

The Airplane Boarding Problem

Modulation and Simulation

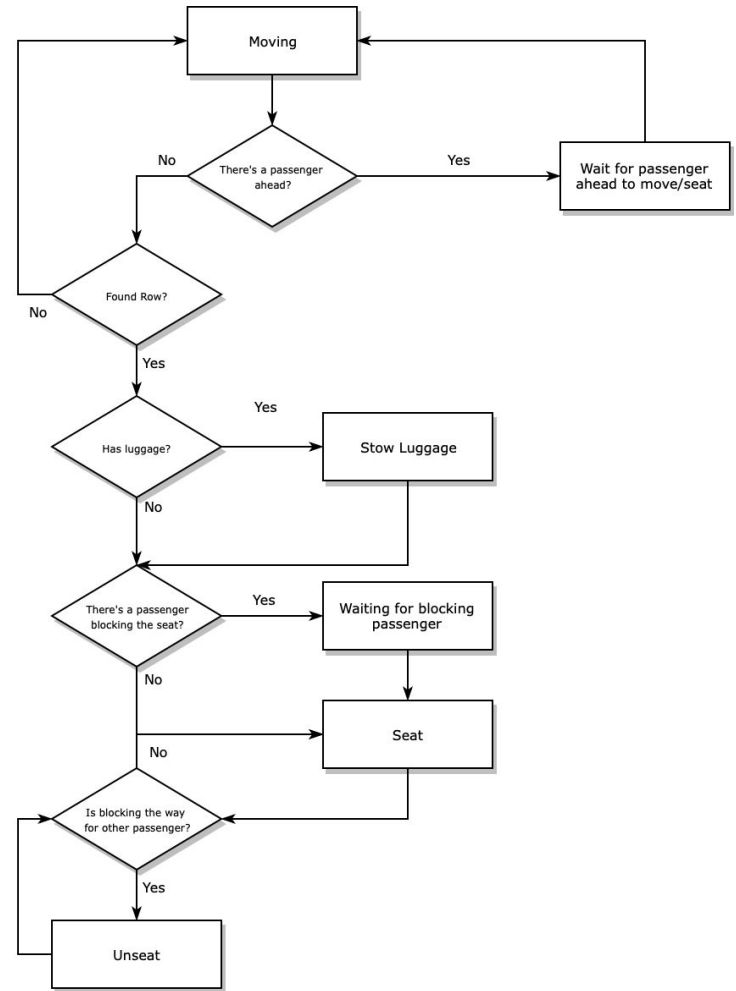
Introduction

1. Problem
2. Background knowledge
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4. Motivation
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Problem

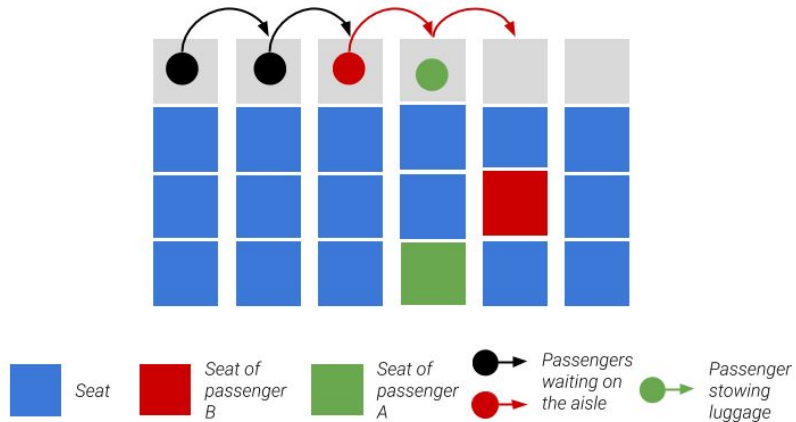
- The **cost** to an airline company **for each minute** spent at the terminal is roughly **\$30**
- **Turnaround critical path** is the disembarkation of passengers, cabin servicing and **passenger boarding**
- Boarding process is **stressful** for everyone, passengers and crew
- Efficient passenger boarding can save a lot of time and money
- There are **efficient boarding methods** which are not implemented in real-life scenarios due to their **complexity** and **pre-ordering process**

