Bridging the gap between Course Work and Real Life Problems

Under the guidance of Prof. Milind Sohoni

Charu Agarwal

IIT Dharwad

March 31, 2018

Today...

- What is the current course structure?
  - How to apply the concepts taught in classroom.
  - Connection with reality.
  - How can we enrich our curriculum?
  - Why engagement with society is important?
- Case Studies
  - Analysing data. The census. The railway system. The bus-depot.
- The Dharwad City Bus Depot
  - Various steps and its connection with our curricula.
  - Intermediate and final output.

What is the current course structure

and what is its connection to everyday problems?

- Asymptotic Notation
- Sorting and Searching
- Divide and Conquer
- Greedy Algorithms
- Graph Theory
- Dynamic Programming
- NP-completeness
- and much more......

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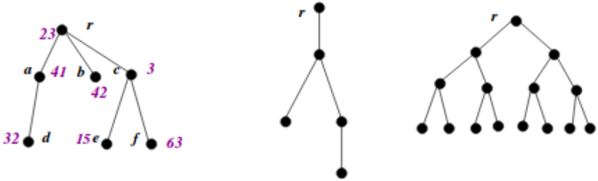
- and much more......

How to adapt them to everyday life?
Real Life Problems are manifold complex than standard textbook problems!

What is being taught?

A rooted tree

Rooted Tree: $T(V, E), r$ is a rooted tree iff (i) T is a tree and $r \in V$ is a vertex (called the **root**, and (ii) there is a function call $level : V \to \mathbb{Z}$ such that (a) $level(r) = 0$, (b) $level(v) \geq 0$, and (c) each vertex v of level $d > 0$ is connected to exactly one vertex w of level $d - 1$. Then w is called the **parent** of v and v the **child** of w. A vertex with no children is called a **leaf node**.



A tree with n vertices has exactly $n - 1$ edges.

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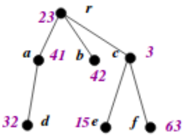

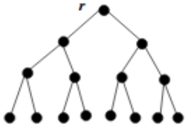

A tree with n vertices has exactly $n-1$ edges.

Too much abstraction!

And what is the reality ...

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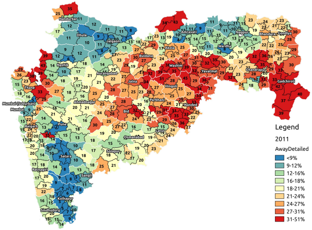
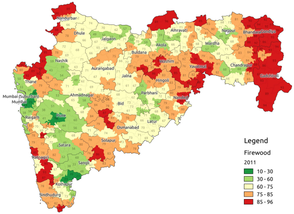
Percentage of Rural Households with Primary Source more than 500m away (2011)

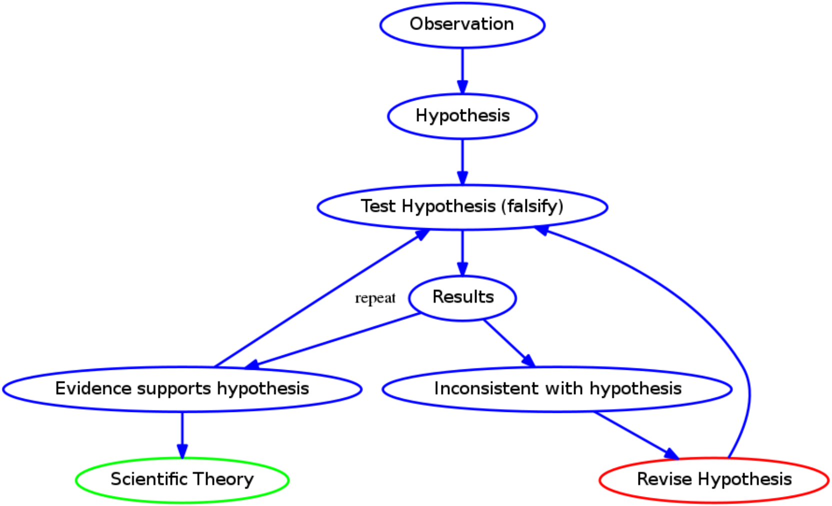


Percentage of Rural Households cooking with Firewood (2011)



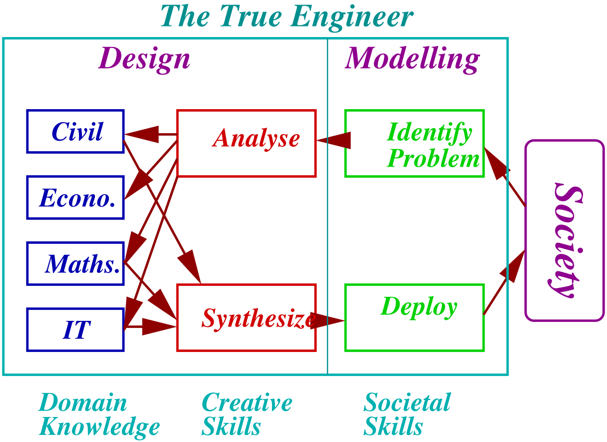
Data from Census 2011

Science



Scientific Method Flow Chart

Engineering



The True Engineer

Design

Modelling

Civil

Econo.

Maths.

IT

Analyse

Synthesize

Identify Problem

Deploy

Society

Domain Knowledge

Creative Skills

Societal Skills

Engineering v/s Science

- Scientist describes society, engineer wants to change it. So how should the change be?
- Obviously which generates value, which is why we engineers need to understand society and how it operates.

Ref: “Engineering Teaching and Research and its Impact on India”, CURRENT SCIENCE, VOL. 102, NO. 11, 10 JUNE 2012 (https://www.cse.iitb.ac.in/ sohoni/RD.pdf)

Problem Statement

- How do we analyse a real-life situation?
- How to use our course-material to model real-life situations.

Solutions?

Students and Case Studies

- Untapped resources of our country
- Can work in teams with the government
- Benefit of society
- Hands-on experience for students

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Several development issues require good engineering methodology!

