isazi

"Transforming Logistics and Education: Leveraging Data & Analytics for Optimal Planning"

Avi Bank
Niambh Blundell

Overview

Isazi Consulting: ML and Optimisation

Data Science platform: Hudson

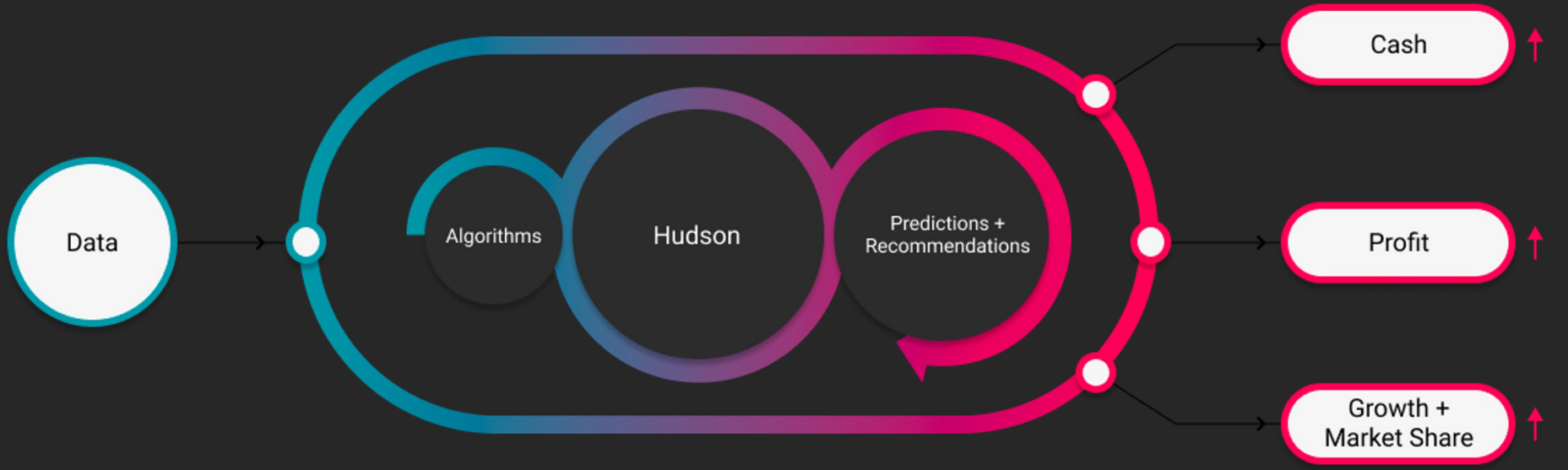
Optimisation Projects:

- Depot Replenishment
- Teacher Assignment and Scheduling

Leveraging Hudson: In-House Data Platform

- Hudson ™ is an AI integration layer and data pipeline that uses a library of mathematical models, integrating seamlessly into a variety of data systems and sources.
- Able to ingest a variety of data, which are both internal and external and are at various levels of data quality.
- Imputes missing data, performs semi-automated data cleaning, and assesses data integrity
- Seamless data integration across diverse projects and departments.
- Empowers teams to adopt agile and data-driven strategies.

Leveraging Hudson: In-House Data Platform



Leveraging Hudson: In-House Data Platform

Integration with Gurobi:

- Hudson serves as a vital trigger for optimisation processes, including the integration with sophisticated tools like Gurobi.
- This allows for efficient and data-informed decisions in a time-sensitive environment.
- Minimises manual intervention and speeds up the decision-making process.
- This results in enhanced operational efficiency and cost reduction through optimised decision-making and resource allocation.

Leveraging Hudson: In-House Data Platform

Future features:

- Automation of data ingestion
- AI-driven generation of interactive dashboards for user input, output and data visualisation
- GUI which allows non-technical users to connect and combine cleaned input with models and model output in order to design their own pipeline.