Boarding Logic

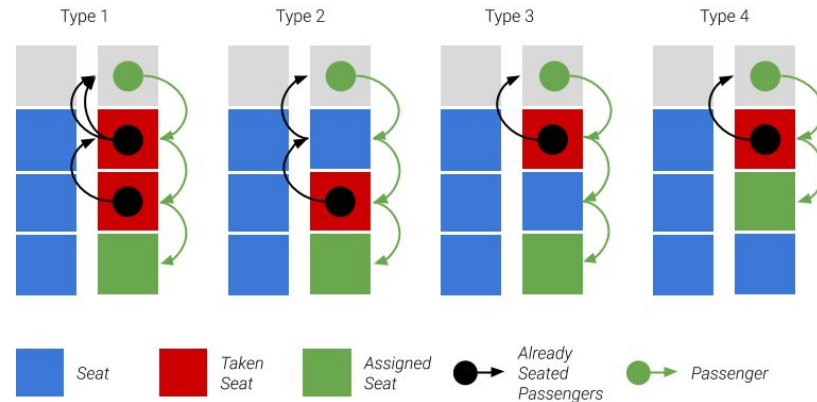


Interferences

1. Aisle Interference



2. Seat Interference



Related Work

Paper Index	Features										
	<i>f0</i>	<i>f1</i>	<i>f2</i>	<i>f3</i>	<i>f4</i>	<i>f5</i>	<i>f6</i>	<i>f7</i>	<i>f8</i>	<i>f9</i>	<i>f10</i>
[Delcea et al., 2018b]	X	X	X	X	X	X		X	X	X	X
[Kierzkowski and Kisiel, 2017]	X	X	X	X		X				X	X
[Kalic et al., 2013]	X	X	X	X		X	X	X	X	X	
[Steffen and Hotchkiss, 2012]	X	X	X	X		X	X	X		X	
[Delcea et al., 2018a]			X	X	X	X		X	X	X	X
[Cimler et al., 2012]	X	X	X	X	X	X		X	X		
[Mas et al., 2013]	X	X	X			X		X	X		

*There's a gap on researches considering both **simulation** and **human behaviour***

- f0.** Considers aisle interferences;
- f1.** Considers seat interferences;
- f2.** Considers time for stowing luggage;
- f3.** Considers a variable luggage count;
- f4.** Analyses 4 or more boarding methods;
- f5.** Uses a single-aisle layout;
- f6.** Has a passenger satisfaction metric;
- f7.** Finds an average boarding time;
- f8.** Uses simulation instead of just observation;
- f9.** Finds a deviation for individual boarding;
- f10.** Uses human behaviour.

Motivation

1. Simulate airplane boarding in the most **realistic** way possible
2. Use of **human behavioural** metrics
3. Easy and cheap way to test **different ways of boarding** people on an aircraft



No Human Behaviour

Confirm Literature
conclusions

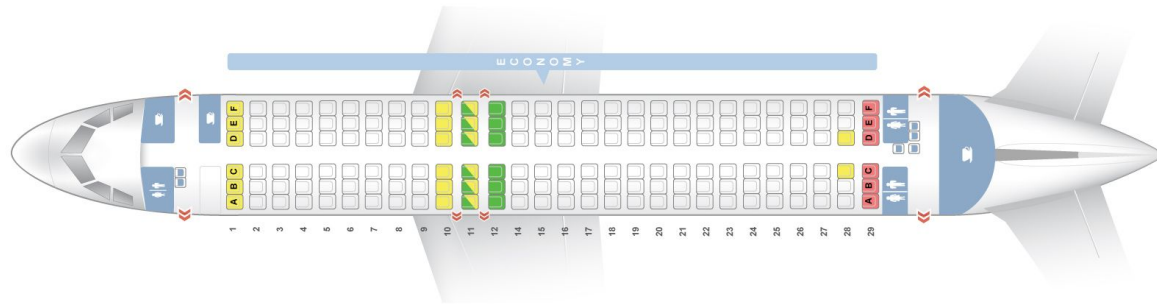
Human Behaviour

Viability of previous
Conclusions in different
Scenarios

Simulation environment

Simulation Plan

1. A320 - 30 rows, 6 seats per row, total of **180 passengers**
2. **9** different boarding **methods**
3. Run simulations in **different scenarios**
4. Gather total **boarding times**
5. Gather total number of **interferences** of each type
6. Calculate passengers **dissatisfaction** level
7. Analyse data and **conclude**/confirm best method



Boarding Methods

1. Random

Front						
1	1	1		1	1	1
1	1	1		1	1	1
1	1	1		1	1	1
1	1	1		1	1	1
1	1	1		1	1	1
1	1	1		1	1	1
1	1	1		1	1	1
1	1	1		1	1	1
1	1	1		1	1	1
1	1	1		1	1	1
1	1	1		1	1	1
1	1	1		1	1	1
1	1	1		1	1	1
1	1	1		1	1	1
1	1	1		1	1	1