The South Western Railway Timetable

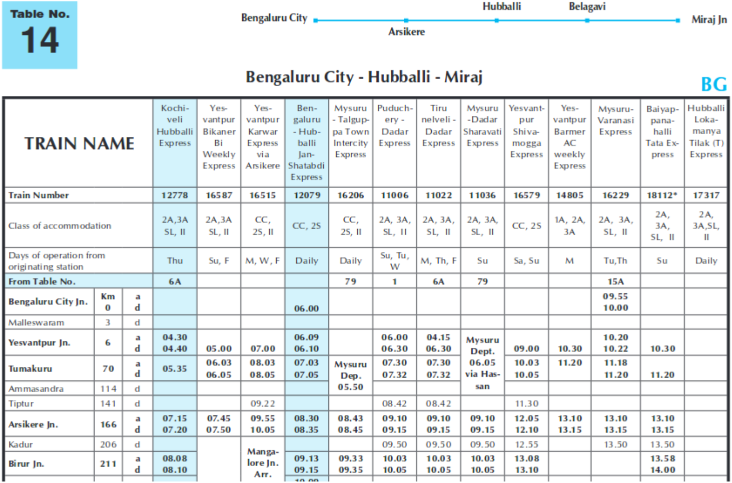

Table No. 14

Bengaluru City - Hubballi - Miraj

BG

TRAIN NAME			Kochi-veli Hubballi Express	Yesvantpur Bikaner Bi Weekly Express	Yesvantpur Karwar Express via Arsikere	Bengaluru - Hubballi Jan-Shatabdi Express	Mysuru - Talguppa Town Intercity Express	Puducherry - Dadar Express	Tirunelveli - Dadar Express	Mysuru -Dadar Sharavati Express	Yesvantpur Shivamogga Express	Yesvantpur Barmer AC weekly Express	Mysuru-Varanasi Express	Baiyappanahalli Tata Express	Hubballi Lokamanya Tilak (T) Express
Train Number			12778	16587	16515	12079	16206	11006	11022	11036	16579	14805	16229	18112*	17317
Class of accommodation			2A,3A SL, II	2A,3A SL, II	CC, 2S, II	CC, 2S	CC, 2S, II	2A, 3A, SL, II	2A, 3A, SL, II	2A, 3A, SL, II	CC, 2S	1A, 2A, 3A	2A, 3A, SL, II	2A, 3A, SL, II	2A, 3A,SL, II
Days of operation from originating station			Thu	Su, F	M, W, F	Daily	Daily	Su, Tu, W	M, Th, F	Su	Sa, Su	M	Tu,Th	Su	Daily
From Table No.			6A				79	1	6A	79			15A		
Bengaluru City Jn.	Km 0	a d				06.00							09.55 10.00		
Malleswaram	3	d													
Yesvantpur Jn.	6	a d	04.30 04.40	05.00	07.00	06.09 06.10		06.00 06.30	04.15 06.30	Mysuru Dept. 06.05 via Hassan	09.00	10.30	10.20 10.22	10.30	
Tumakuru	70	a d	05.35	06.03 06.05	08.03 08.05	07.03 07.05	Mysuru Dep. 05.50	07.30 07.32	07.30 07.32		10.03 10.05	11.20	11.18 11.20	11.20	
Ammasandra	114	d													
Tiptur	141	d			09.22			08.42	08.42		11.30				
Arsikere Jn.	166	a d	07.15 07.20	07.45 07.50	09.55 10.05	08.30 08.35	08.43 08.45	09.10 09.15	09.10 09.15	09.10 09.15	12.05 12.10	13.10 13.15	13.10 13.15	13.10 13.15	
Kadur	206	d			Mangalore Jn. Arr.			09.50	09.50	09.50	12.55		13.50	13.50	
Birur Jn.	211	a d	08.08 08.10			09.13 09.15	09.33 09.35	10.03 10.05	10.03 10.05	10.03 10.05	13.08 13.10			13.58 14.00	

https://www.cse.iitb.ac.in/ cs213d/SWRTimeTable.pdf

The South Western Railway Timetable

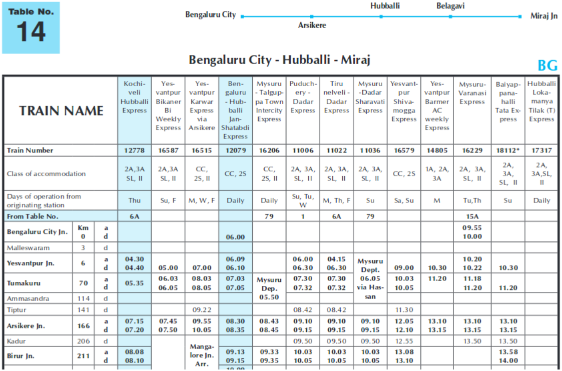

Table No.
14

Bengaluru City
Arsikere
Hubballi
Belagavi
Miraj Jn

Bengaluru City - Hubballi - Miraj

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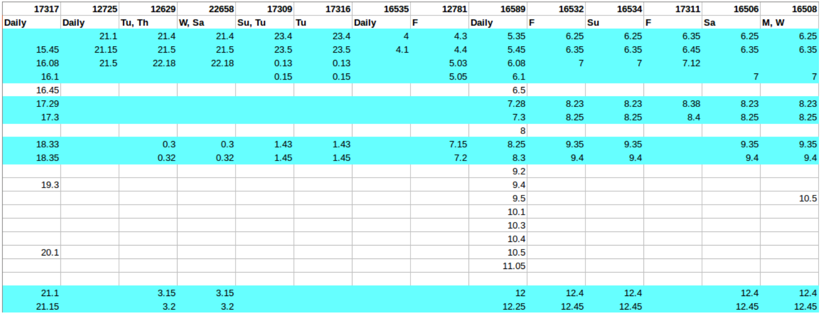
Train Number			**12778**	**16587**	**16515**	**12079**	**16206**	**11006**	**11022**	**11036**	**16579**	**14805**	**16229**	**18112***	**17317**
Class of accommodation			2A,3A SL, II	2A,3A SL, II	CC, 2S, II	CC, 2S	CC, 2S, II	2A, 3A, SL, II	2A, 3A, SL, II	2A, 3A, SL, II	CC, 2S	1A, 2A, 3A	2A, 3A, SL, II	2A, 3A, SL, II	2A, 3A,SL, II
Days of operation from originating station			Thu	Su, F	M, W, F	Daily	Daily	Su, Tu, W	M, Th, F	Su	Sa, Su	M	Tu,Th	Su	Daily
From Table No.			**6A**				**79**	**1**	**6A**	**79**			**15A**		
Bengaluru City Jn.	**Km** **0**	**a** **d**				**06.00**							**09.55** **10.00**		
Malleswaram	3	d													
Yesvantpur Jn.	**6**	**a** **d**	**04.30** **04.40**	**05.00**	**07.00**	**06.09** **06.10**		**06.00** **06.30**	**04.15** **06.30**	**Mysuru Dept. 06.05 via Hassan**	**09.00**	**10.30**	**10.20** **10.22**	**10.30**	
Tumakuru	**70**	**a** **d**	**05.35**	**06.03** **06.05**	**08.03** **08.05**	**07.03** **07.05**	**Mysuru Dep. 05.50**	**07.30** **07.32**	**07.30** **07.32**		**10.03** **10.05**	**11.20**	**11.18** **11.20**	**11.20**	
Ammasandra	114	d													
Tiptur	141	d			09.22			08.42	08.42		11.30				
Arsikere Jn.	**166**	**a** **d**	**07.15** **07.20**	**07.45** **07.50**	**09.55** **10.05**	**08.30** **08.35**	**08.43** **08.45**	**09.10** **09.15**	**09.10** **09.15**	**09.10** **09.15**	**12.05** **12.10**	**13.10** **13.15**	**13.10** **13.15**	**13.10** **13.15**	
Kadur	206	d			**Mangalore Jn. Arr.**			09.50	09.50	09.50	12.55		13.50	13.50	
Birur Jn.	**211**	**a** **d**	**08.08** **08.10**			**09.13** **09.15**	**09.33** **09.35**	**10.03** **10.05**	**10.03** **10.05**	**10.03** **10.05**	**13.08** **13.10**			**13.58** **14.00**	

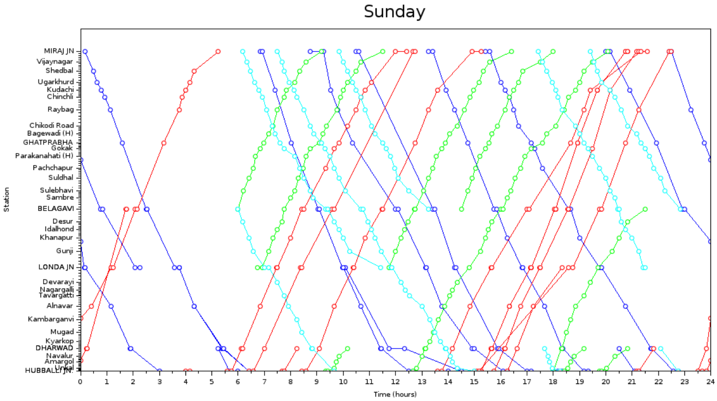
- Extremely rich data-set.
- Available in pdf format online.
- Cannot run basic computation such as number of trains operational at a given time instant!

