**Methodology:**

The work methodology is explained briefly in this chapter. The environment set up, how we install the planners and design of the domain, and the problem are described briefly in this section. First, "Train Scheduling and Planning Model Development" discussed the railway system and some complex decision-making problems in train scheduling. "Domain Design" explains how we design domains. "Problem design" explains how we generate problem files.

"Plan Metrics" explains the metric function. "Planner" explained the planning and installation process of it. Then finally, "Plan Validation," or how we validate a plan.

**Train Scheduling and Planning Model Development:** A railway system is a very complex system. It has many complex decision-making problems like route choice, crossing, waiting and stopping, etc. Line maintenance and accidents are also an obstacle to the scheduled train system. It is a very challenging task to schedule the operation of a train system. This section explains how we design the scheduling model using automated temporal planning.

**Domain design:** When it comes to planning and scheduling issues, domain design is crucial. The train, line, and station are the most significant aspects of our scheduling problem. If the line is not free, a train cannot move from one station to another. If the line is free, the move is valid. Train-at, visited, valid-move, stoppage-at, and free-line are the five predicates we created. Also, take three durative-actions to address real-world issues. Durative-actions are drive, wait, and stop.

**3.2.1-Temporal Action drive-train:**

( (:durative-action drive-train

:parameters (?t - train ?from ?to - station ?l - line)

:duration (= ?duration (/(station-distance ?from ?to ) (train-speed ?t)))

:condition (and (at start (train-at ?t ?from))

(at start (valid-move ?from ?to ?l))

(over all (free-line ?l))

(over all (not (maintenance-line ?l)))

)

:effect(and(at start (not (train-at ?t ?from)))

(at start (not (free-line ?l)))

(at end (train-at ?t ?to))

(at end (free-line ?l))

(at end (increase (total-cost) (\* ?duration 1)))

)

)

In this durative-action train, station and line are the parameters. A train can make a valid move only if the line free condition is true. Duration of the this action is calculated by the driving time with respect to the distance between two stations and the speed of the train. When the drive action is executed, there will be the following effects:

-Train will move to the next station and not be at the previous station.

-At the start line, it will be busy to avoid collision with other trains.

-The train reaches the next station and

-Line will be free again.

-Cost will increase with duration.

**3.2.2- Temporal Action stop-train:**

(:durative-action stop-train

:parameters (?t - train ?s - station)

:duration (= ?duration 2)

:condition (and

(over all (train-at ?t ?s))

(at start (stoppage-at ?t ?s))

)

:effect (and

(at start (not (stoppage-at ?t ?s)))

(at end (visited ?t ?s))

(at end (increase (total-cost) (\* ?duration 0)))

)

)

Train and station are parameters in this durative-action. Duration time is 2 (fixed by duration). The action is executed after checking the train location. If the train is at its stopping station, then the train will stop. After execution, there will be the following effect on our proposed plan:

-Station is visited and the train stopped.

-The train is not at a stoppage.

-Increase the total cost with duration.

**3.2.3- Temporal Action maintenance-for:**

During the maintenance period of a line, no train can pass through this line and trains need to wait at the nearest station until the maintenance period is over.

(:durative-action maintenance-for

:parameters (?l - line ?t - train ?from - station ?to - station)

:duration (= ?duration 3)

:condition (and

(at start (train-at ?t ?from))

(at start (maintenance-line ?l))

(at start (valid-move ?from ?to ?l))

)

:effect (and

(at end (not(maintenance-line ?l)

))

(at end (increase (total-cost) (\* ?duration 0)))

)

)

In this durative-action station, train and line are the parameters. The default waiting time is 3.