2. Back to front /Front to Back (row and block)

Front						
8	10	12		11	9	7
2	4	6		5	3	1

3. Wilma

Front						
1	2	3		3	2	1
1	2	3		3	2	1
1	2	3		3	2	1
1	2	3		3	2	1
1	2	3		3	2	1
1	2	3		3	2	1
1	2	3		3	2	1
1	2	3		3	2	1
1	2	3		3	2	1
1	2	3		3	2	1
1	2	3		3	2	1
1	2	3		3	2	1
1	2	3		3	2	1
1	2	3		3	2	1
1	2	3		3	2	1

4. Steffen

Front						
24						18
12						6
23						17
11						5
22						16
10						28 4
21						15
9						27 3
20						14
8						26 2
19						13
7						25 1

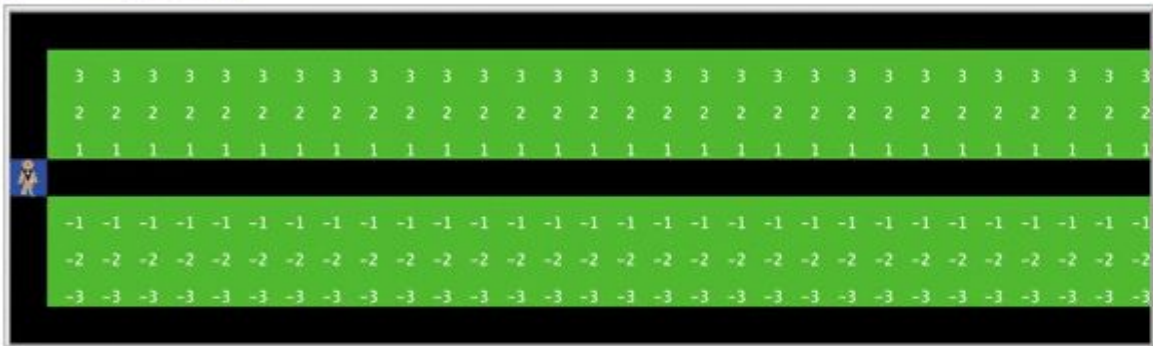
5. Kautzka 3

Front						
23	24				12	11
21	22				10	9
19	20				28	8 7
17	18				27	6 5
15	16				26	4 3
13	14				25	2 1

NetLogo

Now boardi...
75

Elapsed
0



setup

go

go 2

aircraft_model

boarding_method
random

luggage_percentage 50

family_size	3
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luggage_speed 0.81

On human_factor

☐ On ☒ Off distributed_passenger_speed

passenger_no
180

aisle_interferences
0

seat_interferences
0

Default Testing Scenarios

2 Scenarios

1. No passenger have luggage
2. 50% of the passenger have luggage



- 1 - Boarding Time
- 2 - Number of aisle interferences
- 3 - Number of seat interferences

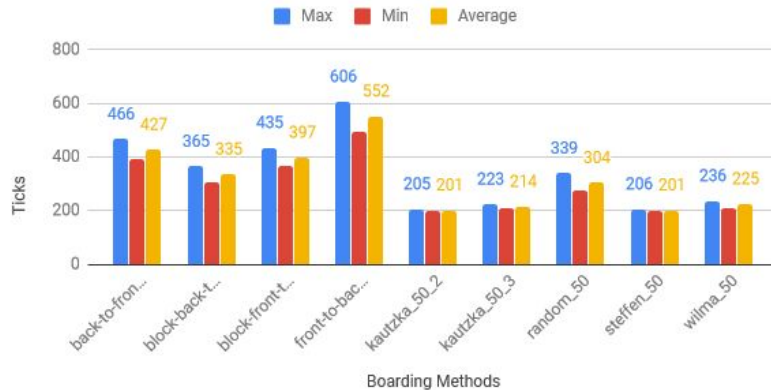
BehaviourSpace - **100 runs**

Results of default tests

Kautzka 3, **Steffen** and **WILMA** are the most performant methods in accordance with the literature studied

