CS 452 Train Control Milestone 2

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Contents

Operation

The elf file is located at `/u/cs452/tftp/ARM/ktverhoo/tc2.elf` and can be initiated using the typical `load` command.

After `load`, wait a few seconds for tasks to initialize.

You should be presented with our interface featuring *windows*.

You can type commands described in the next section.

Commands

- `tr <tr#> <speed>` sets the given train to the given speed.
- `dr <tr#> <>` sets the given train to the given speed.
- `dummy <offx> <offy> <width> <height>` creates a dummy task which writes to the screen in a new window.
- `cal <train> <speed> <pivot>` stopping calibration command, uses pivot as the
- `ms <train>` calibrates the inching speed using train speed 4.
- `tst <train> <node>` tests the calibrated test on a node of your choice.

Design

The Pipeline

We spent a long time and had a number of extended conversations with each other regarding how to design a clean, scalable, testable solution to the problem of interpreting track events. Our solution was to come up with a data pipeline which provides layers of abstraction to real and virtual events.

Events

Raw

We name events that emanate from the real world "raw events". These include `tr` commmands, `sw` commands and results from sensor polls.

Virtual

We name events that are generated by our system (which are fed back into itself) virtual events. These events may correspond to raw events or may not. They help maintain program state that is asynchronous or requires timing.

Virtual events allow our program to achieve a finer grained granularity than mere sensor poll updates. This allows subscriber tasks to subscribe on events on track nodes that are not sensors.

Providers

Waiting Room / Matchmaker

Interpreter

The Interpreter is where most of the logic is performed for figuring out, given both virtual and raw events, what is actually going on, on the track.

We took what we consider to be an interesting approach of associating trains to sensors. We make no assumptions about where and when the train will be. The interpreter assumes that anything can happen and then tries to make sense of the data it gets back.

If irregularities are detected (for example, a train appears to go down both paths of a branch) then the Interpreter invalidates the reading it got and places the train in a `TR_LOST` state. When new events emerge, we check `TR_LOST` trains attempting to re-associate the train.

The Interpreter generates higher level events to pass on to the Representor which then goes on to distribute them to subscribers. Events the Interpreter generates include train i at position n.

Representor

The Representor is a high level event provider that gives subscribing tasks an API to by notified of current events. It essentially passes on some events from the Interpreter with additional computed events.

Subscribers

The subscribers form the bottom of the pipeline. They subscribe to events provided by the Representor. These events are high level events like train `24` at node `B13`.

Some examples of subscribers are the interfaces for the track events. The sensor, switch and train interfaces each subscribe to events provided by the Representor.

Reservation Manager

The Reservation Manager provides a mechanism for trains to allocate track nodes to attempt to avoid collisions.

Our Reservation Manager is extremely conservative, we reserve the stopping distance of the train and a little more at the granularity of sensors for all possible paths ahead of us. That is, a reservation is made between two sensors. So even

if the stopping distance of the train is 1mm, we will reserve all the way to the next sensor in each direction possible.

This is due to the fact that we did not have time to get a finer grained update granularity functional for this milestone.

Trains request track nodes ahead of it and return nodes that it has passed by. Due to the nature of the interpreter model and since the train can potentially be reset a node backwards we free two nodes behind us.

An API for pathing was attempted but not achieved. This API considers current reservations and attempts to path around them.

Train Driver

The Train Driver does just that, drives the train. It is in charge of attempting to allocate and free nodes using the Reservation Manager. If it cannot allocate nodes from the Reservation Manager then it sends the stop command to the train and attempts to reverse and path in the opposite direction.

The Train Driver also keeps track of the state of the train it is driving by subscribing to the Representor. It attempts to path its train to a given position. Once the train has arrived at the position, it re-routes the train to the reversed position. For example, if we route the train to node `A15`, once the train has attempted to stop at `A15` it will re-route to `A16`.

Display Manager

We figured that it would be worth it to have a structured way to present data to the screen both for presentation as well as for debugging.

Terminal Manager

Terminal Manager manages a set of windows. Tasks can request a window from the Terminal Manager and output from the task can be redirected to either its own window or a common-to-all-tasks logging window.

There is currently support (not enabled currently) to route input to windows other than the shell, depending on the cursor focus.