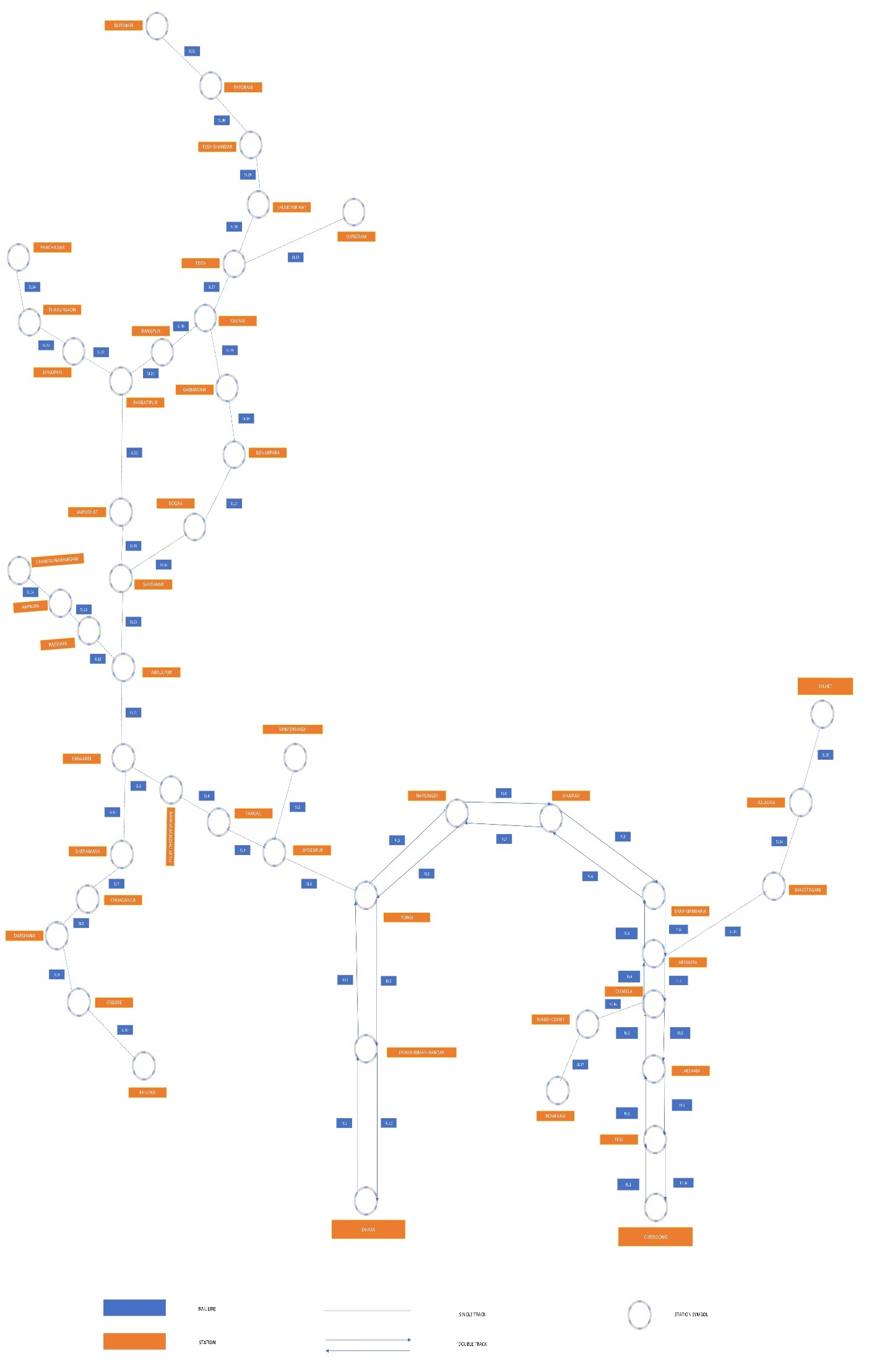
After checking the train location, maintenance and line condition, the action will be executed. After execution, the following effects will be there:

-Maintenance mode is over and the line will be free.

**Problem design:**

Here we designed a problem model of a train scheduling problem. We prepared the initial state, valid moves, distance between two adjacent stations, and goal. In the initial state, we assume that some trains are at stations. The goal is to reach specific other stations. Valid moves, free-lines, and distance are given. The lines that will be in maintenance mode are also given. We also created a problem generator file called "Plan.sh" that can design problem files automatically based on input. In our testing problem, we take 15 different trains, for a total of 57 rail lines and 47 stations. A simplified map of BR with routes and stations is given on the next page.