Impact on Analytics Toolchains and Planning Processes

- Hudson ensures **available** data is turned into **usable** data.
- This allows precise forensic debugging at various stages of the analytics chain.
- This level of organisation frees up time to focus on the more important (fun) things, like modelling and discovering complex operational patterns.
- Data cleaning results in a clearer representation of what is actually going on and what needs to fixed at the source.
- Data driven decisions can now be made.
- Automated data pipeline -> responsive to dynamic changes and trends in the data

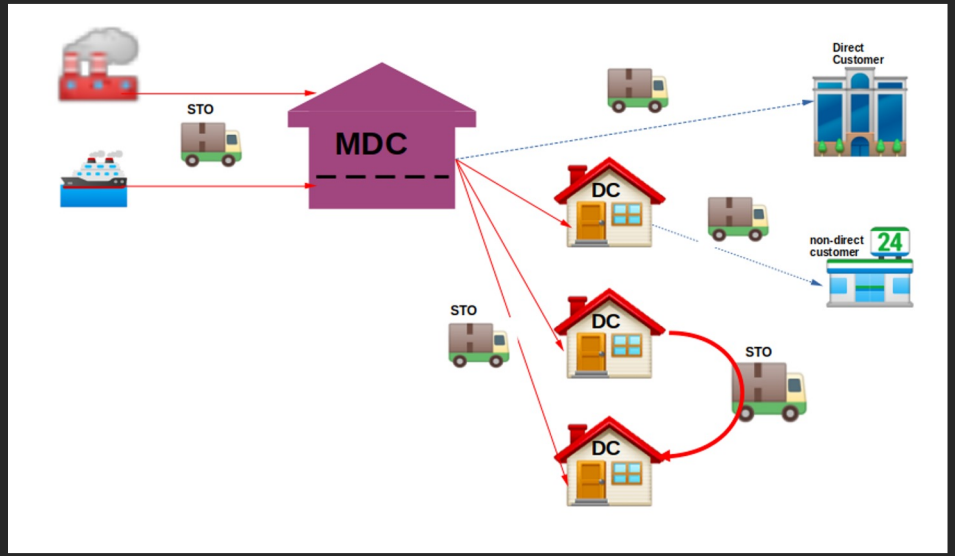
Depot Replenishment Process Optimisation

Problem Overview:

- Calculating the optimal amount of stock to move, where and when , in order to meet customer demand, while minimising costs.
- Type of network flow problem.
- Appliance company with hundreds of SKUs.
- Millions of variables!
- Previously done ‘by hand’ using *some* data but mostly intuition.
    - Time consuming
    - Prone to error

What is DRP

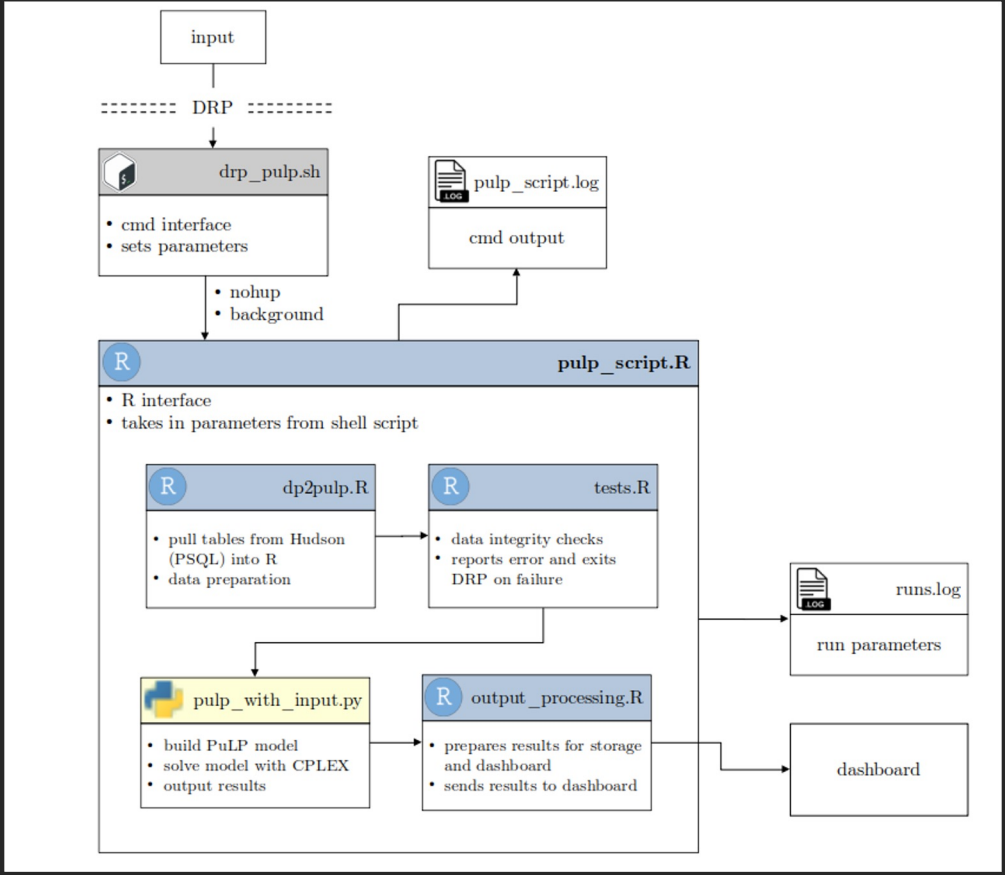
How much stock needs to be transferred in a network, to maximise profit (minimise costs) ?