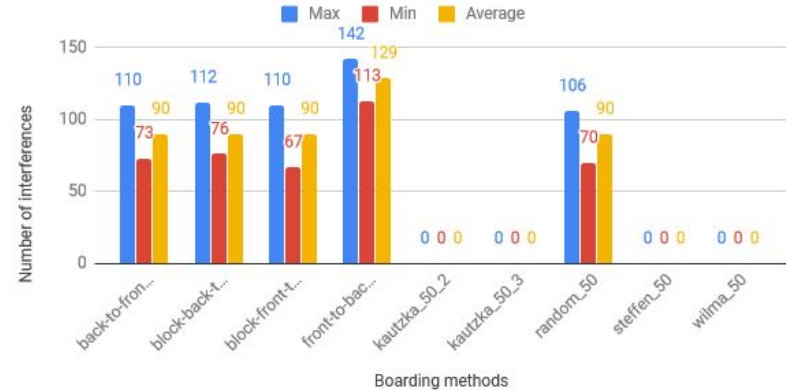
A320 Boarding Time (ticks) with 50% luggage

Lower is better



A320 Boarding seat interferences with 50% luggage

Lower is better



Human Behaviour Metrics

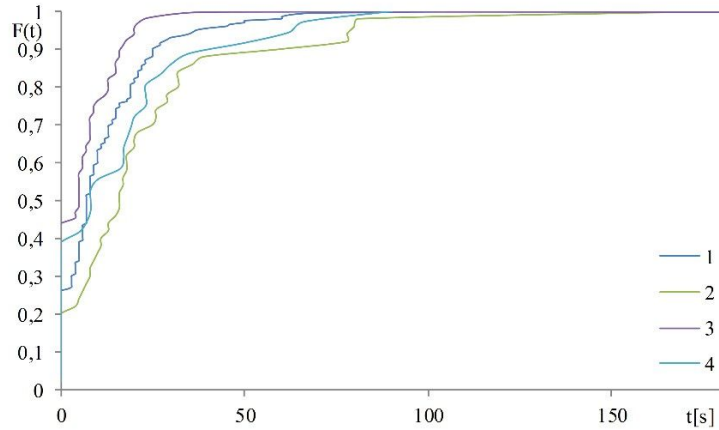
Passenger
Variety

Luggage Stowing
strategy

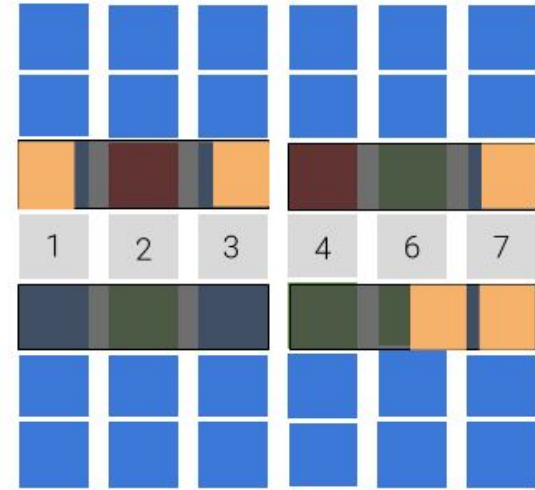
Entrance rate
strategy

Human sympathy

Luggage Stowing Time

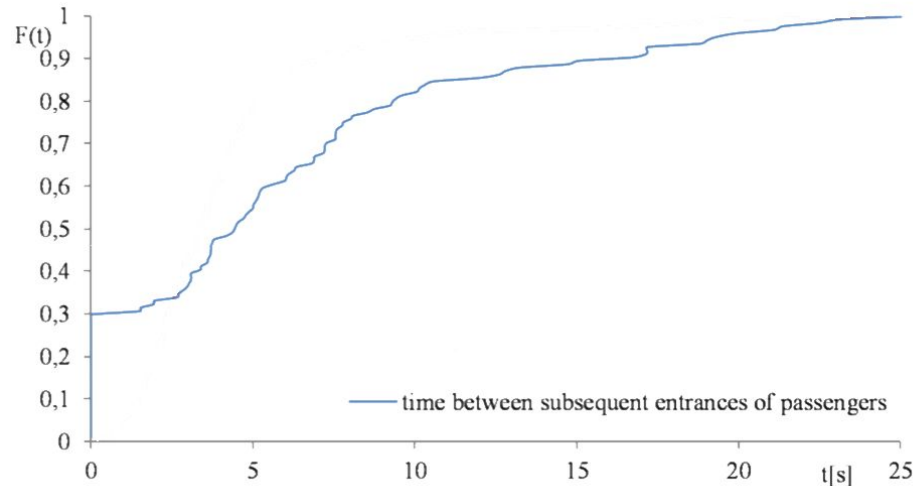


Scenario	Availability of the aisle seat	Filling of the box less than 50%
1	+	+
2	+	-
3	-	+
4	-	-