Now, an automated temporal planner will generate an optimal plan schedule to reach the destination stations.

****

(define (problem train-scheduling)

(:domain temporal-train-schedule)

(:objects

;Train Name

suborno-express truna-express bonolota-express ekota-express drutojan-express chitra-express sundorban-express paharika-express upobon-express titumir-express rupsha-express kurigram-express kapataksha-express udayan-express upokul-express - train

;Station Name

Dhaka Dhaka-Biman-Bandar Tongi Narsingdi Bhairab Brahmanbaria Akhaura Cumilla Laksham Feni Chittagong - station

Maijdi-Court Noakhali Shaestaganj Kulaura Sylhet Joydebpur Mymensingh Tangail Bangabandhu-Setu Ishwardi Khulna Abdulpur Rajshahi - station

Bheramara Chuadanga Darshana Jessore Amnura Chanpainawabganj Santahar Jaypurhat Parbatipur Bogra Bonapara Gaibanda - station

Dinajpur Thakurgaon Panchagar Rangpur Kaunia Tista Kurigram Lalmonir-Hat Tush-Bhandar Patgram Burimari - station

;Forward Line

fl1 fl2 fl3 fl4 fl5 fl6 fl7 fl8 fl9 fl10 - forward-line

;Reverse Line

rl1 rl2 rl3 rl4 rl5 rl6 rl7 rl8 rl9 rl10 - reverse-line

;Single Line

sl1 sl2 sl3 sl4 sl5 sl6 sl7 sl8 sl9 sl10 sl11 sl12 sl13 sl14 sl15 sl16 sl17 sl18 sl19 sl20 sl21 sl22 sl23 sl24 sl25 sl26 sl27 - single-line

sl28 sl29 sl30 sl31 sl32 sl33 sl34 sl35 sl36 sl37 - single-line

)

(:init

;Forward Move

(valid-move Dhaka Dhaka-Biman-Bandar fl1)

(valid-move Dhaka-Biman-Bandar Tongi fl2)

(valid-move Tongi Narsingdi fl3)

(valid-move Narsingdi Bhairab fl4)

(valid-move Bhairab Brahmanbaria fl5)

(valid-move Brahmanbaria Akhaura fl6)

(valid-move Akhaura Cumilla fl7)

(valid-move Cumilla Laksham fl8)

(valid-move Laksham Feni fl9)

(valid-move Feni Chittagong fl10)

(valid-move Tongi Joydebpur sl1)

(valid-move Joydebpur Mymensingh sl2)

(valid-move Joydebpur Tangail sl3)

(valid-move Tangail Bangabandhu-Setu sl4)

(valid-move Bangabandhu-Setu Ishwardi sl5)

(valid-move Ishwardi Bheramara sl6)

(valid-move Bheramara Chuadanga sl7)

(valid-move Chuadanga Darshana sl8)

(valid-move Darshana Jessore sl9)

(valid-move Jessore Khulna sl10)

(valid-move Ishwardi Abdulpur sl11)

(valid-move Abdulpur Rajshahi sl12)

(valid-move Rajshahi Amnura sl13)

(valid-move Amnura Chanpainawabganj sl14)

(valid-move Abdulpur Santahar sl15)

(valid-move Santahar Bogra sl16)

(valid-move Bogra Bonapara sl17)

(valid-move Bonapara Gaibanda sl18)

(valid-move Gaibanda Kaunia sl19)

(valid-move Santahar Jaypurhat sl20)

(valid-move Jaypurhat Parbatipur sl21)

(valid-move Parbatipur Dinajpur sl22)

(valid-move Dinajpur Thakurgaon sl23)

(valid-move Thakurgaon Panchagar sl24)

(valid-move Parbatipur Rangpur sl25)

(valid-move Rangpur Kaunia sl26)

(valid-move Kaunia Tista sl27)

(valid-move Tista Lalmonir-Hat sl28)

(valid-move Lalmonir-Hat Tush-Bhandar sl29)

(valid-move Tush-Bhandar Patgram sl30)

(valid-move Patgram Burimari sl31)

(valid-move Tista Kurigram sl32)

