A SIMULATION DECISION SUPPORT MODEL FOR CHECK-IN DESKS IN AN AIRPORT

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ABSTRACT

The goal of this study is to produce a simulation decision support model for check-in desks in the airport. In particular, this study develops a simulation model can be used to build a structure that helps predict dalay and to produce a logical and rational management of check-in and security checkpoint inside the terminal airport.
The model was tested in the medium size italian airport (Naples Capodichino Airport).

Keywords: airport terminal operation, passenger flow, simulation, decision support system, discrete event simulation.

1. INTRODUCTION

Although probably from the outside it cannot be realized, actually it is not easy to understand and to make people to realize the airport operations, since formed by a set of complex infrastructure and facilities and equipments.
Each airport is to be:
- An ideal point of interchange among different means of inland transport (such as road and rail system) and air system;
- A services' centre, because it must provide the necessary services for ticketing, boarding, documentation, control of passengers and goods;
- A point of connection between arrivals and departures, since it must ensure an easy transit from a system of continuous arrivals (which is the users flow) to a system of discrete departures (which are the scheduled flights).

The overall experience of a passenger at an airport can be demanding and time consuming. Delays occur with parking, checking in, security screening, and boarding. The less time the costumer spends in the systems, the higher the satisfaction. However, at the same time, the airport is obliged to hold standards that the passengers must meet. These standards include proper identification, limited luggage weight, and safety procedures at the security checkpoint.

The airport terminal for passengers represents the connecting interface with the air-side area, the place where the take-off and landing of aircraft take place, enabling the transfer of the aircrafts from the land transport system of land transport (rail or truck) to the aircraft one.

Most of the airports, especially those of large size, shows complex traffic and congestion problems, both as regards the runways and parking areas (airside), both the airport where the public has access (landside).

The characteristics that affect the airport landside capacity refer to the following structures:

- number of check-in desks;
- number of gates;
- baggage handling system;
- Police filters;
- departing, transit and arriving passengers flow systems.

All terminal operations (ticketing, check-in, passport control, security control) are obviously characterized besides a service time and a queue waiting time too. This last time cannot be too high, but so far we need to restrain it in order to ensure all passengers having regular ticket the observance of embarkation time thus avoiding the flight missing. In most the reduced times are for travelers synonymous of high quality, key element in developing a good business image. For both reasons, therefore, is crucial for an airport during the years the infrastructure adaptation due to the increasing demand passengers transportation.

2. BOARDING OPERATIONS

The main planned phases before the flight for departing passengers essentially are three:

1) The check-in operations at check-in desks, where the passenger delivers the baggage and receives the boarding pass;

2) The transit at the security controls in order to proceed to the boarding halls with their hand baggage;

3) The boarding operations on the aircraft: the passenger must be show at the boarding gate of his flight with a boarding pass and a valid identity document.

Generally, passengers must have completed the check-in operations:

- For domestic flights at least 35 minutes before departure;

- For international flights to Europe at least 45 minutes before the flight;

- For intercontinental flights at least 60 minutes before the flight.

Following the check-in the passenger, with boarding passes, valid identity document and hand luggage (weight and dimensions allowed by the company), passes through the expatriation controls and the metal detector where security operators perform a manual control on the person and on the hand luggage ascertaining the absence of improper weapons, real or other dangerous objects.

3. STATE OF ART

As mentioned earlier in the transport sector coexist two different concepts, that of the passenger who expect a customized and quick service and the one of that is suitable to a standard organization. As matter of fact the airline companies are highly geared to offer prompt and appealing service: booking via Internet, online payment, e-ticket services, check-in online. Instead the passenger badly tolerate the contrast between the simplicity that shines from the Internet and the hard reality that he must face on his arrival at the airport: several controls, slow registration procedures, queues to board at the gates.

In this section we show some of these works. The Nagoya University has conducted a simulation using the software Arena on departing flow passengers from the International Kansai airport in Japan, in order to reduce the number of passengers, because of long waiting times in peak periods and because of unavoidable delays, they lose their flights. Preliminary analysis on passengers waiting times showed that the total time spent by passengers in the airport: the 48% is spent moving from place to place within the terminal, the 25% is waiting and only the 4% is doing formalities such as process acceptance, embarkation, and so forth.
In addition, it has been found that the time spent at the check-in desks in waiting queue is more than 80% of total time before embarkation. This output highlights that the check-in should be considered as the main bottleneck.