The Terminal Manager attempts to smartly render the screen as to limit the amount of cursor movement byte-sequences needed.

Shell

Shell is just the first task which registers to the terminal manager which is configured to accept input. It is currently a monstrosity which handles the parsing and executing of all commands.

IOServer

Blocking PutC

We added a blocking version of the `PutC` function which is very useful in applications like the Sensor Manager for when it polls to the train controller.

TC 2

Res

After calibrating, we manually store the stopping distances. The stopping logic is relatively straightforward. We step backwards from the last node until we find the first sensor that is more than the stopping distance away from the node. Then after passing this sensor we can set a delay to stop at the correct position.

Calibrating

Method 1

Our intial method to calibrate train stopping distances was to have the train use a starting sensor as a measuring stick to try to land on a targer sensor further on down the track. We make an intial guess and check whether or not we overshoot the target. We then subtract or add to our guess and bring the train around to try again.

Obviously this is not very efficient and took quite a while to run, taking up to 5 or 6 iterations to achieve accurate results.

The plus side to this technique was that the results we get from the test are quite accurate.

Method 2

Our more efficient method was an inching strategy. Again, we start out with a guess. But this time if we overshoot the sensor we inch at a slow speed that we know to the next sensor, measuring how much time it takes. By using a

slower speed we make the assumption of very little acceleration and thus we can calculate the stopping distance using the time and the speed.

This method is much more efficient and only takes a couple of iterations to get good results.

A problem, not with the method, is that moving at a slow speed means a greater chance of getting stuck, which ruins calibration results.

Pathing

Pathing is done using Dijstra's algorithm using our own heap implementation. There is nothing particularly special about the algorithm or its implementation.

It is thoroughly unit tested and we are fairly confident in its correctness.

When given a node to stop at, we calculate the path starting two sensors ahead of the train to the destination node. Then we check the switches in the path and set them in order starting from the destination node.

Resetting

We have a simple reset task which configures the switches to form a loop which we use to set ourselves up for the pathing and stopping.

Files/Hashes

The code is in the `milestone1` branch at `https://git.uwaterloo.ca/bkcs452/kernel/commits/milestone1`

- 7bc01453e2a66825b5d984a4216e3574 ./src/test/task/task_queue.c
- 327b0827c113d81744ae7a715591bb22 ./src/test/task/priority_queue.c
- 09211d3acbfa0470b3669a928951dc0c ./src/test/test.c
- 783747baaadd9897d757c45e969c258f ./src/test/ioserver_buffer.c
- 9cf0cb153ce0501ff701d4697cfb499d ./src/test/circular_buffer.c
- 4597316f7dce4804c65ae5bf95b39cfd ./src/test/clockserver_queue.c
- 54898386d882746ad9ed1b82cdee951a ./src/test/buffer_pack.c
- adef4b97f55d8c436654d0ebe3c8ec7f ./src/test/nameserver_store.c
- 49054eff298ec05249ead77544bed986 ./src/test/terminal.c
- 6d7814a01bddefe0563bdf4b128c0bc9 ./src/test/string.c
- b1a200870b6c417c8983ffbc4c8d3290 ./src/test/train/path_finding.c
- 4f3cf7d29870fd8cbbfe6c2d984d9a94 ./src/test/train/priority_queue.c
- 8f9b3e57e07155b62fc4d9b4eab5ce87 ./src/kernel/kernel.c
- 0cb04e53a4725343cf696fde41cb7975 ./src/kernel/system.c
- 1780d5505c810553781b815ff4107f4d ./src/kernel/kernel_task.c
- 03cca0cec7568d69b69dcb9434669eca ./src/kernel/bwio.c