(valid-move Akhaura Shaestaganj sl33)

(valid-move Chanpainawabganj Kulaura sl34)

(valid-move Kulaura Sylhet sl35)

(valid-move Cumilla Maijdi-Court sl36)

(valid-move Maijdi-Court Noakhali sl37)

;Reverse Move

(valid-move Chittagong Feni rl1)

(valid-move Feni Laksham rl2)

(valid-move Laksham Cumilla rl3)

(valid-move Cumilla Akhaura rl4)

(valid-move Akhaura Brahmanbaria rl5)

(valid-move Brahmanbaria Bhairab rl6)

(valid-move Bhairab Narsingdi rl7)

(valid-move Narsingdi Tongi rl8)

(valid-move Tongi Dhaka-Biman-Bandar rl9)

(valid-move Dhaka-Biman-Bandar Dhaka rl10)

(valid-move Joydebpur Tongi sl1)

(valid-move Mymensingh Joydebpur sl2)

(valid-move Tangail Joydebpur sl3)

(valid-move Bangabandhu-Setu Tangail sl4)

(valid-move Ishwardi Bangabandhu-Setu sl5)

(valid-move Bheramara Ishwardi sl6)

(valid-move Chuadanga Bheramara sl7)

(valid-move Darshana Chuadanga sl8)

(valid-move Jessore Darshana sl9)

(valid-move Khulna Jessore sl10)

(valid-move Abdulpur Ishwardi sl11)

(valid-move Rajshahi Abdulpur sl12)

(valid-move Amnura Rajshahi sl13)

(valid-move Chanpainawabganj Amnura sl14)

(valid-move Santahar Abdulpur sl15)

(valid-move Bogra Santahar sl16)

(valid-move Bonapara Bogra sl17)

(valid-move Kaunia Bonapara sl18)

(valid-move Jaypurhat Santahar sl19)

(valid-move Bheramara Chuadanga sl20)

(valid-move Parbatipur Jaypurhat sl21)

(valid-move Dinajpur Parbatipur sl22)

(valid-move Thakurgaon Dinajpur sl23)

(valid-move Panchagar Thakurgaon sl24)

(valid-move Rangpur Parbatipur sl25)

(valid-move Kaunia Rangpur sl26)

(valid-move Tista Kaunia sl27)

(valid-move Lalmonir-Hat Tista sl28)

(valid-move Tush-Bhandar Lalmonir-Hat sl29)

(valid-move Patgram Tush-Bhandar sl30)

(valid-move Burimari Patgram sl31)

(valid-move Kurigram Tista sl32)

(valid-move Shaestaganj Akhaura sl33)

(valid-move Kulaura Shaestaganj sl34)

(valid-move Sylhet Kulaura sl35)

(valid-move Maijdi-Court Cumilla sl36)

(valid-move Noakhali Maijdi-Court sl37)

;line-status

(free-line fl1)

(free-line fl2)

(free-line fl3)

(free-line fl4)

(free-line fl5)

(free-line fl6)

(free-line fl7)

(free-line fl8)

(free-line fl9)

(free-line fl10)

(free-line rl1)

(free-line rl2)

(free-line rl3)

(free-line rl4)

(free-line rl5)

(free-line rl6)

(free-line rl7)

(free-line rl8)

(free-line rl9)

(free-line rl10)

(free-line sl1)

(free-line sl2)

(free-line sl3)

(free-line sl4)

(free-line sl5)

(free-line sl6)

(free-line sl7)

(free-line sl8)

(free-line sl9)

(free-line sl10)

(free-line sl11)

(free-line sl12)

(free-line sl13)

(free-line sl14)

(free-line sl15)

(free-line sl16)

(free-line sl17)

(free-line sl18)

(free-line sl19)

(free-line sl20)

(free-line sl21)

(free-line sl22)

(free-line sl23)

(free-line sl24)

(free-line sl25)

(free-line sl26)

(free-line sl27)

(free-line sl28)

(free-line sl29)

(free-line sl30)

(free-line sl31)

(free-line sl32)

(free-line sl33)

(free-line sl34)

(free-line sl35)