The simulation was conducted considering the condition of congestion based on flight operations of a regular working day, usually adjusted on a number of 100 flights and boarding operations of 70%. In particular, it refers to the airline's "A Company" which operates about 25% of all flights of the Japanese airport. The results of the simulation suggests that the number of passengers loosing their flights can be drastically reduced by the addition of a staff supporting the standard working group, and by the use of check-in desks different for passengers class, such as tourists, business and first class. This is a solution already adopted by many carriers both Italian and International.

The departing passengers flow at the Buffalo International Airport (Niagara) has been studied by researchers from the Department of Industrial Engineering and Systems at the University of Buffalo, Particular attention has been shown to the check-in process, considering that the waiting system times besides varying depending on week day and the time of the day, are function of different check-in available to passengers, the number of bags and the chosen airline to fly.

Interesting is also the work proposed by the School of Mathematics and Statistics Carleton University (Ontario, Canada), where a linear programming model minimizing the total work hours at the check-in ensuring a satisfactory customer service level has been developed. The output of this alternative method shows a significant performance improvement since it provides a shorter queues length, reduced waiting times and an increase in satisfied customers percentage.

4. DATA COLLECTION

This study developed a simulation model able of managing in a logical and rational mode all check-in desks and security control inside the airport.

The importance of this model lies in the ability to identify, at any time of the year and depending on the airport traffic volume, the required number of check-in required and at the same time adequate to perform the check-in operations in full compliance and regularity of the scheduled flights ensuring a satisfactory service level for departing travelers. The close correlation between the check-in operations and the security controls allows to obtain in the same way the number of the security control accesses to be made operational during the referred period.

Building the model is equivalent to virtually retrace the journey made by departing passengers studying the issues and highlighting all the available alternatives. Essential to this development is the visit at the terminal, useful to understand in general the passengers approach and both in order to have all information needed for the continuation of this work. To fully clarify the issue we must know the number of check-in and the available security control checkpoint: these number are 56 and 12.

Obviously at the changing flight destination varies the check-in time at desks which is usually an interval of 90 minutes for international flights and approximately one hour for domestic one. While as regards the security passengers control of any airline company can be served at any desk regardless flight destination, related to the check-in process is essential to examine how the airport operator assigns the desks to airline companies or handler. The airlines that operate more flights simultaneously adopt the solution of the common check-in (as the case of AIRONE company in our study), in which passengers on same company flights may be served on any desk regardless destination. Also the management queue can be different: in Naples airport, e.g., Airone manages several desks through a single queue, while other companies like Air France arranges passengers to many queues as much available desks.

This clarification is crucial for an easier understanding of the logical model described in the next paragraph.

Today's airport terminals offer to tourists real business galleries, thus finished the check-in phase passengers are increasingly tempted to delay the next operation of security control since they prefer last shopping before departure or at least visiting other shops, always consistent with the remaining time for boarding.

4.1. Naples Airport Terminal

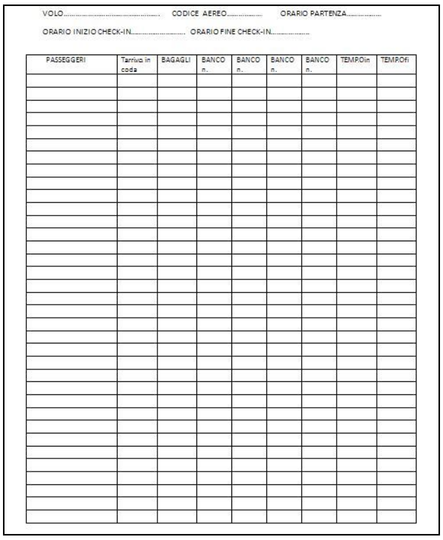
The landside of the Naples International airport consists of two terminals, Terminal 1 (T1) and Terminal 2 (T2). As the Terminal 2 is operating only in spring-summer season, and almost exclusively for charter flights, focus our study on passenger traffic on the only Terminal 1. The path related to passengers departing from Terminal 1 consists of two floors: on the ground floor we have the check-in desks, and on the first floor, accessible by escalators, the security control checkpoint and some shops and food services are located. On the other side of the ground floor besides the path related to arriving passengers there are the ticket office, the two currency exchange offices, several car rentals, and so forth.