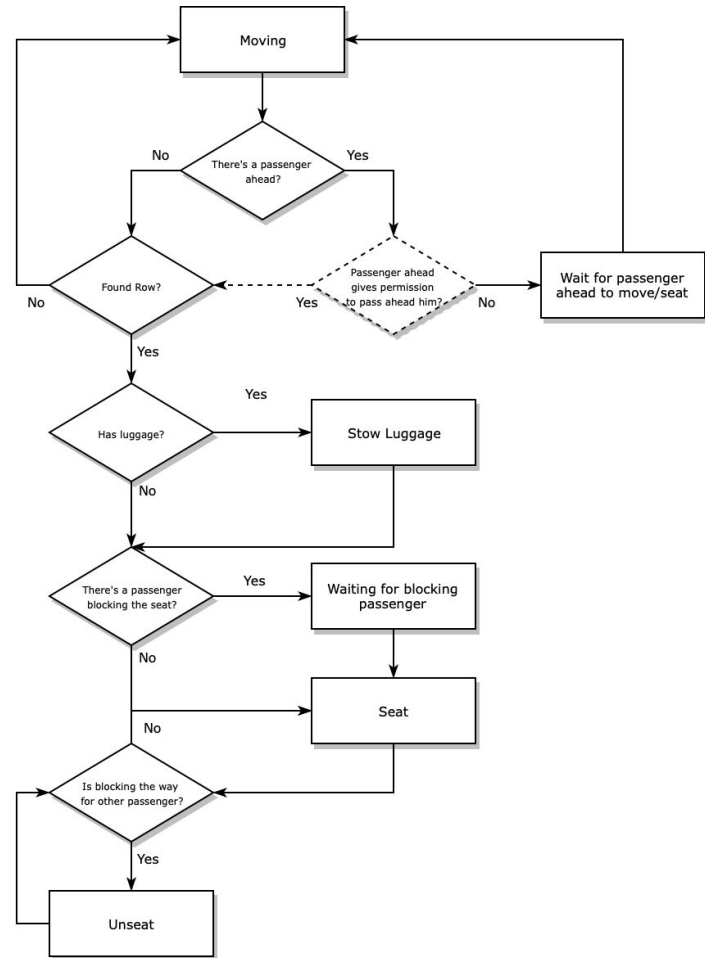


Passenger Entrance Rate

People have different needs so **some of them may take some time** to enter the aircraft since they have to **show their boarding ticket** to the crew and it may **not be always on their hand ready to be shown**



Boarding Humanized Passengers



Human Behaviour Testing Scenarios

2 Scenarios

1. No passenger have luggage
2. 50% of the passenger have luggage



- 1 - Boarding Time
- 2 - Number of aisle interferences
- 3 - Number of seat interferences
- 4 - Dissatisfaction of each passenger
 - a - Boarding time
 - b - Time on aisle interferences
 - c - Time on seat interferences

BehaviourSpace - **100 runs**

Results of Boarding passenger with Human Behaviour

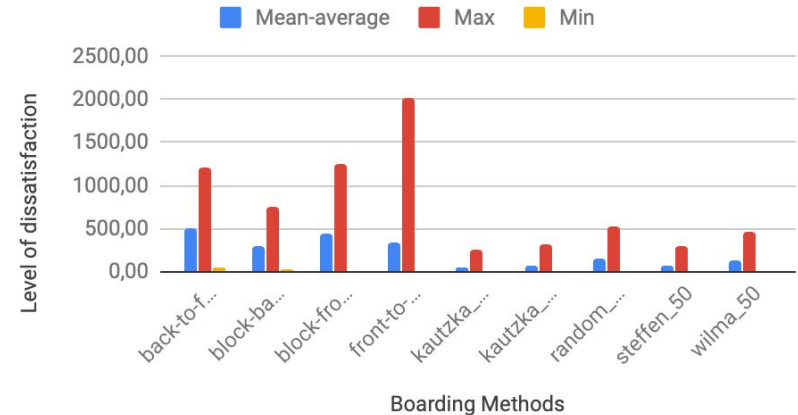
1. **Best methods remain the same**
2. **WILMA** takes a little **more time**
3. Methods which **take less time** are also the ones with **better satisfaction**

A320 Boarding Times (ticks) with 50% luggage

Lower is better



A320 Boarding dissatisfaction with 50% luggage



Conclusion

Theory

Kautzka and **Steffen** are the best
methods ❌

Reality

These methods don't work!

Wilma then? ❌

Maybe the best method is **not using
any method at all**

Future work

Good results but...

1.

Model the **time** needed to **solve seat interferences**

2.

Deep understanding on **what people really care about**:

- a. Boarding in less time
- b. Not so many interferences
- c. ...

References

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Thank you! Questions?