- Stock Transfer Order (STO)
- Manual planning is very time consuming and subject to errors
- Cannot consider all aspects at once (lead time, demand, transit costs etc)
- A linear optimisation model can do it better and faster.
- We don't model deliveries to **customers.** Demand is consolidated to reduce model runtime.

Hudson DRP System

File Level



- Bash, R, Python framework
- CMD interface
- Shiny Dashboard
- MILP Solver (Gurobi/CPLEX/CBC)
    - *Gurobi is best*

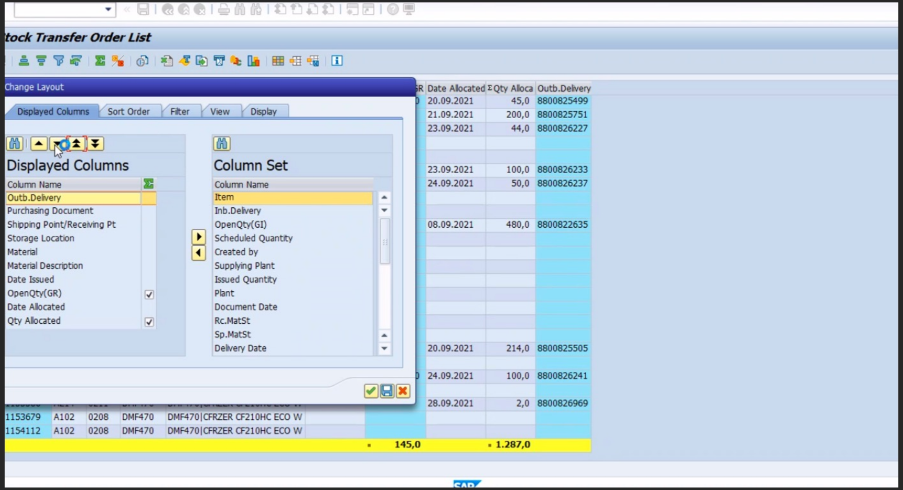
isazi

Challenges

Data

output_created_on	sap_and_ips_payer	customer_group	country	region	parent_group	payer	ips_payer	for_zips	for_zips_2	ips_check
	chicken	All	All	All	All	All	All	All	All	All
2021-02-19 10:53:25	chicken	Independents	ZA	Domestic	Independents	Independents other	Independents other	Independents other	ZA	Independents other

material_description	order_quantity
DBO483 SLIMLINE 600E BLACK GLASS	2.6
DBO483 SLIMLINE 600E BLACK GLASS	2.6
DBO483 SLIMLINE 600E BLACK GLASS	2.6
DBO483 SLIMLINE 600E BLACK GLASS	2.6
DBO483 SLIMLINE 600E BLACK GLASS	2.6
DBO483 SLIMLINE 600E BLACK GLASS	2.6
DBO483 SLIMLINE 600E BLACK GLASS	2.6
DBO483 SLIMLINE 600E BLACK GLASS	2.6
DBO483 SLIMLINE 600E BLACK GLASS	2.6
DBO483 SLIMLINE 600E BLACK GLASS	2.6



isazi

Challenges

Window centred on: Monday

Customers who accept deliveries on Monday: **C1, C2, C3**

	MON	TUE	WED	THU	FRI
C1	10	0	0	0	0
C2	5	1	0	0	0
C3	0	0	10	30	0
Total	**26**				

Delivery days are more important to some than others...