(free-line sl36)

(free-line sl37)

;station-distance in meters

(= (station-distance Dhaka-Biman-Bandar Dhaka)60)

(= (station-distance Tongi Dhaka-Biman-Bandar)70)

(= (station-distance Narsingdi Tongi)50)

(= (station-distance Bhairab Narsingdi)80)

(= (station-distance Brahmanbaria Bhairab)75)

(= (station-distance Akhaura Brahmanbaria)55)

(= (station-distance Cumilla Akhaura)28)

(= (station-distance Laksham Cumilla)25)

(= (station-distance Laksham Feni)90)

(= (station-distance Feni Chittagong)52)

(= (station-distance Tongi Joydebpur)20)

(= (station-distance Joydebpur Mymensingh)40)

(= (station-distance Joydebpur Tangail)40)

(= (station-distance Tangail Bangabandhu-Setu)60)

(= (station-distance Bangabandhu-Setu Ishwardi)30)

(= (station-distance Ishwardi Bheramara)95)

(= (station-distance Bheramara Chuadanga)25)

(= (station-distance Chuadanga Darshana)80)

(= (station-distance Darshana Jessore)75)

(= (station-distance Jessore Khulna)45)

(= (station-distance Ishwardi Abdulpur)20)

(= (station-distance Abdulpur Rajshahi)70)

(= (station-distance Rajshahi Amnura)50)

(= (station-distance Amnura Chanpainawabganj)65)

(= (station-distance Abdulpur Santahar)55)

(= (station-distance Santahar Bogra)40)

(= (station-distance Bogra Bonapara)30)

(= (station-distance Bonapara Gaibanda)40)

(= (station-distance Gaibanda Kaunia)20)

(= (station-distance Santahar Jaypurhat)35)

(= (station-distance Jaypurhat Parbatipur)60)

(= (station-distance Parbatipur Dinajpur)26)

(= (station-distance Dinajpur Thakurgaon)47)

(= (station-distance Thakurgaon Panchagar)50)

(= (station-distance Parbatipur Rangpur)36)

(= (station-distance Rangpur Kaunia)61)

(= (station-distance Kaunia Tista)47)

(= (station-distance Tista Lalmonir-Hat)36)

(= (station-distance Lalmonir-Hat Tush-Bhandar)45)

(= (station-distance Tush-Bhandar Patgram)55)

(= (station-distance Patgram Burimari)68)

(= (station-distance Tista Kurigram)88)

(= (station-distance Akhaura Shaestaganj)35)

(= (station-distance Shaestaganj Kulaura)40)

(= (station-distance Kulaura Sylhet)30)

(= (station-distance Cumilla Maijdi-Court)42)

(= (station-distance Maijdi-Court Noakhali)80)

; Reverse station-distance

(= (station-distance Dhaka Dhaka-Biman-Bandar)60)

(= (station-distance Dhaka-Biman-Bandar Tongi)70)

(= (station-distance Tongi Narsingdi)50)

(= (station-distance Narsingdi Bhairab)80)

(= (station-distance Bhairab Brahmanbaria)75)

(= (station-distance Brahmanbaria Akhaura)55)

(= (station-distance Akhaura Cumilla)28)

(= (station-distance Cumilla Laksham)25)

(= (station-distance Laksham Feni)90)

(= (station-distance Feni Chittagong)52)

(= (station-distance Joydebpur Tongi)20)

(= (station-distance Mymensingh Joydebpur)40)

(= (station-distance Tangail Joydebpur)40)

(= (station-distance Bangabandhu-Setu Tangail)60)

(= (station-distance Ishwardi Bangabandhu-Setu)30)

(= (station-distance Bheramara Ishwardi)95)

(= (station-distance Chuadanga Bheramara)25)

(= (station-distance Darshana Chuadanga)80)

(= (station-distance Jessore Darshana)75)

(= (station-distance Khulna Jessore)45)

(= (station-distance Abdulpur Ishwardi)20)

(= (station-distance Rajshahi Abdulpur)70)

(= (station-distance Amnura Rajshahi)50)

(= (station-distance Chanpainawabganj Amnura)65)