From PDF to Excel...



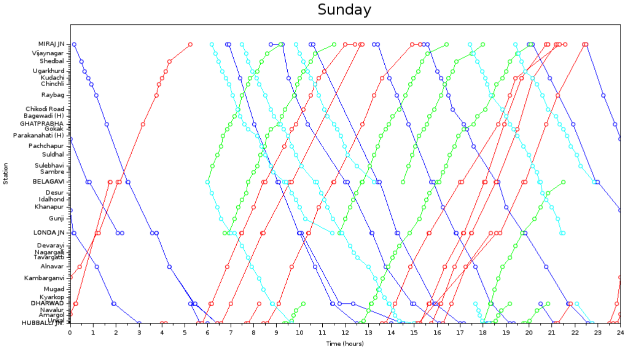
17317	12725	12629	22658	17309	17316	16535	12781	16589	16532	16534	17311	16506	16508
Daily	Daily	Tu, Th	W, Sa	Su, Tu	Tu	Daily	F	Daily	F	Su	F	Sa	M, W
	21.1	21.4	21.4	23.4	23.4	4	4.3	5.35	6.25	6.25	6.35	6.25	6.25
15.45	21.15	21.5	21.5	23.5	23.5	4.1	4.4	5.45	6.35	6.35	6.45	6.35	6.35
16.08	21.5	22.18	22.18	0.13	0.13		5.03	6.08	7	7	7.12		
16.1				0.15	0.15		5.05	6.1				7	7
16.45								6.5					
17.29								7.28	8.23	8.23	8.38	8.23	8.23
17.3								7.3	8.25	8.25	8.4	8.25	8.25
								8					
18.33		0.3	0.3	1.43	1.43		7.15	8.25	9.35	9.35		9.35	9.35
18.35		0.32	0.32	1.45	1.45		7.2	8.3	9.4	9.4		9.4	9.4
								9.2					
19.3								9.4					
								9.5					10.5
								10.1					
								10.3					
								10.4					
20.1								10.5					
								11.05					
21.1		3.15	3.15					12	12.4	12.4		12.4	12.4
21.15		3.2	3.2					12.25	12.45	12.45		12.45	12.45

…To Graphical Visualization



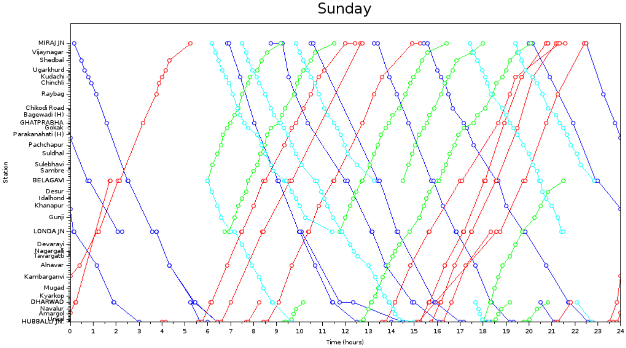
Software Used: Scilab

…To Graphical Visualization



- Space-time representation of timetable
- Can be used to analyze bottlenecks in schedule, minimization of delays, possible collision domains.
- Time Table Optimization!

…To Graphical Visualization



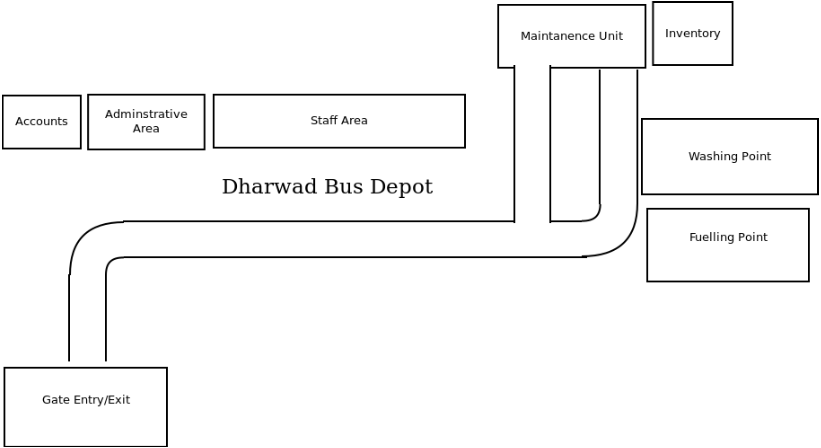
The above example was based on secondary data and its analysis. That is important too, since it trains you in understanding how to represent and what would be of interest to people and the limitations of the implementation agency, in this case, a single track. Also understand what could be changed, e.g., signal spacing and loops, but that needs primary work. The next example is different.

Dharwad bus Depot

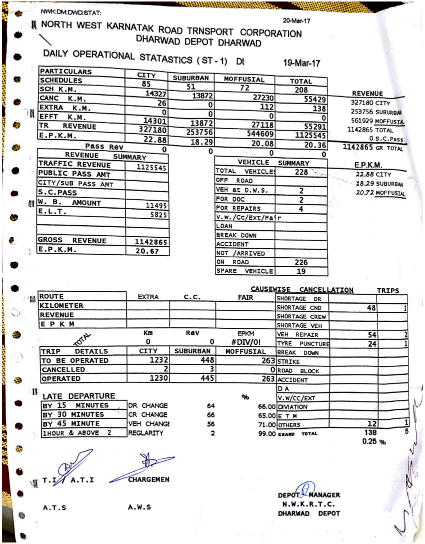
The Dharwad Bus Depot

- One of the eight division headquarters under North Western Karnataka Road Transport Corporation.
- operates 208 schedules with strength of 228 vehicles.
- covers 55k kms and is utilising the services of 1000 regular employees, which includes Officers, Supervisory and Administrative staff, Mechanical staff and Drivers and Conductors.
- Plethora of natural data generated on a daily basis.

Dharwad Bus Depot: Basic Physical Units



Basic Data-sets



NWK:DM:DWD:STAT:

20-Mar-17

NORTH WEST KARNATAK ROAD TRNSPORT CORPORATION
DHARWAD DEPOT DHARWAD

DAILY OPERATIONAL STATASTICS (ST - 1) Dt 19-Mar-17

PARTICULARS	CITY	SUBURBAN	MOFFUSIAL	TOTAL
SCHEDULES	85	51	72	208
SCH K.M.	14327	13872	27230	55429
CANC K.M.	26	0	112	138
EXTRA K.M.	0	0	0	0
EFFT K.M.	14301	13872	27118	55291
TR REVENUE	327180	253756	544609	1125545
E.P.K.M.	22.88	18.29	20.08	20.36
Pass Rev	0	0	0	0

REVENUE

327180	CITY
253756	SUBURBAN
561929	MOFFUSIAL
1142865	TOTAL
0	S.C.Pass
1142865	GR TOTAL

E.P.K.M.