Flexible deliveries mean less lost sales.

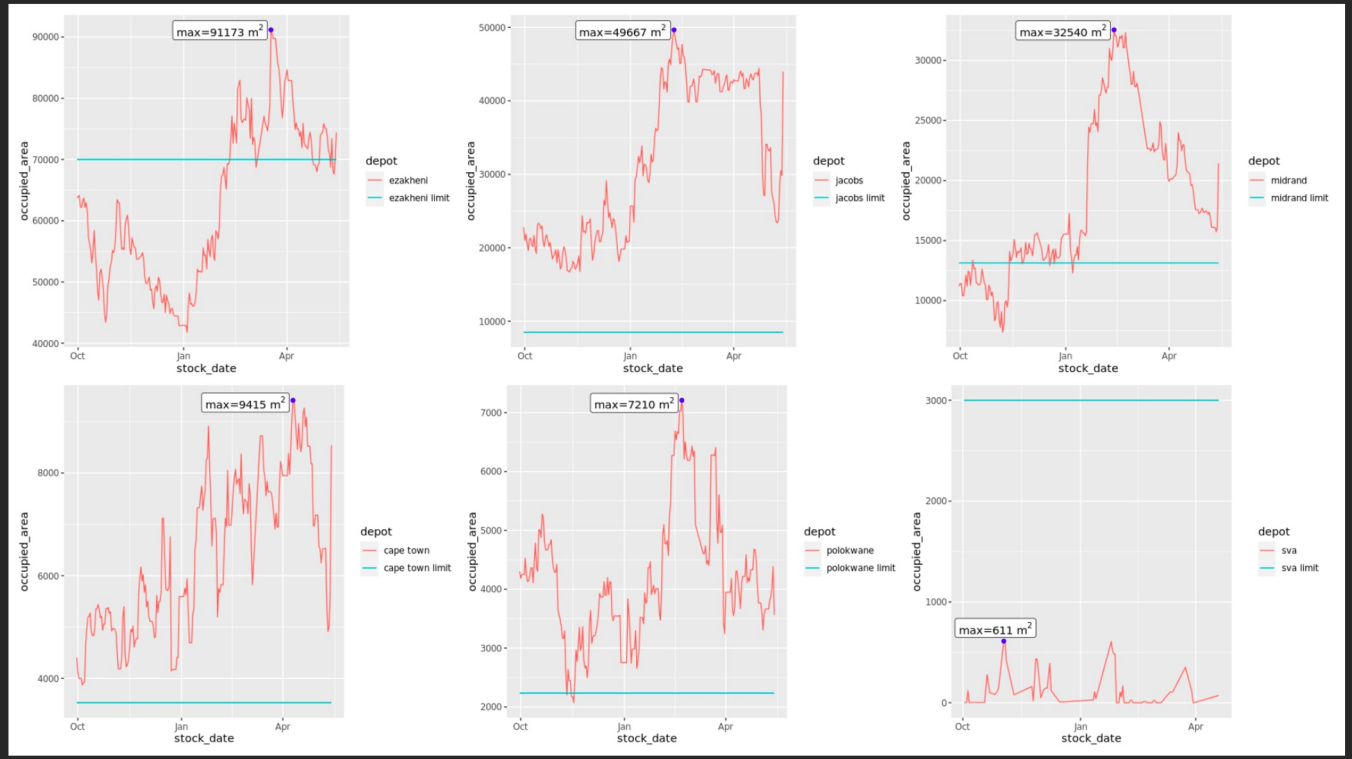
```
for each product in model products do
    for each day D in model days do
        Calculate window W
        Maximum delivery amount M ← 0
        Find set of customers who accept deliveries on day D
        for each customer C do
            X ← All orders of customer C whose requested delivery day
             falls within the window W
            M ← M + X
        end
    end
end
```

Algorithm 1: Algorithm for calculating the maximum delivery amount for each day.