(= (station-distance Santahar Abdulpur)55)

(= (station-distance Bogra Santahar)40)

(= (station-distance Bonapara Bogra)30)

(= (station-distance Gaibanda Bonapara)40)

(= (station-distance Kaunia Gaibanda)20)

(= (station-distance Jaypurhat Santahar)35)

(= (station-distance Parbatipur Jaypurhat)60)

(= (station-distance Dinajpur Parbatipur)26)

(= (station-distance Thakurgaon Dinajpur)47)

(= (station-distance Panchagar Thakurgaon)50)

(= (station-distance Rangpur Parbatipur)36)

(= (station-distance Kaunia Rangpur)61)

(= (station-distance Tista Kaunia)47)

(= (station-distance Lalmonir-Hat Tista)36)

(= (station-distance Tush-Bhandar Lalmonir-Hat)45)

(= (station-distance Patgram Tush-Bhandar)55)

(= (station-distance Burimari Patgram)68)

(= (station-distance Kurigram Tista)88)

(= (station-distance Shaestaganj Akhaura)35)

(= (station-distance Kulaura Shaestaganj)40)

(= (station-distance Sylhet Kulaura)30)

(= (station-distance Maijdi-Court Cumilla)42)

(= (station-distance Noakhali Maijdi-Court)80)

(maintenance-line sl37)

(=(train-speed upokul-express)10)

(train-at upokul-express Dhaka)

(visited upokul-express Dhaka)

(stoppage-at upokul-express Dhaka-Biman-Bandar)

(stoppage-at upokul-express Narsingdi)

(stoppage-at upokul-express Bhairab)

(stoppage-at upokul-express Brahmanbaria)

(stoppage-at upokul-express Akhaura)

(stoppage-at upokul-express Cumilla)

(stoppage-at upokul-express Maijdi-Court)

(stoppage-at upokul-express Noakhali)

(=(train-speed drutojan-express)10)

(train-at drutojan-express Dhaka)

(visited drutojan-express Dhaka)

(stoppage-at drutojan-express Tangail)

(stoppage-at drutojan-express Bangabandhu-Setu)

(stoppage-at drutojan-express Ishwardi)

(stoppage-at drutojan-express Joydebpur)

(stoppage-at drutojan-express Panchagar)

(stoppage-at drutojan-express Dhaka-Biman-Bandar)

(stoppage-at drutojan-express Dhaka)

)

(:goal

(and(visited upokul-express Dhaka-Biman-Bandar)

(visited upokul-express Narsingdi)

(visited upokul-express Bhairab)

(visited upokul-express Brahmanbaria)

(visited upokul-express Akhaura)

(visited upokul-express Cumilla)

(visited upokul-express Maijdi-Court)

(visited upokul-express Noakhali)

(visited drutojan-express Tangail)

(visited drutojan-express Bangabandhu-Setu)

(visited drutojan-express Ishwardi)

(visited drutojan-express Joydebpur)

(visited drutojan-express Panchagar)

(visited drutojan-express Dhaka-Biman-Bandar)

(visited drutojan-express Dhaka)

))

(:metric minimize (total-cost))

)

**Plan Metrics:** The goals of the objectives function are modeled as plan metrics. The automated temporal planner generates the plan according to plan metrics. We used the following metrics in our work:

1. (:metric minimize (total-cost))

**Planner:** We chose LPG-TD as the automated temporal planner to generate the plan schedule. LPG-TD can handle most of the PDDL 2.1 likes numeric fluents, durative actions, continuous effects and negative preconditions etc. [1]  and all the features of PDDL2.2. LPG-TD planner can also give us an optimal plan when quality is more important than solutions. It can be operated in three modes. These are speed, quality, and n [the number of plans we want to generate]. LPG-TD keeps searching for a better solution, also known as plan schedule, as long as time and memory permits although it finds the first solution. That’s why we chose the LPG-TG planner in our work to generate optimal train schedules.

**Installation:**

***Installation process of LPG-td:***

First, download the LPG-td planner, https://lpg.unibs.it/lpg/

Then,

- Copy lpgtd-linux.tar.gz into the directory where you want to have the planner.