- e581ee01479deda5eb171d247e089207 ./src/kernel/handlers/msg.c
- b11f00af3a714dead92a96092ca7ca69 ./src/kernel/handlers/nameserver.c
- 607e3d31085df8178e5547d8af120aa9 ./src/kernel/handlers/interrupt.c
- 667fe1323f70da8555d2b46efdb5a9db ./src/kernel/handlers/create.c
- ddd7b9779d3370b6dac42cfc765a2be6 ./src/lib/buffer_pack.c
- f1fd28d9ac218a4c7a2526876d7e05c4 ./src/lib/clockserver_queue.c
- e20782ab90404b887f3d12eb0d863a3a ./src/lib/nameserver_store.c
- 245aaf4de0c3520922c0f1fea6c22655 ./src/lib/circular_buffer.c
- c767bbca689325f83a1822f7bc15f124 ./src/lib/clock.c
- b35de9fb9161e8e8ff11e828479b9c07 ./src/lib/i2a.c
- 611e2f67107f05d633c83642699014b3 ./src/lib/parse.c
- 27de508c4afe9cf6a7f24a465d3d26bf ./src/lib/recency_buffer.c
- e47314a170c84b56cff8e3d4804db8a1 ./src/lib/terminal.c
- 55ee7a58d484e86d2e0c107e4e2064d0 ./src/lib/ioserver_buffer.c
- d41d8cd98f00b204e9800998ecf8427e ./src/lib/memcpy.c
- 596b9be6f258f28607c46866ca5cb48c ./src/lib/stdlib.c
- 29a31eb41a9a378d9e50f7c7e1e80c61 ./src/lib/string.c
- bce684858eef59ee6d7b7b36cf8c4be7 ./src/lib/task/char_buffer.c
- 8d123b7f3a75b8c80f28526428be60ec ./src/lib/task/im_buffer.c
- 4bea16c0cdea605e9ca3148de52dd81d ./src/lib/task/interrupt_matrix.c
- abf42fa7624fe7d54d090e02b488946e ./src/lib/task/priority_queue.c
- c11c8ccdfead0b0728e9e8377d18093b ./src/lib/task/task.c
- e0a93e5f5b3d54fde762c8f94c6cbb26 ./src/lib/task/task_queue.c
- 83eb05fe6603a44761c7a8079b10508d ./src/lib/task/tid_buffer.c
- 3f1f81e839797e965aec70c8c41ad361 ./src/lib/train/path_finding.c
- 4d9564bea15a35986fa36b50169b9ce0 ./src/lib/train/priority_queue.c
- 9321219a84aafdba77ffc3cdcc053ed9 ./src/lib/train/track_data.c
- 01d06a823467959f955f15ca17d027f4 ./src/user/nameserver.c
- 3f4e5b939ed717651e8f389ef99f81c1 ./src/user/test/k1_task.c
- d2bb5793c80004c81c3e03a5b46529ac ./src/user/test/k2_metric.c
- e0107e022729bd8c40c4214ba8cc13d6 ./src/user/test/k2_task.c
- 7d0348c52aab6d98b3a0b93236b46f62 ./src/user/test/k3_task.c
- 449ba5f34132de0c728ef6a98147a647 ./src/user/test/clockserver_test.c
- 6923917dc2e70092c5466ad7ffedf560 ./src/user/test/create_args.c
- bb5855e4c02fe0fe993b2967b21815e5 ./src/user/test/context_switch_test.c
- cbc54858690eec30e3f81fcb38d1d812 ./src/user/test/nameserver_test.c
- c559ba59cb79ac4f87151bb8cbccdaf8 ./src/user/test/messaging_test.c
- 503b85250b7780b2de1d8bd69097e622 ./src/user/test/schedule_test.c
- 03eaadbdd97acc91db51671a1b74389a ./src/user/test/test_task.c
- 0a0f07cfda7db021d79dfccba5b0429a ./src/user/test/taskid_test.c
- 30294b450e3ac868ad35ba51b938a530 ./src/user/test/ioserver_test.c
- 4d7a394fb31dd29fc4c472d2dd040954 ./src/user/test/ui_test.c
- 9e5b3a4cc477d6e711174ca6c68c0942 ./src/user/test/train_controller_test.c
- 345b271b10254b8b9d54009a68b5d363 ./src/user/test/stoppingcalibration_test.c
- 50bff5093b9aeb785566ab92f6ca8203 ./src/user/test/stop_at_test.c
- b83adf61a76405ca40695c0cd79242b9 ./src/user/clockserver.c