isazi

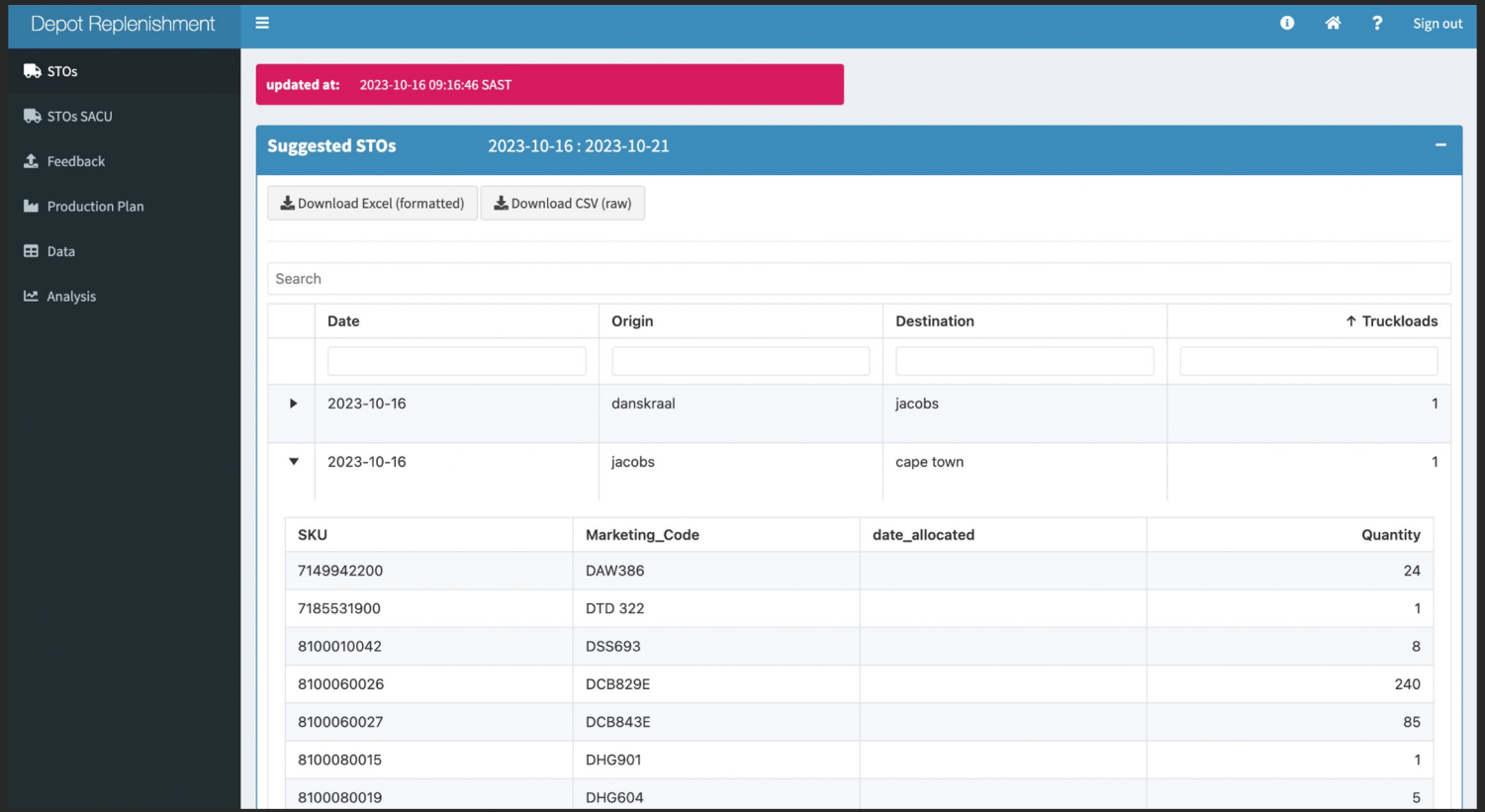
Challenges

Data: warehouses are always over the specified capacity



isazi

DRP Output



isazi

Depot Replenishment Process Optimisation

- Model has to run hourly!
- Need a fast, reliable solver
- Tried a few, and Gurobi seems to handle this problem the best.

Teacher Assignment & Timetable Optimisation

Problem Overview:

- An online school with thousands of students and hundreds of teachers.
- The previously used software was inadequate for the job.
- Two stages - teacher assignment and timetable.
    - Student class assignment done with heuristics.

Teacher Assignment & Timetable Optimisation

Challenges:

- Business rescue means reducing teaching staff - but the student requirements still have to be met.
- Managing diverse curricula, grades, teaching formats, and language of instruction.
- Unclear and inconsistent rules and inputs
- Bad data management
- High staff turnover and many students leaving and joining.