-From this directory, run the following code:

gunzip lpgtd-linux.tar.gz

tar xvf pgtd-linux.tar

To test the plan, run the following script in a terminal:

./lpg-td -o op-file-name -f p-file-name -n 3

where op-file-name represents the domain file, p-file-name represents the problem file, and -n represents the desired number of solutions.

Before running the planner, you need to know about the basic and necessary settings.

Check here for details: https://github.com/fawcettc/planning-features/blob/master/lpg/README-LPGTD

Additionally, to run LPG-td, Singularity and GO are needed.

To install Singularity and Go on your machine, visit: https://github.com/sylabs/singularity/blob/main/INSTALL.md

1

@inproceedings{Gerevini2004LPGTDA,

title={LPG-TD : a Fully Automated Planner for PDDL 2 . 2 Domains},

author={Alfonso Gerevini and Alessandro Saetti and Ivan Serina and Paolo Toninelli},

year={2004}

}

**Model Evaluation:** We evaluate our scheduling model domain with respect to our problem statement in the previous section. Our first challenge was whether the domain model could be developed using temporal specifications. The second question was, "Can an automated schedule be generated using the model?" The third question was, "Is the generated schedule correct?" The fourth question was whether the generated schedule could optimize train scheduling, and the final question or challenge was whether the domain model could generate a schedule at the optimal time.

**Generated Plan:**

; Version LPG-td-1.4

; Seed 68031938

; Command line: ./lpg-td -o domain\_temporal.pddl -f problem\_temporal.pddl -quality -timesteps -out train\_plan

; Problem problem\_temporal.pddl

; Time 1.01

; Plan generation time 0.55

; Search time 0.54

; Parsing time 0.01

; Mutex time 0.00

; MetricValue 118.50

0.0003: (DRIVE-TRAIN DRUTOJAN-EXPRESS DHAKA DHAKA-BIMAN-BANDAR FL1) [6.0000]

6.0005: (STOP-TRAIN DRUTOJAN-EXPRESS DHAKA-BIMAN-BANDAR) [2.0000]

8.0007: (DRIVE-TRAIN DRUTOJAN-EXPRESS DHAKA-BIMAN-BANDAR TONGI FL2) [7.0000]

15.0010: (DRIVE-TRAIN DRUTOJAN-EXPRESS TONGI JOYDEBPUR SL1) [2.0000]

17.0012: (STOP-TRAIN DRUTOJAN-EXPRESS JOYDEBPUR) [2.0000]

6.0015: (DRIVE-TRAIN UPOKUL-EXPRESS DHAKA DHAKA-BIMAN-BANDAR FL1) [6.0000]

12.0017: (STOP-TRAIN UPOKUL-EXPRESS DHAKA-BIMAN-BANDAR) [2.0000]

15.0020: (DRIVE-TRAIN UPOKUL-EXPRESS DHAKA-BIMAN-BANDAR TONGI FL2) [7.0000]

22.0023: (DRIVE-TRAIN UPOKUL-EXPRESS TONGI NARSINGDI FL3) [5.0000]

27.0025: (STOP-TRAIN UPOKUL-EXPRESS NARSINGDI) [2.0000]

29.0028: (DRIVE-TRAIN UPOKUL-EXPRESS NARSINGDI BHAIRAB FL4) [8.0000]

37.0030: (STOP-TRAIN UPOKUL-EXPRESS BHAIRAB) [2.0000]

39.0033: (DRIVE-TRAIN UPOKUL-EXPRESS BHAIRAB BRAHMANBARIA FL5) [7.5000]

46.5035: (STOP-TRAIN UPOKUL-EXPRESS BRAHMANBARIA) [2.0000]

48.5037: (DRIVE-TRAIN UPOKUL-EXPRESS BRAHMANBARIA AKHAURA FL6) [5.5000]

54.0040: (STOP-TRAIN UPOKUL-EXPRESS AKHAURA) [2.0000]

56.0042: (DRIVE-TRAIN UPOKUL-EXPRESS AKHAURA CUMILLA FL7) [2.8000]