22.88	CITY
18.29	SUBURBAN
20.72	MOFFUSIAL

REVENUE SUMMARY	
TRAFFIC REVENUE	1125545
PUBLIC PASS AMT	
CITY/SUB PASS AMT	
S.C.PASS	
W. B. AMOUNT	11495
E.L.T.	5825
GROSS REVENUE	1142865
E.P.K.M.	20.67

VEHICLE SUMMARY	
TOTAL VEHICLES	228
OFF ROAD	
VEH at D.W.S.	2
FOR DOC	2
FOR REPAIRS	4
V.W./Cc/Ext/Fair	
LOAN	
BREAK DOWN	
ACCIDENT	
NOT /ARRIVED	
ON ROAD	226
SPARE VEHICLE	19

ROUTE	EXTRA	C.C.	FAIR
KILOMETER			
REVENUE			
E P K M			
TOTAL	Km 0	Rev 0	EPKM #DIV/0!

TRIP DETAILS	CITY	SUBURBAN	MOFFUSIAL
TO BE OPERATED	1232	448	263
CANCELLED	2	3	0
OPERATED	1230	445	263

CAUSEWISE CANCELLATION		TRIPS
SHORTAGE DR		
SHORTAGE CND	48	1
SHORTAGE CREW		
SHORTAGE VEH		
VEH REPAIR	54	2
TYRE PUNCTURE	24	1
BREAK DOWN		
STRIKE		
ROAD BLOCK		
ACCIDENT		
D A		
V.W/CC/EXT		
DIVIATION		
E T M		
OTHERS	12	1
GRAND TOTAL	138	5
	0.25 %	

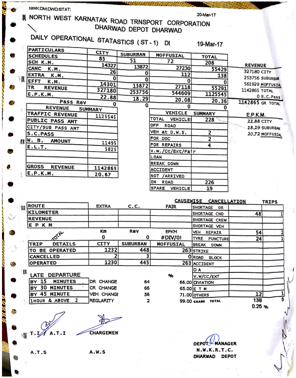
LATE DEPARTURE				%
BY 15 MINUTES		DR CHANGE	64	66.00
BY 30 MINUTES		CR CHANGE	66	65.00
BY 45 MINUTE		VEH CHANGE	56	71.00
1HOUR & ABOVE	2	REGLARITY	2	99.00

T.I / A.T.I CHARGEMEN

A.T.S A.W.S

DEPOT MANAGER
N.W.K.R.T.C.
DHARWAD DEPOT

Basic Data-sets



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REVENUE
327180 CITY
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KILOMETER			
REVENUE			
E P K M			

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	0	0	#DIV/0!

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LATE DEPARTURE

				%
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CAUSEWISE CANCELLATION

		TRIPS
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STRIKE		
ROAD BLOCK		
ACCIDENT		
D A		
V.W/CC/EXT		
DIVIATION		
E T M		
OTHERS	12	1
GRAND TOTAL	138	5
	0.25 %	

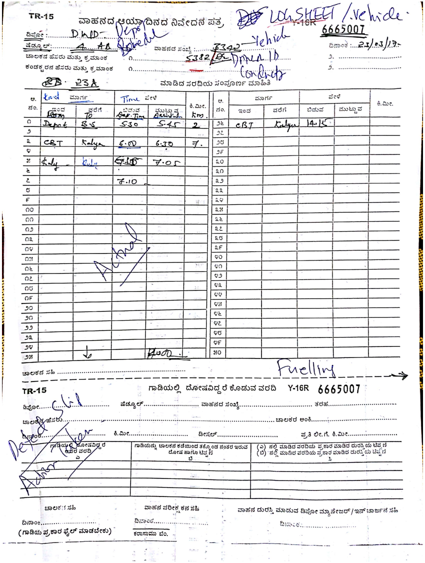
T.I / A.T.I CHARGEMEN

A.T.S A.W.S

DEPOT MANAGER
N.W.K.R.T.C.
DHARWAD DEPOT

- Daily Operation Statistics
- Summary of revenue collection, EPKM (earnings per km), vehicle allocation, cancellations/late departures.

Basic Data-sets



TR-15 ವಾಹನದ ಆಯ್ದಾ ದಿನದ ನಿವೇದನ ಪತ್ರ, ~~DS~~ LOG SHEET /.Vehicle.

Y-16R **6665007**

ಡಿಪೋ: D.W.D. Depot

ಷೆಡ್ಯೂಲ್: 4 AA Schedule

ವಾಹನದ ಸಂಖ್ಯೆ: 3342 — Vehicle

ದಿನಾಂಕ: 23/03/17.

ಚಾಲಕನ ಹೆಸರು ಮತ್ತು ಕ್ರಮಾಂಕ ೧. 5382/Dr Driver ID ೨. ....

ಕಂಡಕ್ಟರನ ಹೆಸರು ಮತ್ತು ಕ್ರಮಾಂಕ ೧. Conductor ೨. ....

RB. 23A

ಮಾಡಿದ ಸರದಿಯ ಸಂಪೂರ್ಣ ಮಾಹಿತಿ

ಅ. ನಂ.	End ಮಾರ್ಗ ಇಂದ From	ವರೆಗೆ To	Time ವೇಳೆ ಬಿಡುವ Dep. Time	ಮುಟ್ಟುವ Arrival	ಕಿ.ಮೀ. Km.	ಅ. ನಂ.	ಮಾರ್ಗ ಇಂದ	ವರೆಗೆ	ವೇಳೆ ಬಿಡುವ	ಮುಟ್ಟುವ	ಕಿ.ಮೀ.
೧	Depot	B.S	5.30	5.45	2	೨೬	CBT	Kalyn	14.15		
೨						೨೭					
೩	CBT	Kalya	6.00	6.30	7.	೨೮					
೪						೨೯					
೫	Kaly	Kaly	[illegible]	7.05		೩೦					
೬						೩೧					
೭			7.10			೩೨					
೮						೩೩					
೯						೩೪					
೧೦						೩೫					
೧೧						೩೬					
೧೨						೩೭					
೧೩						೩೮					
೧೪						೩೯					
೧೫						೪೦					
೧೬						೪೧					
೧೭						೪೨					
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೧೯						೪೪					
೨೦						೪೫					
೨೧						೪೬					
೨೨						೪೭					
೨೩						೪೮					
೨೪						೪೯					
೨೫		↓		[illegible]		೫೦					

Actual

ಚಾಲಕನ ಸಹಿ ....

Fuelling →

TR-15 ಗಾಡಿಯಲ್ಲಿ ದೋಷವಿದ್ದರೆ ಕೊಡುವ ವರದಿ Y-16R **6665007**

Defect Slip

ಡಿಪೋ.......... ಷೆಡ್ಯೂಲ್.......... ವಾಹನದ ಸಂಖ್ಯೆ.......... ತರಹ..........

ಚಾಲಕನ ಹೆಸರು.......... ಚಾಲಕರ ಅಂಕಿ..........

ದಿನಾಂಕ.......... ಕಿ.ಮೀ.......... ಡೀಸಲ್.......... ಪ್ರತಿ ಲೀ.ಗೆ. ಕಿ.ಮೀ..........

Action taken

ಗಾಡಿಯಲ್ಲಿ ದೋಷವಿದ್ದರೆ ಚಾರ ವರದಿ ಎ	ಗಾಡಿಯನ್ನು ಚಾಲಕನ ಕಡೆಯಿಂದ ತಕ್ಕೊಂಡ ನಂತರ ಇರುವ ದೋಷ ಹಾಗೂ ಟಿಪ್ಪಣಿ ಬಿ	(ಎ) ನಲ್ಲಿ ಮಾಡಿದ ವರದಿಯ ಪ್ರಕಾರ ಮಾಡಿದ ದುರಸ್ತಿಯ ಟಿಪ್ಪಣಿ (ಬಿ) ನಲ್ಲಿ ಮಾಡಿದ ವರದಿಯ ಪ್ರಕಾರ ಮಾಡಿದ ದುರಸ್ತಿಯ ಟಿಪ್ಪಣಿ ಸಿ

ಚಾಲಕನ ಸಹಿ

ದಿನಾಂಕ..........

