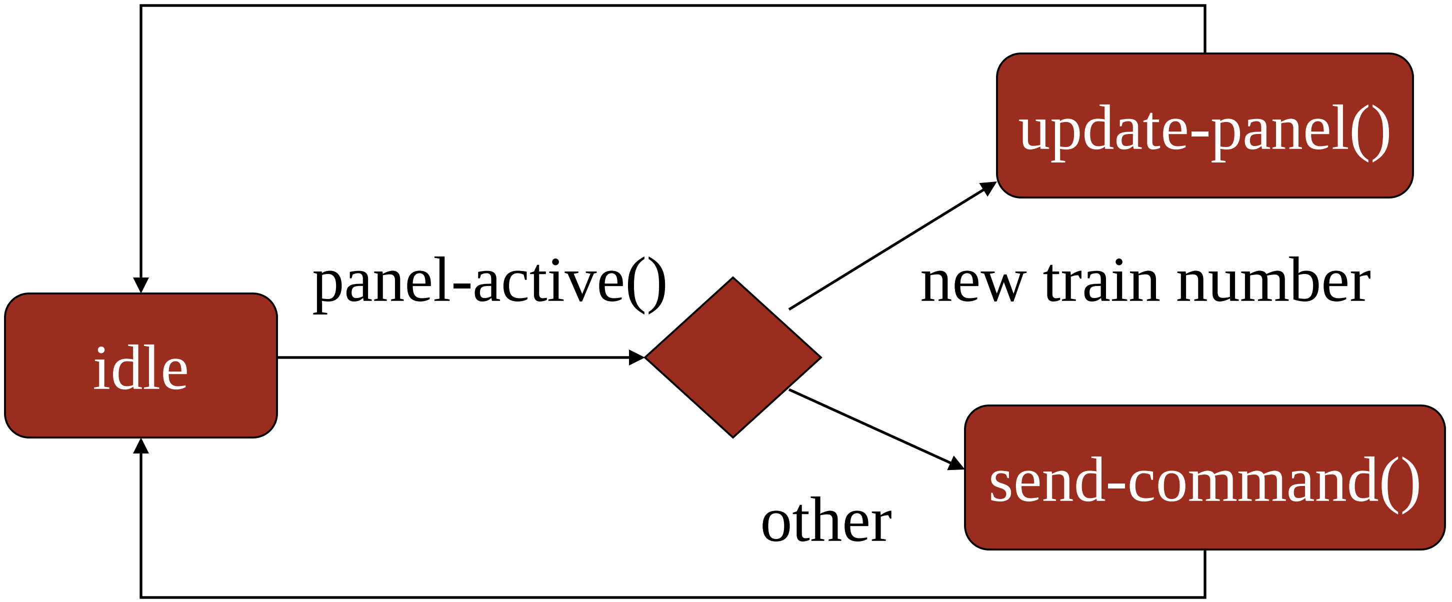
- Formatter class holds state for each train, setting for current train.
- The operate() operation performs the basic formatting task.

