A tool for periodic timetabling (for suburban railways)

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Outline

- Objectives of the tool: 'IITB-Suburban-Service-Timetabler'
- Types of constraints
- Data formats: input and output
- Methods/techniques
- Further plans

Objective

- Timetabling: Herculean task when done manually
- Various complex constraints
- Only few experts can modify manually
- Can only 'tweak' existing timetable
- Periodic constraints: need of the 'hour'

Periodic timetable

- Desired: hourly timetable
- Only minute-value to remember (for each service)
- Need not be exactly evenly spaced
- Repeats each hour: for example:
- from CST to Vashi, say 3 services per hour:
  8:13, 8:40, 8:52,
  9:13, 9:40, 9:52,
  10:13, 10:40, 10:52
- Aim: 'quite' well-spaced within the hour

Constraints

Hard constraints:

- Headway constraints
- Frequency of service
- Minimum traversal times
- Turn-around constraints

Soft constraints:

- Spacing between consecutive ‘similar’ services

Inputs to the tool

Inputs offline (for now):
Different infrastructural parameters:

- Stations, tracks
- types of services:

Inputs Online: web-version:

- Passenger demands, traversal times
- turnaround times at terminals

Timetable downloadable from the website in a few hours (or minutes)

Tool output

A feasible periodic timetable
Guaranteed to satisfy:

- headway, turnaround, traversal constraints
- specified frequency

Incorporated into timetable generation
Output-format: One up-file, and one down-file

More output

Rake linkage chart:

- Rake cycles
  list of services to be performed by each rake
- Number of rakes also calculated

More output

A terminal occupancy chart:
Occupancy of each major station
Number of trains occupying terminal resources plotted time-wise

Future plan: A graphical way of viewing terminal occupancy

Planned improvements

- Line planning can be incorporated
- Proper platform allocation at all stations
- A graphical editing tool for viewing the network and changing any infrastructure

PRESENT PLAN

- As of now inputs will be taken from the Central Railways office through a web-interface.
- The inputs asked will be frequency, turnaround time and traversal times.
- The outputs will be displayed on a web page within a day

Sample output timetable

Arrival and departure timings

CSTa	CSTd	VDRDa	VDRDd	TNAa	TNAd	TUHa	TUHd	MNKDa	MNKDd	VSHa	VSHd	NERa	NERd	BEPRa	BEPRd	PNVLa	PNVLd	BAa	BAd	ANDa	ANDd
	53	10	10.5					30.5	31	38	38.5	46.5	47	52	52.5	8.5					
	24.5	41.5	42.5					2.5	3	10	11	19	20	25	25.5	41.5					
	36	53	53.5					13.5	14	21	22	30	31	36	37	53					
	15.5	32.5	33.5					53.5	54	1	1.5	9.5	10	15	15.5	31.5					
	5.5	22.5	23.5					43.5	44	51	52	0	0.5	5.5	6	22					
	8.5	25.5	26.5					46.5	47	54	55	3	3.5	8.5							
	33	50	50.5					10.5	11	18	18.5	26.5	27	32							
	50	7	7.5					27.5	28	35	35.5	43.5	44	49							
	30	47	47.5					7.5	8	15											
	57	14	14.5					34.5	35	42											

Each column: arrival or departure at station

Each row: one service

Hour-value not required, minute-values

$45.5 \equiv 45$ minutes, 30 seconds

Sample: rake linkage

Service-type	Service num-ber	Source	Dest.	Dep	Arr.	linking service	
1	6	PNVL	CST	28	45	linked with	service number 15
2	15	CST	BEPR	50	49	linked with	service number 12
2	12	BEPR	CST	55	54	linked with	service number 19
4	19	CST	VSH	57	42	linked with	service number 18
4	18	VSH	CST	48	33	linked with	service number 5
1	5	CST	PNVL	36	53	linked with	service number 34
8	34	PNVL	VDRD	1	0.5	linked with	service number 31
8	31	VDRD	PNVL	3.5	1.5	linked with	service number 8
1	8	PNVL	CST	4.5	21.5	linked with	service number 3

Sample: platform occupancy

Service no. 10 enters CST as PNVL-CST service at 30.0 and leaves at 33.0 as CST-BEPR service with service no. 13

Service no. 18 enters CST as VSH-CST service at 33.0 and leaves at 36.0 as CST-PNVL service with service no. 5

Service no. 16 enters CST as BEPR-CST service at 36.0 and leaves at 39.0 as CST-AND service with service no. 25

Service no. 28 enters CST as BA-CST service at 39.0 and leaves at 42.0 as CST-BA service with service no. 27

Working time table (taken from Central Railway)

Train No.	99001	98025	98811	98027	98303	98711	98029	98031
Train Code	TPL 1 DC 12 CAR	PL 21 DC	B 11 AC DC	PL 23 AC DC	BR 3 DC	AD 11 AC DC	PL 25 DC	PLVD 1 DC
					X		X	X
Stations Code								
CSTM	TNA	06:00	06:04	06:08	06:12	06:16	06:20	
MSD	06:20	06:03	06:07	06:11	06:15	06:19	06:23	
SNRD		06:06	06:10	06:14	06:18	06:22	06:26	R/O
DKRD		06:08	06:12	06:16	06:20	06:24	06:28	VVD 2
RRD		06:10	06:14	06:18	06:22	06:26	06:30	06:34
CTGN		06:12	06:16	06:20	06:24	06:28	06:32	
SVE		06:15	06:19	06:23	06:27	06:31	06:35	
VDLR		06:18	06:22	06:26	06:30	06:34	06:38	06:42
RVJ		06:20	06:24	06:28	06:32	06:36	06:40	06:45
KCE			06:26			06:38		
MM			06:28			06:40		
BA			06:32			06:44		
KHR						06:48		
STC						06:51		
VLP						06:54		
ADH						06:58		
GTBN		06:22		06:30	06:34		06:42	06:47
CHF		06:25		06:33	06:37		06:45	06:50
CLA		06:28		06:36	06:40		06:48	06:53
TKNG		06:31		06:39	06:43		06:51	06:56
CMBR		06:33		06:41	06:45		06:53	06:58
GV		06:36		06:44	06:48		06:56	07:01
MNKD		06:39		06:47	06:51		06:59	07:04
VSH		06:47		06:55	06:59		07:07	07:12
SNPD		06:49		06:57	07:01		07:09	07:14
JNJ		06:52		07:00	07:04		07:12	07:17
NEU	06:51	06:56		07:04	07:08		07:16	07:21
SWDV	06:55	06:59		07:07	07:11		07:19	07:24
BEPR	06:58	07:02		07:10	07:15		07:22	07:29
KHAG	07:02	07:06		07:14			07:26	07:33
MANR	07:05	07:09		07:17			07:29	07:36
KNDS	07:08	07:12		07:20			07:32	07:39
PNVL	07:13	07:17		07:25			07:37	07:44
Rake will work as	TPL 10 07:24	PLVD 4 07:28	B 14 06:40	PLAD 5 07:40	BR 22 07:26	AD 14 07:06	PL 28 07:48	PLVD 6 07:56

Method/techniques used

- Mixed Integer Linear Programming (MILP) formulation
- Due to soft/hard (and integer) constraints
- Computationally difficult to solve
- Gurobi for solving MILP
- For pre-post processing: Python and Bash scripting
- Final output: xls-like file (csv file)
- Web-interface for input/output

Credits for Gurobi/Python implementation: Shashank Dangayach and Soumya Dutta

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Thank you