(ಗಾಡಿಯ ಪ್ರಕಾರ ಫೈಲ್ ಮಾಡಬೇಕು)

ವಾಹನ ಪರೀಕ್ಷಕನ ಸಹಿ

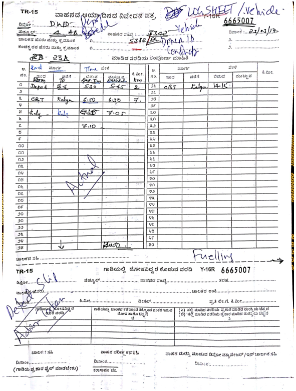
ದಿನಾಂಕ..........

ಕರಾಸಾಮು ಬೆಂ.

ವಾಹನ ದುರಸ್ತಿ ಮಾಡುವ ಡಿಪೋ ಮ್ಯಾನೇಜರ್/ಇನ್ ಚಾರ್ಜನ ಸಹಿ

ದಿನಾಂಕ..........

Basic Data-sets



TR-15 ವಾಹನದ ಆಯಾ ದಿನದ ನಿವೇದನ ಪತ್ರ ~~DS~~ LOGSHEET / Vehicle

Y-16R 6665007

ಡಿಪೋ: DWD Depot

ಶೆಡ್ಯೂಲ್: A AB Schedule

ವಾಹನದ ಸಂಖ್ಯೆ: 3342 Vehicle

ದಿನಾಂಕ: 23/03/17

ಚಾಲಕನ ಹೆಸರು ಮತ್ತು ಕ್ರಮಾಂಕ ೧. 5382 Driver ID

ಕಂಡಕ್ಟರನ ಹೆಸರು ಮತ್ತು ಕ್ರಮಾಂಕ ೧. Conductor

RB 23A

ಮಾಡಿದ ಸರದಿಯ ಸಂಪೂರ್ಣ ಮಾಹಿತಿ

ಕ್ರ. ಸಂ.	End ಮಾರ್ಗ ಇಂದ From	ವರೆಗೆ To	Time ವೇಳೆ ಬಿಡುವ Dep. Time	ಮುಟ್ಟುವ Arrival	ಕಿ.ಮೀ. Km.	ಕ್ರ. ಸಂ.	ಮಾರ್ಗ ಇಂದ	ವರೆಗೆ	ವೇಳೆ ಬಿಡುವ	ಮುಟ್ಟುವ	ಕಿ.ಮೀ.
೧	Depot	B.S	5.30	5.45	2	೨೬	CBT	Kalyan	14.15		
೨						೨೭					
೩	CBT	Kalya	6.00	6.30	7.	೨೮					
೪						೨೯					
೫	Kaly -	Kaly	6.40	7.05		೩೦					
೬						೩೧					
೭			7.10			೩೨					
೮						೩೩					
೯						೩೪					
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೧೫						೪೦					
೧೬						೪೧					
೧೭						೪೨					
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೨೧						೪೬					
೨೨						೪೭					
೨೩						೪೮					
೨೪						೪೯					
೨೫		↓				೫೦					

Actual

ಚಾಲಕನ ಸಹಿ ....

Fuelling →

TR-15 ಗಾಡಿಯಲ್ಲಿ ದೋಷವಿದ್ದರೆ ಕೊಡುವ ವರದಿ Y-16R 6665007

ಡಿಪೋ........ ಶೆಡ್ಯೂಲ್........ ವಾಹನದ ಸಂಖ್ಯೆ........ ತರಹ........

ಚಾಲಕನ ಹೆಸರು........ ಚಾಲಕರ ಅಂಕಿ........

ದಿನಾಂಕ........ ಕಿ.ಮೀ........ ಡೀಸೆಲ್........ ಪ್ರತಿ ಲೀ.ಗೆ. ಕಿ.ಮೀ........

Defect Slip

Admin Sector

ಗಾಡಿಯಲ್ಲಿ ದೋಷವಿದ್ದರೆ ಬರೆ ವರದಿ ೧	ಗಾಡಿಯನ್ನು ಚಾಲಕನ ಕಡೆಯಿಂದ ತಕ್ಕೊಂಡ ನಂತರ ಇರುವ ದೋಷ ಹಾಗೂ ಟಿಪ್ಪಣಿ ೨	(ಎ) ಸಲ್ಲಿ ಮಾಡಿದ ವರದಿಯ ಪ್ರಕಾರ ಮಾಡಿದ ದುರಸ್ತಿಯ ಟಿಪ್ಪಣಿ (ಬಿ) ಸಲ್ಲಿ ಮಾಡಿದ ವರದಿಯ ಪ್ರಕಾರ ಮಾಡಿದ ದುರಸ್ತಿಯ ಟಿಪ್ಪಣಿ ೩

ಚಾಲಕನ ಸಹಿ

ದಿನಾಂಕ........

(ಗಾಡಿಯ ಪ್ರಕಾರ ಫೈಲ್ ಮಾಡಬೇಕು)

ವಾಹನ ಪರೀಕ್ಷಕನ ಸಹಿ

ದಿನಾಂಕ........

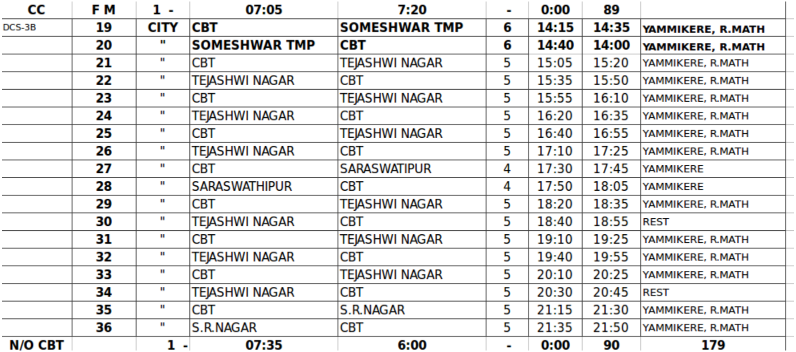
ಕಠಾಸಾಮು ಬೆಂ.

ವಾಹನ ದುರಸ್ತಿ ಮಾಡುವ ಡಿಪೋ ಮ್ಯಾನೇಜರ್ / ಇನ್ ಚಾರ್ಜನ ಸಹಿ

ದಿನಾಂಕ........

- Log sheet
- To be filled in by the conductor after every trip.
- Contains stopwise distribution of ridership.