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

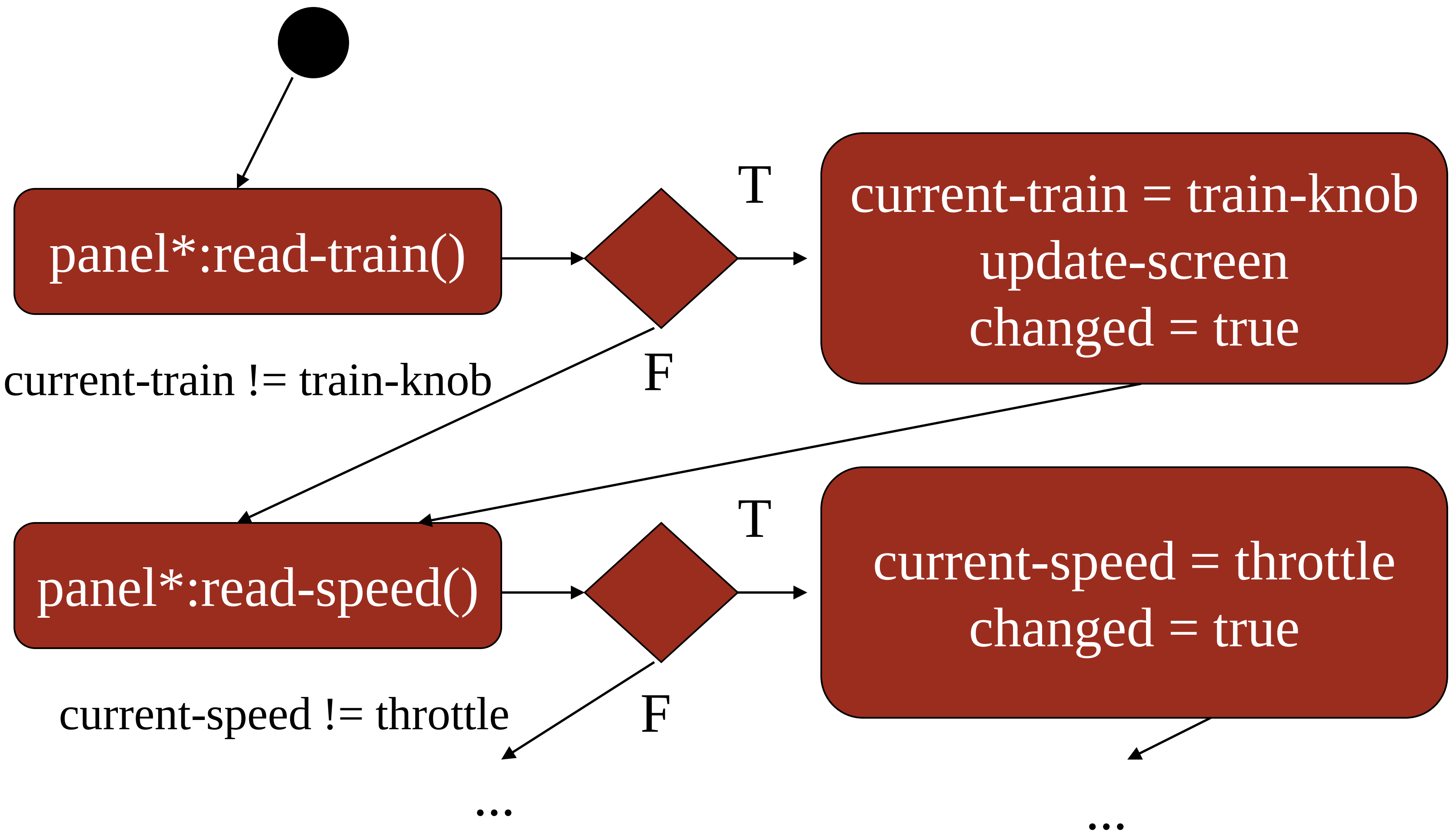


Formatter *operate()* behavior
(in the formatter class)



Formatter *panel-active()* behavior

(in the formatter class)



Train controller class

controller

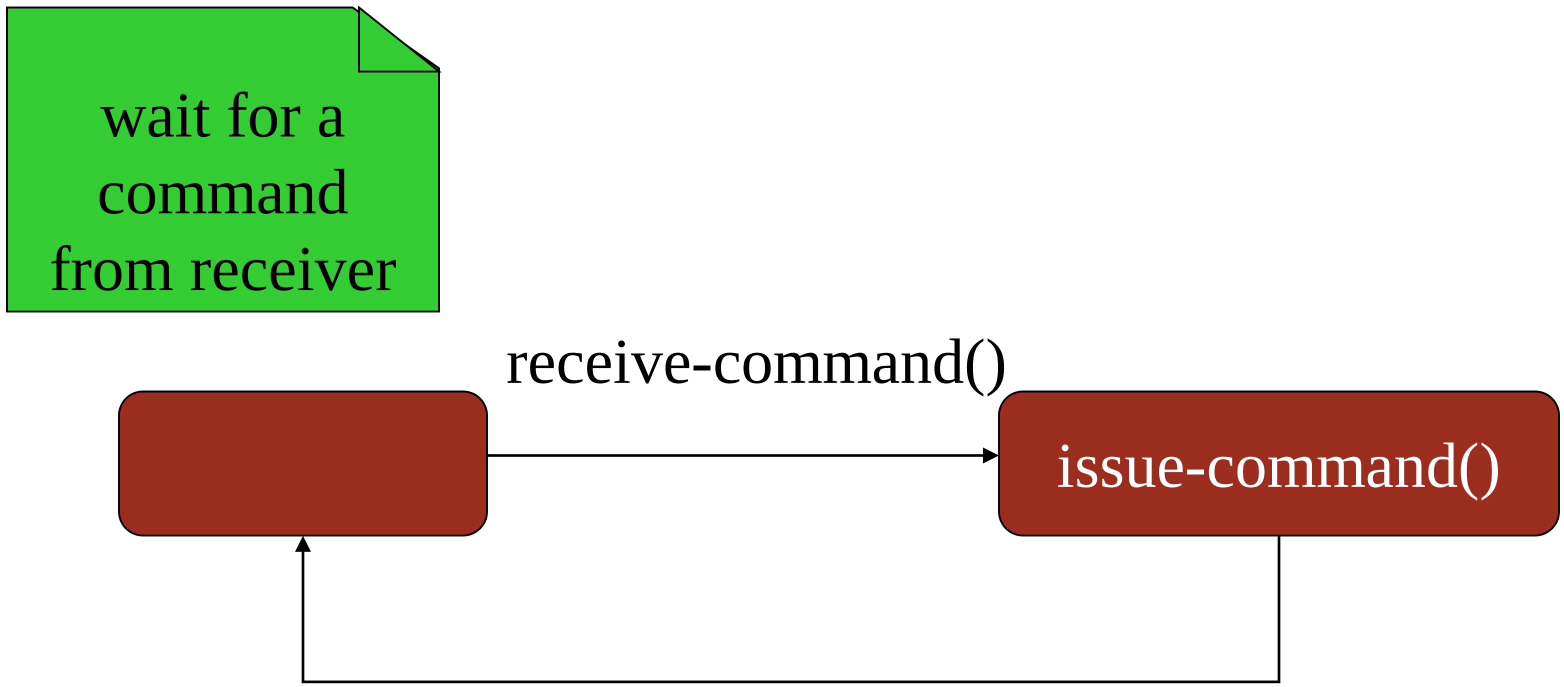
current-train: integer
current-speed[ntrains]: integer
current-direction[ntrains]: boolean
current-inertia[ntrains]: unsigned-integer