58.8045: (STOP-TRAIN UPOKUL-EXPRESS CUMILLA) [2.0000]

60.8047: (DRIVE-TRAIN UPOKUL-EXPRESS CUMILLA MAIJDI-COURT SL36) [4.2000]

65.0050: (MAINTENANCE-FOR SL37 UPOKUL-EXPRESS MAIJDI-COURT NOAKHALI) [3.0000]

65.0052: (STOP-TRAIN UPOKUL-EXPRESS MAIJDI-COURT) [2.0000]

68.0055: (DRIVE-TRAIN UPOKUL-EXPRESS MAIJDI-COURT NOAKHALI SL37) [8.0000]

76.0058: (STOP-TRAIN UPOKUL-EXPRESS NOAKHALI) [2.0000]

19.0060: (DRIVE-TRAIN DRUTOJAN-EXPRESS JOYDEBPUR TANGAIL SL3) [4.0000]

23.0063: (STOP-TRAIN DRUTOJAN-EXPRESS TANGAIL) [2.0000]

25.0065: (DRIVE-TRAIN DRUTOJAN-EXPRESS TANGAIL BANGABANDHU-SETU SL4) [6.0000]

31.0068: (STOP-TRAIN DRUTOJAN-EXPRESS BANGABANDHU-SETU) [2.0000]

33.0070: (DRIVE-TRAIN DRUTOJAN-EXPRESS BANGABANDHU-SETU ISHWARDI SL5) [3.0000]

36.0073: (STOP-TRAIN DRUTOJAN-EXPRESS ISHWARDI) [2.0000]

38.0075: (DRIVE-TRAIN DRUTOJAN-EXPRESS ISHWARDI ABDULPUR SL11) [2.0000]

40.0078: (DRIVE-TRAIN DRUTOJAN-EXPRESS ABDULPUR SANTAHAR SL15) [5.5000]

45.5080: (DRIVE-TRAIN DRUTOJAN-EXPRESS SANTAHAR JAYPURHAT SL20) [3.5000]

49.0083: (DRIVE-TRAIN DRUTOJAN-EXPRESS JAYPURHAT PARBATIPUR SL21) [6.0000]

55.0085: (DRIVE-TRAIN DRUTOJAN-EXPRESS PARBATIPUR RANGPUR SL25) [3.6000]

58.6087: (DRIVE-TRAIN DRUTOJAN-EXPRESS RANGPUR PARBATIPUR SL25) [3.6000]

62.2090: (DRIVE-TRAIN DRUTOJAN-EXPRESS PARBATIPUR DINAJPUR SL22) [2.6000]

64.8092: (DRIVE-TRAIN DRUTOJAN-EXPRESS DINAJPUR THAKURGAON SL23) [4.7000]

69.5095: (DRIVE-TRAIN DRUTOJAN-EXPRESS THAKURGAON PANCHAGAR SL24) [5.0000]

74.5098: (STOP-TRAIN DRUTOJAN-EXPRESS PANCHAGAR) [2.0000]

We validated the first three questions using a validation tool called VAL [1]. VAL tools verify domain development is correct according to PDDL 2.2 and the PDDL 2.2 specification. The plan schedule we generated is correct. Forth answer, using the automated temporal planner, our domain mode can generally optimally solve problems using quality operation mode. Finally, the domain model can generate a schedule in optima time using speed operation mode. But the generated plan is not the optimal solution.

1.

@INPROCEEDINGS{1374201, author={Howey, R. and Long, D. and Fox, M.}, booktitle={16th IEEE International Conference on Tools with Artificial Intelligence}, title={VAL: automatic plan validation, continuous effects and mixed initiative planning using PDDL}, year={2004}, volume={}, number={}, pages={294-301}, doi={10.1109/ICTAI.2004.120}}

**Summary:** This chapter explains the working process. It explains briefly how we design domain and problem files step by step. The domain consists of 3 functions: drive-train, stop-train, and maintenance-for. In our testing problem, we take 15 different trains, for a total of 57 rail lines and 47 stations. This chapter also describes the plan metrics, planner, and the installation process of the planner. And at last, the model evaluation is described.