- bcab996e84cb6ea74518df761015cac3 ./src/user/bootstrap.c
- 82d4eaf3983c63b1282dea5b67d1a38b ./src/user/shell.c
- a6c21989cbc5917013056df138033706 ./src/user/ioserver.c
- b8e239fc45829546c975b5d8025319f1 ./src/user/logger.c
- 3d69d9b2f002c2914d238cb0eed8f02c ./src/user/writerservice.c
- 3cad6cf77cf1ca22d5589f46850aff1d ./src/user/train/railway_manager.c
- ffce6e766074747d619c00ab544bc5ce ./src/user/train/sensor_manager.c
- 256647d2a5bba7b7ab3795d95ea79fcd ./src/user/train/switch_manager.c
- f90803e74ebe7a2c74fe7ce6b0324bc1 ./src/user/train/train_manager.c
- 50504bf01cb9f0870c0b23f69ada6a3e ./src/user/train/prediction_manager.c
- d9c0475599c79cc1897082274d7fd6aa ./src/user/train/m1_reset.c
- 463566ff0e0aa270fd89d6088e6b01fd ./src/user/ui/timer_interface.c
- 3dd62a75003f52d9edba59c3195142af ./src/user/ui/idle_time.c
- 12a8bb32fd0191f2049ba24c5c86c0bd ./src/user/ui/num_procs.c
- e66be29d9073eeda0d56c5542f95466f ./src/user/ui/sensor_interface.c
- dec05547eb5279e99f718fd39a70023f ./src/user/ui/pathing.c
- bbb58fa3d50be8b49bdf60eabf78455e ./src/user/uio.c
- 80751bebce615a30cdbb2405b76133c5 ./src/user/terminal_manager.c
- b75d30bb4f36768d13df52369eb2b7c6 ./src/user/syscalls.c
- 0b47e5d1d218e6f9c0ca5cd51c540978 ./src/user/mem_usage.c
- bf5ac1d25a2700f14eba551bbd8b913a ./include/ts7200.h
- 0a8eb8e25d782c8f03088bd4a07714f0 ./include/defines.h
- 54a9e7b49e4d4c77c2b0a4e10575ddf4 ./include/types.h
- 86fc78f49f55524678967ec1fa3a252d ./include/debug/debug.h
- c5f3dda3b7812e2937274f4faf3ed8f7 ./include/kernel/kernel.h
- 6a30a46d154cdebdb5ebcad41a9292bf ./include/kernel/kernel_task.h
- 341330a8a526cd428eaf7cac6ae513ce ./include/kernel/bwio.h
- ead9cee2101cf0d98c46b93a8e4a0fd6 ./include/kernel/handlers/msg.h
- 41287f7a320d833e26ca14c4b72b41f8 ./include/kernel/handlers/nameserver.h
- 2af4e31c8fe3f015ff02cc5abccb6f1e ./include/kernel/handlers/interrupt.h
- 652b7caad84a6dc196b0696ce170317a ./include/kernel/handlers/create.h
- 2006cd22303f1d33759e094b4e75d3cf ./include/system.h
- d7253bd5a0f41ac142619e9292f976ed ./include/stdlib.h
- 4926d4831fd27abc0be742a2fd87d1a5 ./include/lib/ioserver_buffer.h
- e0a6cd9d05e086d8c9516e2ef2b007cf ./include/lib/va_arg.h
- a2652b04b1f6a23f200f8a4c8d42e815 ./include/lib/clockserver_queue.h
- e8eef067fafcb2f4d61ec20d39960c1c ./include/lib/nameserver_store.h
- fe10a8e2e82975e0132ab35937a2480d ./include/lib/circular_buffer.h
- bf3791c795f5e83d7e127509868a8409 ./include/lib/clock.h
- 6059589db4f2933ba1d820ba725720c3 ./include/lib/i2a.h
- 51385af5c1466f4e6b75c5c149caa01f ./include/lib/buffer_pack.h
- a1ebbca0cec01e1116e80ef5bd5cca6b ./include/lib/recency_buffer.h
- dbea0c0c66a0692713486169ce15dd37 ./include/lib/parse.h
- eabb03f9a1194d122c3936a39f83249c ./include/lib/string.h
- d41d8cd98f00b204e9800998ecf8427e ./include/lib/memcpy.h
- ffe9e5735f045715087c3b4ed9074e48 ./include/lib/priority_queue.h