operate()
issue-command()

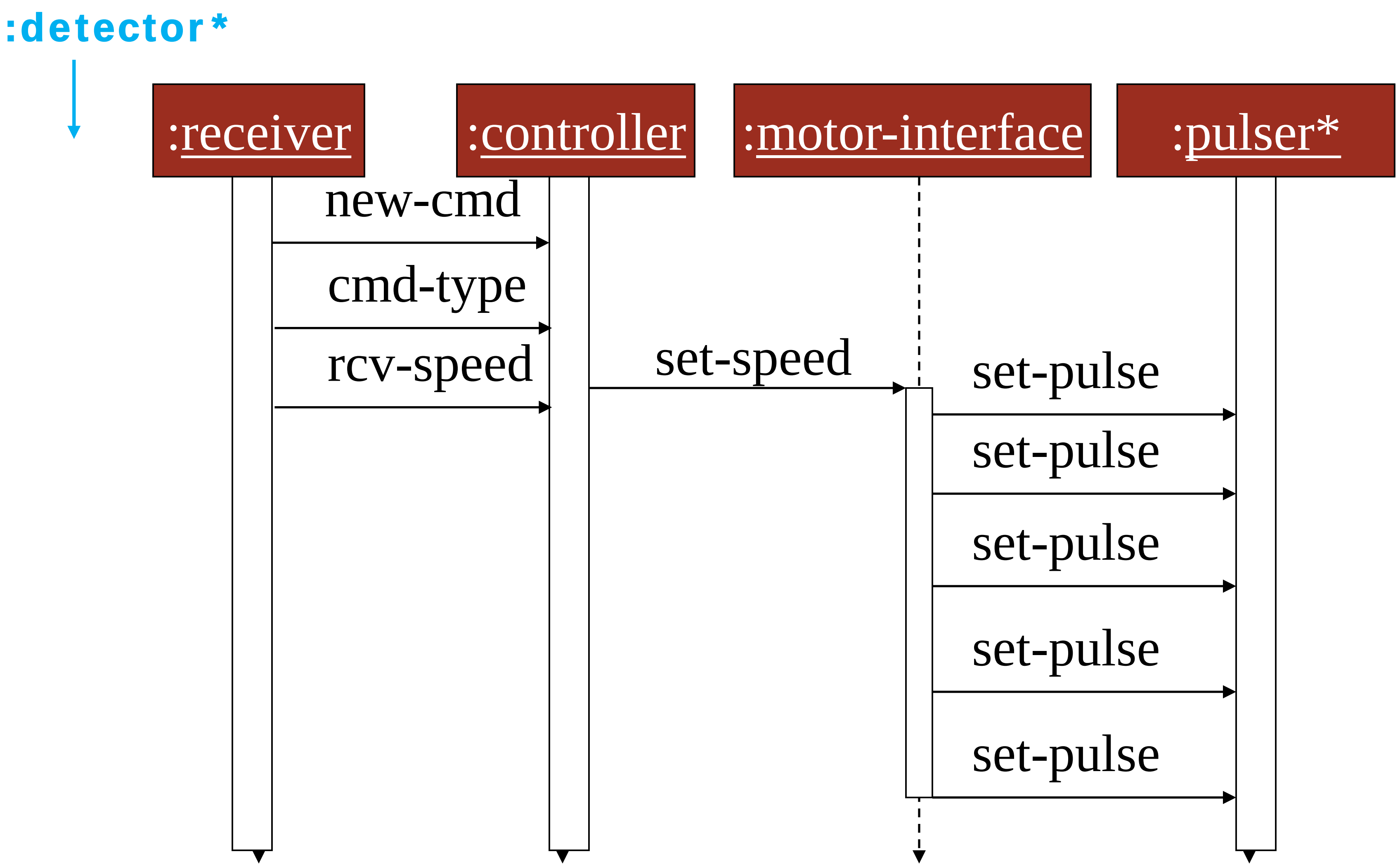
Setting the speed

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