Figure 1: Map of Terminal 1 at the Naples airport

4.2. Data Analisys

The most problematic phase of this study has been with no doubt that on data acquisition. Sampling took place in the passenger terminal 1 at Naples International airport. After a thorough inspection of Capodichino airport it came out that passenger traffic peaks during the whole week were on Monday morning and Friday afternoon. Therefore the focus data collection phase was on three week days: Monday, Wednesday and Friday. The survey was repeated for several weeks by 2 people with different recognition tasks: the first one monitored near the check-in the passengers arrival at the counter to get the determination of so-called 'curves of presentation' and the service time of the check-in formalities, instead the second one has carefully considered the queue near the desks by defining the queue length and service time.

The spreadsheets show on the header some information such as basic information flight (the airline and destination), time of departure, time of opening and closing its check-in and finally we added the flight code. This information is important because from the flight code it is possible to know the type of the aircraft used for that flight and then the total number of aircraft available seats. From this number it is possible the value of a important factor called load factor or filling factor, defined as the ratio between the number of seats occupied by passengers and the total number of available seats on the aircraft. In most of the studies this problem is simplified approximating the filling factor at a constant value and equal to 0.65.


VOLO.................. CODICE AEREO.............. ORARIO PARTENZA..............

ORARIO INIZIO CHECK-IN.................. ORARIO FINE CHECK-IN..............

PASSEGGERI	Tarrivo in coda	BAGAGLI	BANCO n.	BANCO n.	BANCO n.	BANCO n.	TEMP.Oin	TEMP.Ofi

Figure 2: Spreadsheet data collection

As for the security control at checkpoint (located on the first floor of the terminal), we used both historical data in our possession and new collected data. The survey in any case was simpler than the one made at check-in desks, because there is not flights distinction or other it is enough to consider the number of active locations and the time of queue clearing.

In order to carry out a correct analysis of collected data it was necessary to make an appropriate data stratification for highlighting some key aspects. This was a crucial step in order to get to the distributions to be included in the simulation model to be validated. The stratification concerns different features that are showed through aerograms summarizing the contents.

- Airline. Mainly we focused on check-in desks number dedicated at Airone, the airline company currently operate the largest number of flights per day at Naples International airport (61% vs 39% for the others). In particular, the Airone company exploits its available desks through a mode called 'Common Check-in generalised', with which all counters are indiscriminately opened to any flight operated by the company itself, so at the same desk are recorded passengers to different destinations. For most other airlines instead check-in is 'dedicated' to a specific flight.

- Flight destinations. The distinction between domestic (65%) and international flights (35%) is crucial in our study for the different approach that passengers show towards the second flight category compared to the next (eg arriving at the terminal generally more advance time) and for the different opening check-in desk times. The opening check-in desk times for the major airlines operating in Capodichino airport are:
- AIRONE: for domestic flights from 1.5 h to 25 ' before departure and for international flights from 2h 30' before the flight;

  BRITISH AIRWAYS: from 2h 30 ' before the flight;

  AirFrance: from 2h 30 ' before the flight;

  MERIDIANA: from 2h 30 ' before the flight;

  LUFTHANSA: 2.5 h at 35 ' before the flight.
- Type of passengers. Last but not least important distinction is that which concerns the two main categories of passengers: tourist and business passengers, 80% and 20% respectively

5. SIMULATION MODEL

The simulation is a very useful tool to predict the constant changes that result in a highly dynamic as the airport, and in particular, it refers to the discrete event simulation (DES), in which the state variables vary only at of discrete events (special moment), determined in turn by activity and delay, and not continuously, adapting perfectly to the systems characterized by complex processes, combined with limited infrastructure capacity.

It's possible to think in terms of modular system, developing model through different submodels that make cleaner the understanding and allow for easier management of the whole.

Three used submodels to represent whole system are:

- Generation passengers;
- Check-in;
- Security control.

In particular we considered it appropriate to divide the acceptance process depending on the type of servicing check-in: common desks and dedicated desks.

The passenger traffic flow at the airport is a discrete stochastic process. The simulation of discrete event is often used to model systems characterized by complex processes, combined with infrastructure at limited capacity. The airports are therefore ideal places to work with simulations having these features. The software used for the case study of our study is Rockwell Arena. Retracing the considerations made in the logical model, the simulation has been developed in submodels allowing to obtain all advantages inherent to a modular system representation. Having discussed the model widely from a logical point of view, to avoid unnecessary repetitions, now we restrict the study in highlighting only some key aspects.