- 64d7260d2cb4bd9518ec309e271a682d ./include/lib/terminal.h
- e9c99ca69a1c6fb2078507b8d14b4b7c ./include/lib/task/char_buffer.h
- 4b60707d78c00c9861e01ada26b6dfc0 ./include/lib/task/im_buffer.h
- a01a5c4475867f6f36ea366cbab44467 ./include/lib/task/interrupt_matrix.h
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- 251b5d369ac99103b0ec4c9334d96d68 ./include/lib/task/task.h
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- 34cc2df343137316c5c5be057882fc70 ./include/lib/task/tid_buffer.h
- 51314fc3ed5469c40a3cf988d8d449ff ./include/lib/train/path_finding.h
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- 49233680a59a4564ba8ea540f9f39254 ./include/lib/train/track_node.h
- 3832d3ebce59f64f05aaa29ea99569cc ./include/asm/asm.h
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- 76fbcc66e11439d9b51e66121d4efa3a ./include/user/test/k2_metric.h
- 630fc8bedeedbe2a49d1ba3f73c8604c ./include/user/test/test_task.h
- 100f2b5eab0102dea3394f5f61cb3fa4 ./include/user/test/k3_task.h
- adb5169ba3ef5fbebab09c8a38eca3c3 ./include/user/test/taskid_test.h
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- 9fc89ea20734f8be65741732c26fa1d9 ./include/user/test/stop_at_test.h
- 27bd446c153d4083f14efd4bb66d868f ./include/user/clockserver.h
- 07f1b821f0364ad27ef66f562024f6e4 ./include/user/syscalls.h
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- c4d34d7a068646a1d137ea8e513bad07 ./include/user/train/train_defines.h
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- 8c6a2e37d0c190a1f2f18376fe81467d ./include/user/train/train_move.h
- 3e535930e99041bfd11bb6ab38734b51 ./include/user/train/prediction_manager.h
- 9749072d9586c150af2296f4a69d2764 ./include/user/train/m1_reset.h

- 66a3b502e1a982f62816d1795ce65b96 ./include/user/ui/timer_interface.h
- d2f38dc2005150fe3726ead7ca80f5a2 ./include/user/ui/idle_time.h
- 06333a1acf3d9e6af666e6986148754d ./include/user/ui/mem_usage.h
- 899f3082e36d7d817d348f150179cc2f ./include/user/ui/num_procs.h
- 049a26eebf44e1623f54566b1ea9348b ./include/user/ui/sensor_interface.h
- 56b38ac61d67f9a222db25c9b1ab9de8 ./include/user/ui/pathing.h
- 9156648c3a0d7d5b91bf3fc402d1cc34 ./include/user/uio.h
- d47d233638965087188ea0d520eecf86 ./include/user/writerservice.h
- da562ad7f15a420875928af0ccf95c75 ./include/user/shell.h
- d59d57ef40d540f2e1b1ea9cc3e3a198 ./include/user/terminal_manager.h
- cef618f750b9cab519c49a2c48d6209a ./include/test/task_queue.h
- da8f87595b3fe2fb7515375e774f84e3 ./include/test/priority_queue.h
- 690895d6c3b3b0f0c0f3c2ab91e81af7 ./include/test/ioserver_buffer.h
- 413f9dc24b31e9664043e5231749a17b ./include/test/nameserver.h
- 2e764754296ba831c89b7e03929de399 ./include/test/clockserver_queue.h
- 660038d9adc85b7933a6e8444dbfe997 ./include/test/test.h
- f8a3ef8926a2bffe49f879b30525f787 ./include/test/circular_buffer.h
- 2912cfa8be65ab45df105fe59e1330aa ./include/test/buffer_pack.h
- 4bd5f32fc2ad8650a9aeeaea0c402338 ./include/test/terminal.h
- 5244e365f5db2ec3ab2ccb0cf8cb788c ./include/test/string.h
- 9bef2af3f9fd38e976b440c999cd56a8 ./include/test/train/path_finding.h
- 96df9c7f7c72e0006d7fc798681f16fc ./include/test/train/priority_queue.h
- 3aa975dfcc7e26668a308385c0098ca4 ./include/ascii.h
- 657c7352e7cfeae7f26433f4d1525ddd ./include/io.h
- 52f043964db83fc21ce5fa90a176a586 ./include/conf/windows.h