Basic Data-sets



CC	F M	1 -	07:05	7:20	-	0:00	89	
DCS-3B	**19**	**CITY**	**CBT**	**SOMESHWAR TMP**	**6**	**14:15**	**14:35**	**YAMMIKERE, R.MATH**
	20	**"**	**SOMESHWAR TMP**	**CBT**	**6**	**14:40**	**14:00**	**YAMMIKERE, R.MATH**
	21	"	CBT	TEJASHWI NAGAR	5	15:05	15:20	YAMMIKERE, R.MATH
	22	"	TEJASHWI NAGAR	CBT	5	15:35	15:50	YAMMIKERE, R.MATH
	23	"	CBT	TEJASHWI NAGAR	5	15:55	16:10	YAMMIKERE, R.MATH
	24	"	TEJASHWI NAGAR	CBT	5	16:20	16:35	YAMMIKERE, R.MATH
	25	"	CBT	TEJASHWI NAGAR	5	16:40	16:55	YAMMIKERE, R.MATH
	26	"	TEJASHWI NAGAR	CBT	5	17:10	17:25	YAMMIKERE, R.MATH
	27	"	CBT	SARASWATIPUR	4	17:30	17:45	YAMMIKERE
	28	"	SARASWATHIPUR	CBT	4	17:50	18:05	YAMMIKERE
	29	"	CBT	TEJASHWI NAGAR	5	18:20	18:35	YAMMIKERE, R.MATH
	30	"	TEJASHWI NAGAR	CBT	5	18:40	18:55	REST
	31	"	CBT	TEJASHWI NAGAR	5	19:10	19:25	YAMMIKERE, R.MATH
	32	"	TEJASHWI NAGAR	CBT	5	19:40	19:55	YAMMIKERE, R.MATH
	33	"	CBT	TEJASHWI NAGAR	5	20:10	20:25	YAMMIKERE, R.MATH
	34	"	TEJASHWI NAGAR	CBT	5	20:30	20:45	REST
	35	"	CBT	S.R.NAGAR	5	21:15	21:30	YAMMIKERE, R.MATH
	36	"	S.R.NAGAR	CBT	5	21:35	21:50	YAMMIKERE, R.MATH
N/O CBT		**1 -**	**07:35**	**6:00**	**-**	**0:00**	**90**	**179**

Form IV(The city bus schedule)

Form IV: Our first Data-set

The Schedule

- `SCH.NO.`: The Schedule Number (Typical schedule is 8 hours long.)
- `TRIP`: trip number
  - `FROM` and `TO`: The first and last stops.
  - `KM`: distance covered
  - `DEP` and `ARR` : departure and arrival timings
  - `VIA`: place en route

Very linear representation of data.

- No information about sub-stops.
- Does not describe the spatial distribution of route-data.
- Insufficient for proper analysis.

Questions

It is natural to generate many domain specific questions of value:

- Passenger: What is the route to travel from Ganesh Temple to Central School, starting at 7:15 AM, in the minimum possible time?
- Depot Manager: How to maximize the profit subject to budget constraints?
- Planning Committee: Which are the more profitable areas to add a new bus route?
- Researcher : How much percentage of the rural population has access to a bus within 500m?

Questions

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- Planning Committee: Which are the more profitable areas to add a new bus route?
- Researcher : How much percentage of the rural population has access to a bus within 500m?

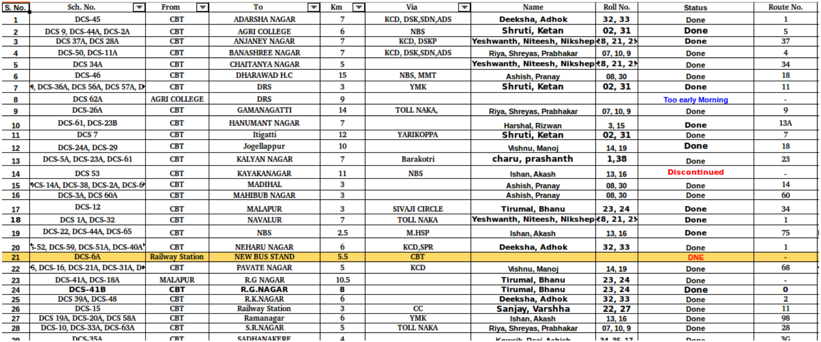
We will answer the first question through this study and do preliminary work to answer the other questions.

Work done at IIT Dharwad

The 39 students of the course CS213 (Jan. 2017-May. 2017), at IIT Dharwad map Dharwad city bus routes.

- They first analyze the 8000-line city bus schedule.
- prepare a summary and allocate routes
- travel them and generate kml files
- and finally compile them together.

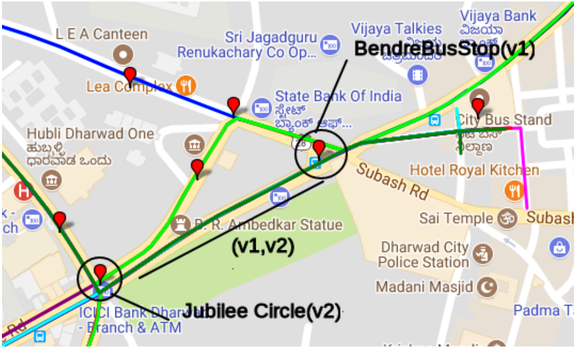
Summary and Route Allocation



S. No.	Sch. No.	From	To	Km	Via	Name	Roll No.	Status	Route No.
1	DCS-45	CBT	ADARSHA NAGAR	7	KCD, DSK,SDN,ADS	Deeksha, Adhok	32, 33	Done	1
2	DCS 9, DCS-44A, DCS-2A	CBT	AGRI COLLEGE	6	NBS	Shruti, Ketan	02, 31	Done	5
3	DCS 37A, DCS 28A	CBT	ANJANEY NAGAR	7	KCD, DSKP	Yeshwanth, Niteesh, Nikshep	8, 21, 2	Done	37
4	DCS-50, DCS-11A	CBT	BANASHREE NAGAR	7	KCD, DSK,SDN,ADS	Riya, Shreyas, Prabhakar	07, 10, 9	Done	4
5	DCS 34A	CBT	CHAITANYA NAGAR	5		Yeshwanth, Niteesh, Nikshep	8, 21, 2	Done	34
6	DCS-46	CBT	DHARAWAD H.C	15	NBS, MMT	Ashish, Pranay	08, 30	Done	18
7	, DCS-36A, DCS 56A, DCS 57A, D	CBT	DRS	3	YMK	Shruti, Ketan	02, 31	Done	11
8	DCS 62A	AGRI COLLEGE	DRS	9				Too early Morning	-
9	DCS-26A	CBT	GAMANAGATTI	14	TOLL NAKA,	Riya, Shreyas, Prabhakar	07, 10, 9	Done	9
10	DCS-61, DCS-23B	CBT	HANUMANT NAGAR	7		Harshal, Rizwan	3, 15	Done	13A
11	DCS 7	CBT	Itigatti	12	YARIKOPPA	Shruti, Ketan	02, 31	Done	7
12	DCS-24A, DCS-29	CBT	Jogellappur	10		Vishnu, Manoj	14, 19	Done	18
13	DCS-5A, DCS-23A, DCS-61	CBT	KALYAN NAGAR	7	Barakotri	charu, prashanth	1,38	Done	23
14	DCS 53	CBT	KAYAKANAGAR	11	NBS	Ishan, Akash	13, 16	Discontinued	-
15	CS-14A, DCS-38, DCS-2A, DCS-6	CBT	MADIHAL	3		Ashish, Pranay	08, 30	Done	14
16	DCS-3A, DCS 60A	CBT	MAHIBUB NAGAR	3		Ashish, Pranay	08, 30	Done	60
17	DCS-12	CBT	MALAPUR	3	SIVAJI CIRCLE	Tirumal, Bhanu	23, 24	Done	34
18	DCS 1A, DCS-32	CBT	NAVALUR	7	TOLL NAKA	Yeshwanth, Niteesh, Nikshep	8, 21, 2	Done	1
19	DCS-22, DCS-44A, DCS-65	CBT	NBS	2.5	M.HSP	Ishan, Akash	13, 16	Done	75
20	S-52, DCS-59, DCS-51A, DCS-40A	CBT	NEHARU NAGAR	6	KCD,SPR	Deeksha, Adhok	32, 33	Done	1
21	DCS-6A	Railway Station	NEW BUS STAND	5.5	CBT			DNE	-
22	5, DCS-16, DCS-21A, DCS-31A, D	CBT	PAVATE NAGAR	5	KCD	Vishnu, Manoj	14, 19	Done	68
23	DCS-41A, DCS-18A	MALAPUR	R.G NAGAR	10.5		Tirumal, Bhanu	23, 24	Done	-
24	DCS-41B	CBT	R.G.NAGAR	8		Tirumal, Bhanu	23, 24	Done	0
25	DCS 39A, DCS-48	CBT	R.K.NAGAR	6		Deeksha, Adhok	32, 33	Done	2
26	DCS-15	CBT	Railway Station	3	CC	Sanjay, Varshha	22, 27	Done	11
27	DCS 19A, DCS-20A, DCS 58A	CBT	Ramanagar	6	YMK	Ishan, Akash	13, 16	Done	98
28	DCS-10, DCS-33A, DCS-63A	CBT	S.R.NAGAR	5	TOLL NAKA	Riya, Shreyas, Prabhakar	07, 10, 9	Done	28
29	DCS-35A	CBT	SADHANAKERE	4		Kowsik, Raai, Ashish	34, 35, 17	Done	3G