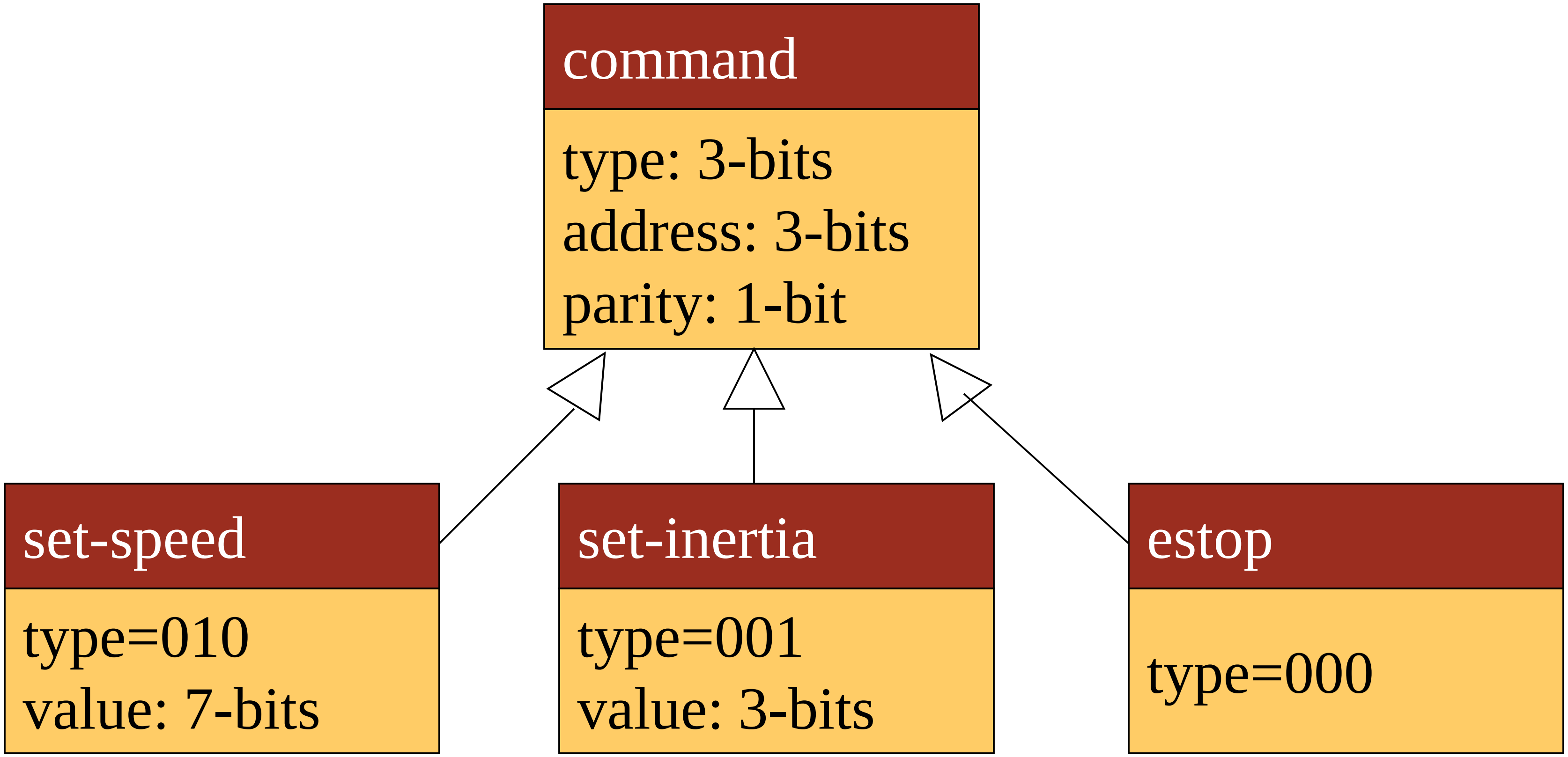
Controller operate behavior



Sequence diagram for set-speed cmd.



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.