Teacher Assignment & Timetable Optimisation

Timetable Optimality:

- In general, one timetable is as good as another as long as constraints are met.
- Objective function terms will depend on the needs of the particular school.
- Went from objective function terms to hard constraints - now every valid solution is also an optimal one.
    - Takes longer to solve, but more likely to find optimal solution in time limit.

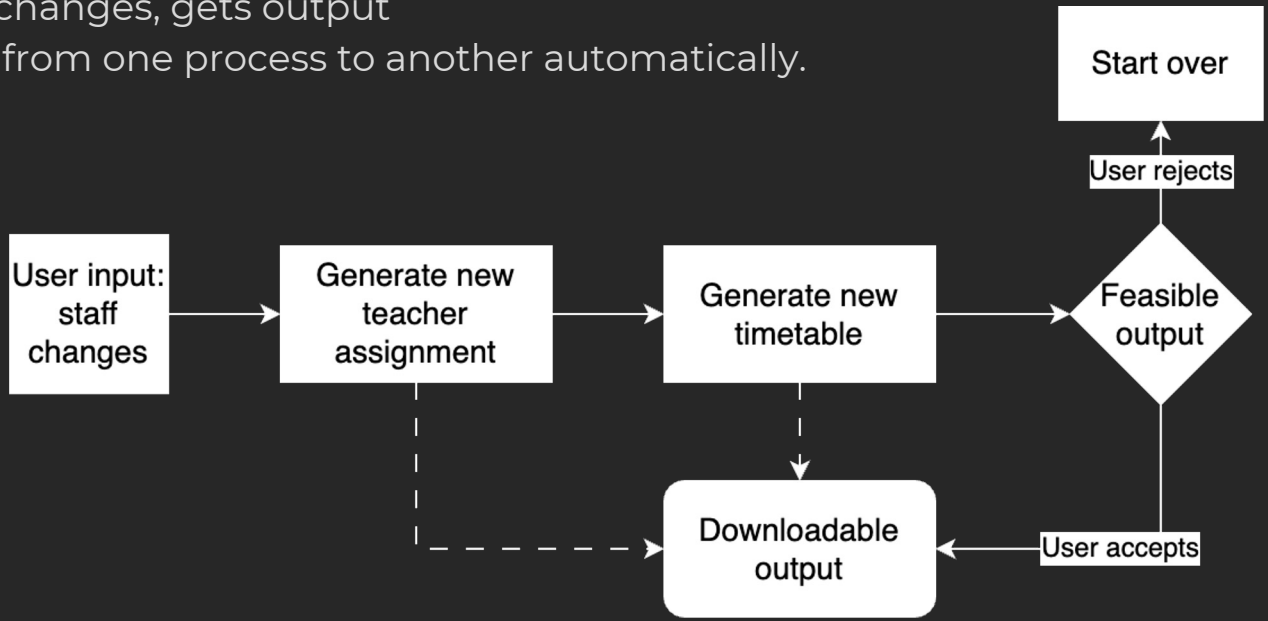
Teacher Assignment & Timetable Optimisation

Outcomes:

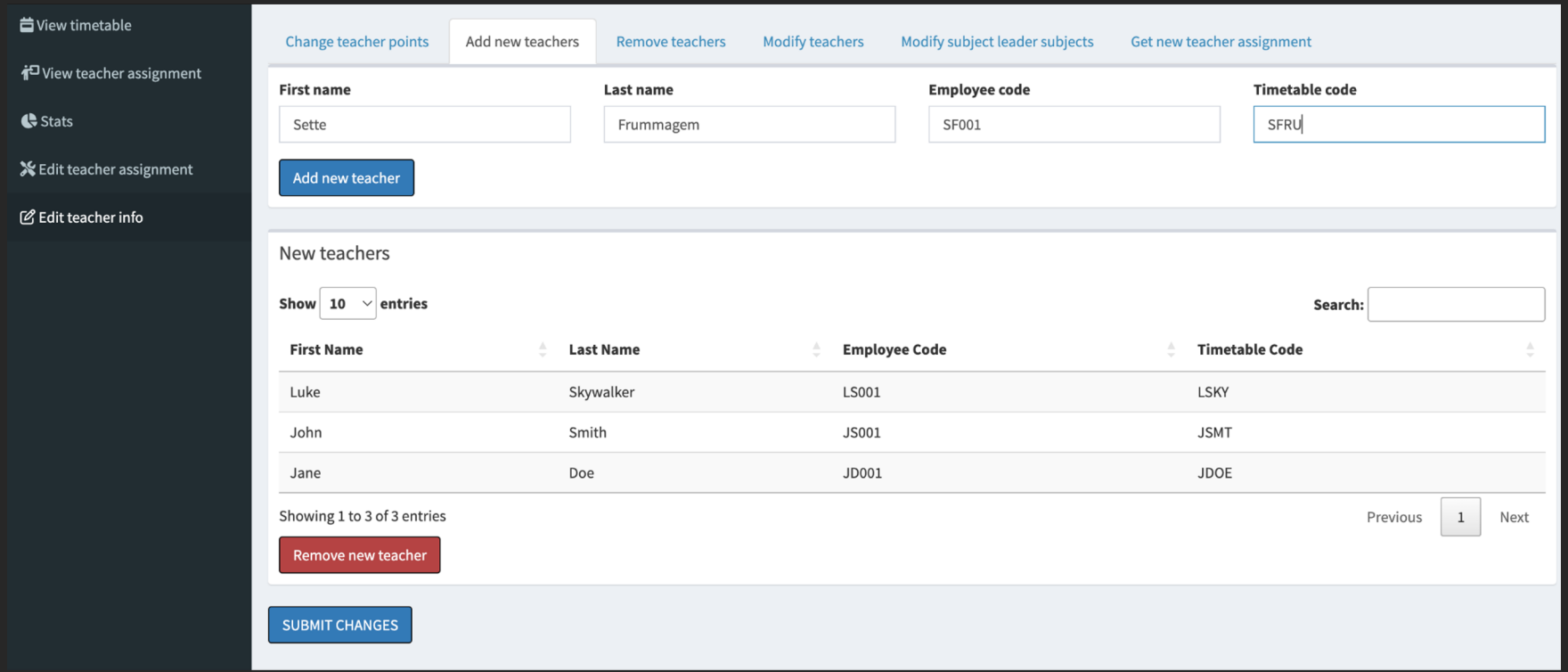
- Less overworked/under utilised teachers.
- Optimal number of teachers on staff.
- No time clashes for students or teachers.
- Staff freed up to spend more time on curriculum development and student support.
- Saved company!

Teacher Assignment & Timetable Optimisation

- Interactive and user driven.
- User inputs changes, gets output
- Data moves from one process to another automatically.