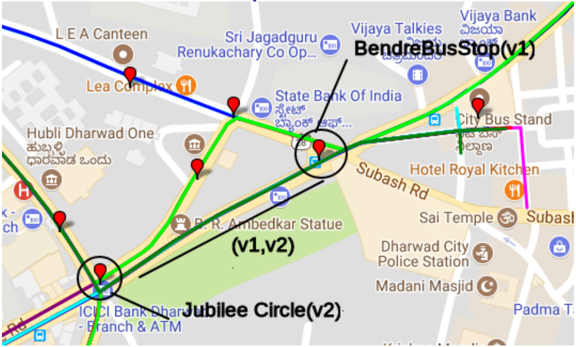
75 distinct routes were allocated to the students, out of which 12 were reported to be disfunctional or duplicate.

The Representation



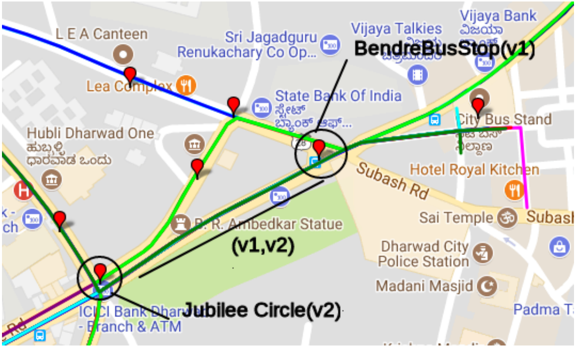
A graph $G(V, E)$ is eminently suitable to represent locations (as vertices) and paths between locations (as edges).

The Representation



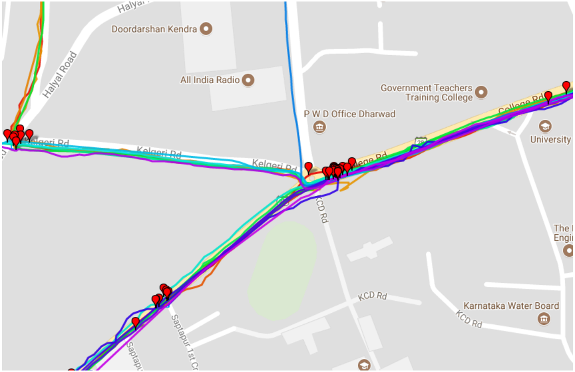
- The place (v) represents an actual location and contains location data (latitude-longitude (lat-long)), name and other attributes specific to the place and the route on which it lies.
- An edge consists of two places (v_1, v_2) and a track between them.
- A route consists of a sequence of places, connected by the edges.

The Representation



- A service from v_i to v_j, $S(v_i, v_j, t_0, d)$, consists of a route followed by a bus along with the start time(t_0) and the trip duration (d).
- Finally, a schedule is a set of services carried out by a single bus.

Figure: The KML tracks generated from real-time GPS tracking.

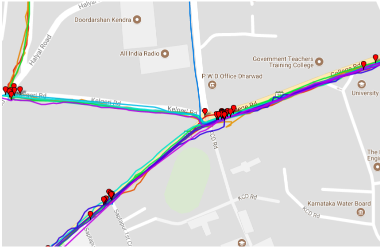


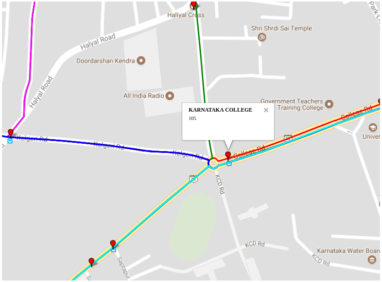
Some Issues

- The KML tracks are irregular and not aligned to official road polylines.
- Multiple coordinates and multiple names for the same stops.
- Names in the schedule are not standardized.
- Data not fit for graph representation.

Cleanup

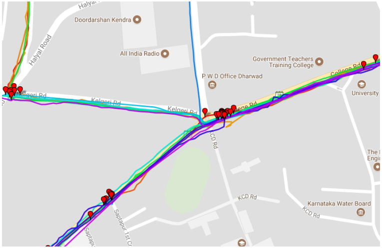
- Clustering of Stops
  We used a clustering algorithm (see breadth-first search) using connected components to cluster stops within 50 m into unique stops.

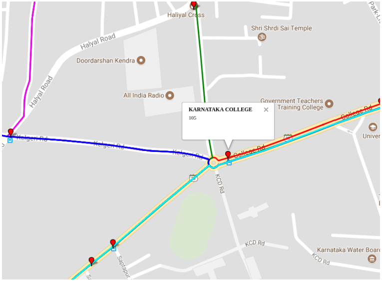




Cleanup

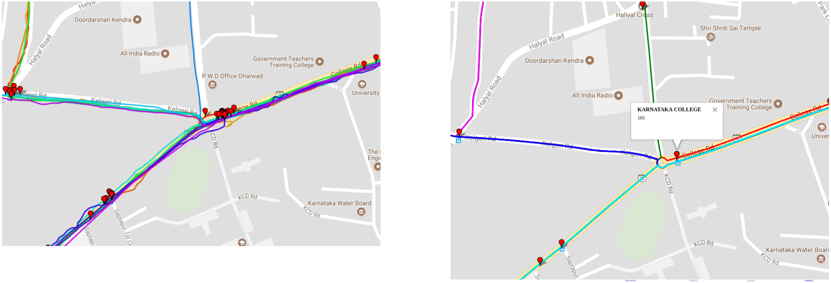
- Fitting the GPS generated tracks with the Google Map Roads
  It was decided that the edges between places (whose preliminary lat-longs and names are now available) will follow existing roads, i.e., polylines as shown by Google Maps. To align the tracks with the official road polylines, we used a Google API



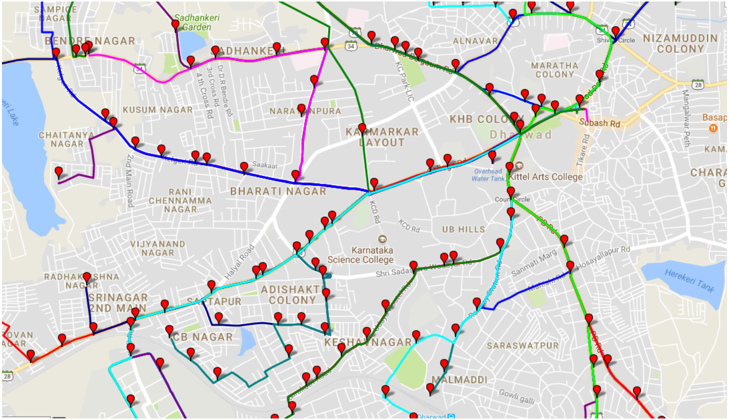


Cleanup

- Inserting stops into polylines
  As the data was generated from one trip only, many buses did not stop at all the stops which lie on the route depending on the ridership that day. So, we then wrote a program which took all the stops, computed its minimum distance from the track and inserted it into the track O_i if the distance was less than some chosen epsilon.



After Cleanup



Question Revisited

Question: How can you reach Srinagar from High Court in the minimum possible time starting at time t_0?

Question Revisited

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This can be modelled as a graph theory problem.

Question Revisited

Question: How can you reach Srinagar from High Court in the minimum possible time starting at time t_0?

This can be modelled as a graph theory problem.

- Here the vertices(V) are the bus stops.
- Let v_0= Srinagar and v_n=High Court.
- There edges are the services.
- The edge weights are the trip length of the service $S(v_i, v_j, t, d)$.

Question Revisited

- Initialization: The edge cost of $S(v_0, v_i, t, d) = (t - t_0) + d$ where $(t - t_0) > 0$, ∞ otherwise.
- Constraint: (v_i, v_j) can be followed by (v_j, v_k) iff arrival time($S(v_i, v_j, t_1, d_1)$) $<$ departure time($S(v_j, v_k, t_2, d_2)$).
- Run Dijkstra's algorithm and get the shortest path from v_0 to v_n.

Ref: https://en.wikipedia.org/wiki/Dijkstra's_algorithm

Can we do better?

- Suppose there are k routes with n stops each and 1 route has m trips in a day, the number of edges becomes $(n-1) \times k \times m$.
- So the complexity of above alogrithm is $O((n-1) \times k \times m + |V| log |V|)$!
- This is significant amount of computation if done on the average mobile phone processors.

Can we do better?

- Solution: Edge generation on demand.
- Note that we are only interested in the next bus.
- So instead of explicitly storing the edges for all buses, we simply compute the cost of next bus from the current time.
- This brings the complexity of the algorithm by a multiplicative factor of m : Significant Improvement

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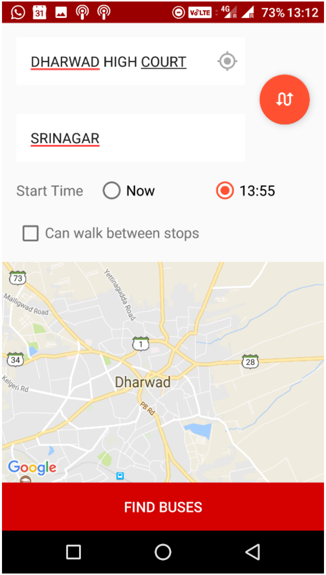
Our algorithm is ready to be implemented on a mobile phone!

Algorithm 1 Algorithm for finding bus route

```
procedure RoutePlanner(Graph, source, destination, start time)
    create vertex set Q
    for each vertex v in Graph do                          ▷ Initialization
        $dist[v] \leftarrow \infty$          ▷ Unknown distance from source to v
        $prev[v] \leftarrow UNDEFINED$       ▷ Previous edge in optimal path from source
        $arrival\_time[v] \leftarrow \infty$ ▷ Stores the best arrival time at each vertex
    end for
    add v to Q                     ▷ All nodes initially in Q (unvisited nodes)
    $dist[source] \leftarrow 0$              ▷ Distance from source to source
    $arrival\_time[source] \leftarrow start\ time$
    while Q is not empty do
        $u \leftarrow$ vertex in Q with min dist[u]   ▷ Node with the least distance will be selected first
        remove u from Q
        if u is destination then
            break                            ▷ no need of further computation
        end if
        for each edge starting from u do     ▷ where v is still in Q
            $length(u, v) \leftarrow waitingtime(arrival\_time[u]) + length(u, v)$   ▷ re compute edge cost
            $alt \leftarrow dist[u] + length(u, v)$
            if alt $<$ dist[v] then           ▷ A shorter path to v has been found
                $dist[v] \leftarrow alt$
                $prev[v] \leftarrow e(u, v)$
                $arrival\_time[v] \leftarrow arrival\_time[u] + length(u, v)$
            end if
        end for

        return dist[ ], prev[ ]
```

Development of an android app for passengers



73% 13:12

DHARWAD HIGH COURT

SRINAGAR

Start Time ○ Now ● 13:55

☐ Can walk between stops

Figure: Route generated by shortest path algorithm

DHARWAD HIGH COURT TO...

DHARWAD HIGH COURT TO SRINAGAR

14:00 — 41 m, 1 stops — 14:41

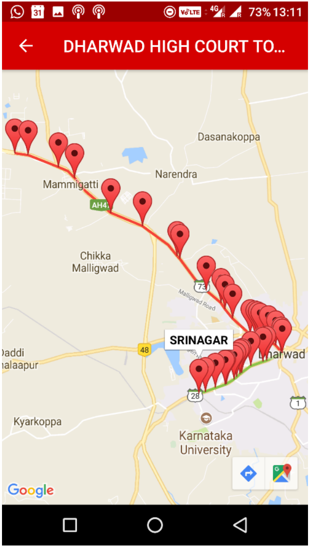
DHARWAD HIGH COURT	JUBILEE CIRCLE
14:00	14:29

ENROUTE DHARWAD HIGH COURT TO CBT

JUBILEE CIRCLE	SRINAGAR
14:31	14:41

ENROUTE CBT TO PAVATE NAGAR

Figure: Route viewed on map



GIS

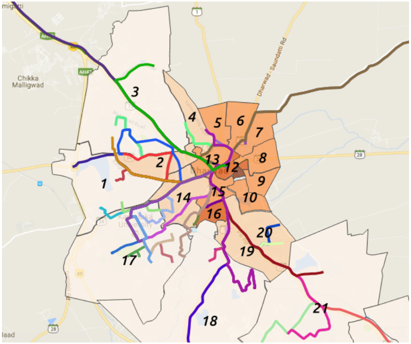


Figure: Ward map of Dharwad (classified by population density) superimposed on the bus network.

The way ahead...

- Implement a similar strategy in your town/taluka to generate a database.
- Scale the database over multiple talukas.
- Encourage addition of development course projects into the curriculum.
- There are other fields that need work also:
  Energy sector, public transport, more water, town planning,...
- See : www.ctara.iitb.ac.in for project ideas.

For full report on Dharwad Bus Depot:
https://www.cse.iitb.ac.in/ sohoni/dharwadbus.pdf

Thanks


ವಾ.ಕ.ರ.ಸಾ.ಸಂಸ್ಥೆ- ಧಾರವಾಡ ವಿಭಾಗ.
ಧಾರವಾಡ ಘಟಕ
N.W.K.R.T.C- DHARAWD DIVISION.
DHARWAD DEPOT
HERO HONDA
Splendor