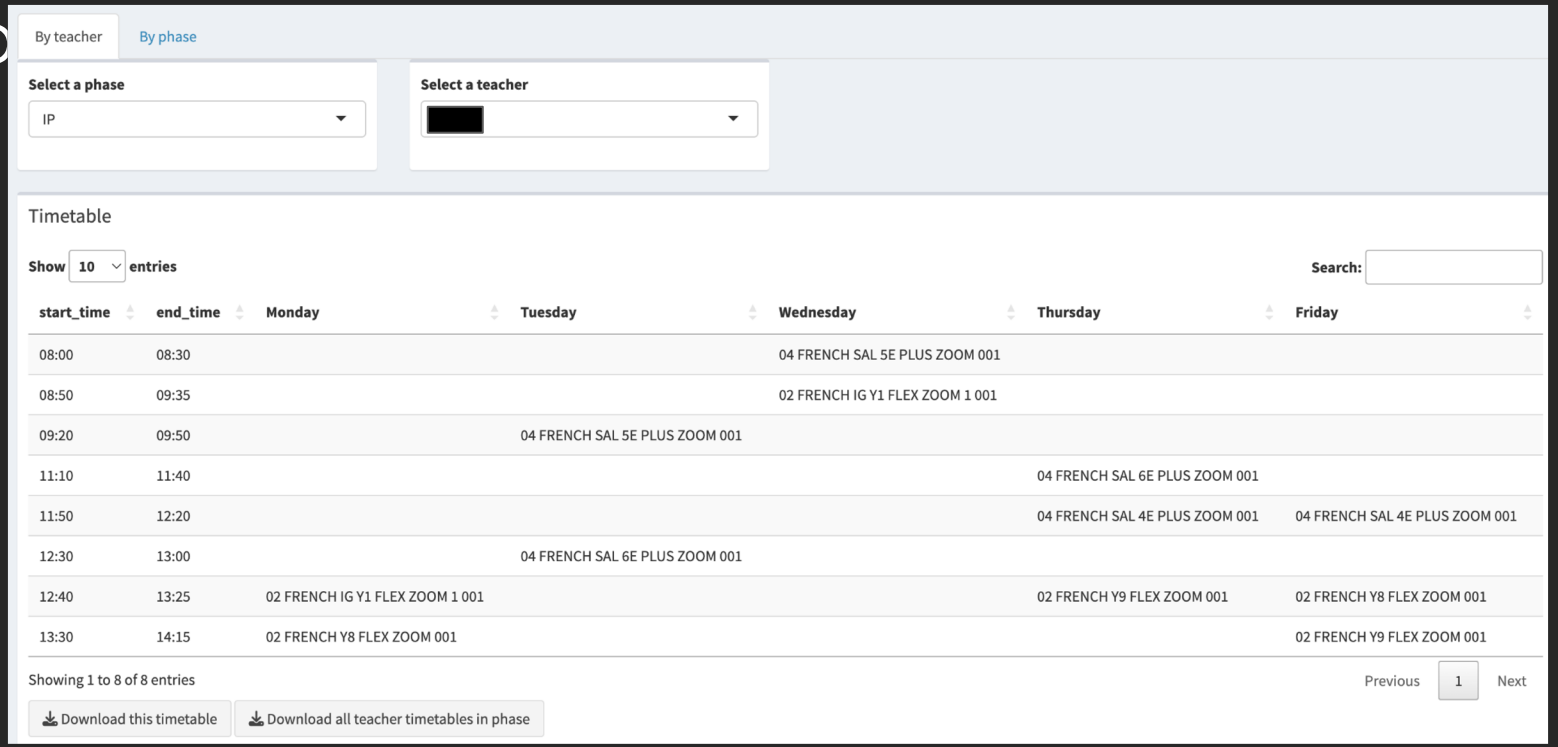


Teacher Assignment & Timetable



Input example

Teacher Assignment & Timetable Op



Output example

Teacher Assignment & Timetable Opti

Assignment full | Assignment summary | Recent changes

Show 10 entries | Search:

Employee Code	Timetable Code	Ssgf	Ssgfc	Num Students in Class	Num Students in Subject	Curriculum	Language	Phase	Grade	Format	Total Hours
All	All	All	All	All	All	All	All	All	All	All	All
[redacted]	[redacted]	SACAI-E-geog-10-H	SACAI-E-geog-10-H-class-1	30	30	SACAI	E	FET	10	H	23.32
[redacted]	[redacted]	SACAI-E-geog-10-P	SACAI-E-geog-10-P-2-class-1	24	49	SACAI	E	FET	10	P	23.32
[redacted]	[redacted]	SACAI-E-geog-11-P	SACAI-E-geog-11-P-1-class-1	34	124	SACAI	E	FET	11	P	23.32
[redacted]	[redacted]	SACAI-E-geog-11-P	SACAI-E-geog-11-P-2-class-1	29	124	SACAI	E	FET	11	P	23.32
[redacted]	[redacted]	SACAI-E-geog-12-H	SACAI-E-geog-12-H-class-1	30	30	SACAI	E	FET	12	H	23.32
[redacted]	[redacted]	SACAI-E-geog-12-P	SACAI-E-geog-12-P-1-class-3	25	116	SACAI	E	FET	12	P	23.32
[redacted]	[redacted]	SACAI-E-lo-10-P	SACAI-E-lo-10-P-class-7	37	400	SACAI	E	FET	10	P	23.32
[redacted]	[redacted]	IEB-E-french-sal-4-P	IEB-E-french-sal-4-P-class-1	7	7	IEB	E	IP	4	P	24.67
[redacted]	[redacted]	IEB-E-french-sal-5-P	IEB-E-french-sal-5-P-class-1	7	7	IEB	E	IP	5	P	24.67

Output example

Conclusion

- Model is only as good as data (garbage in, garbage out)
- Data gets stale: having the *latest* data is critical
- Having an automated pipeline to feed the latest data into the best model/solver gives the best output

isazi

Thank you