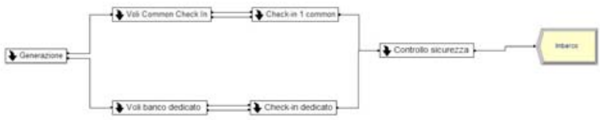


Figure 3: Model representation

As already said, the available resources (check-in desks and security control checkpoint) are considered as variables with a value equal to 1, in the case of free state, and 0 if engaged. At this point the queues are managed through hold of scan for condition type, in which block the phrase allowing users to leave the queue and to continue the path is inserted.

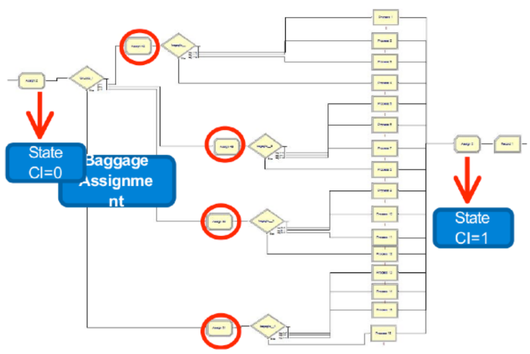


Figure 4: Common Check – in management

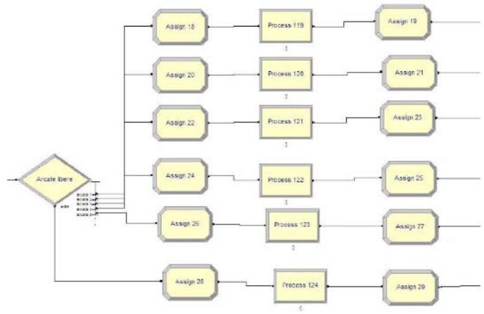


Figure 5: Security Checkpoint management

The first step has been to verify the correct model functionality towards implemented logics.

Verified the correct operation the simulation of the current situation is carried out. Initially are open all check-in desks (4 for the commons and 4 for the dedicated) and all six security control checkpoint inserted into the model and we advance the simulation with a number of 100 replications.

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Coda A.Queue	0.3106	0,04	0.2516	0.4293	0.00001208	0.9017
coda Bd.Queue	0.02447783	0,01	0.01058678	0.04985998	0.00079936	0.08864483
coda4.Queue	0.0902	0,03	0.03910184	0.1457	0.00118771	0.3265
coda5.Queue	0.0903	0,03	0.03289742	0.1325	0.00005032	0.4291
coda6.Queue	0.08695318	0,03	0.04967483	0.1562	0.00017434	0.4000
Codabus.Queue	0.01748204	0,00	0.01181466	0.02965474	0.00001276	0.1225
CodaT.Queue	0.04333903	0,01	0.02537405	0.08383999	0.00004206	0.1613

Figure 6: Hourly queue waiting time with all available resources

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Coda A.Queue	21.7389	3,53	15.9816	32.5216	0.00	199.00
coda Bd.Queue	0.02260145	0,01	0.00132335	0.06232497	0.00	3.0000
coda4.Queue	0.6582	0,22	0.2151	1.0447	0.00	14.0000
coda5.Queue	0.6593	0,22	0.1933	1.0351	0.00	15.0000
coda6.Queue	0.6678	0,21	0.2856	1.1128	0.00	15.0000
Codabus.Queue	0.04970299	0,02	0.02615481	0.08802838	0.00	5.0000
CodaT.Queue	1.6089	0,48	1.0276	3.2907	0.00	48.0000

Figure 7: Number of users in the queue with all available resources

As can be seen from Figure 7, while the number of users in the queue at check-in desk is quite low, which implies that too many desks are open, the values of the queue at the security control checkpoint is quite high therefore this scenario is not satisfactory to the customer. Then we add 2 more security control checkpoint in the model, initializing it with value 1 (free state) and we launch again the simulation.

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Coda A.Queue	0.1442	0,03	0.08273419	0.1898	0.00001713	0.4012
coda Bd.Queue	0.02710774	0,01	0.00849423	0.07885684	0.00482387	0.1219
coda4.Queue	0.1394	0,03	0.08541390	0.1838	0.00013671	0.4811
coda5.Queue	0.1325	0,02	0.0948	0.1881	0.00001231	0.5248
coda6.Queue	0.1316	0,02	0.08474739	0.1666	0.00018533	0.4373
Codabus.Queue	0.01880890	0,00	0.01524115	0.02770415	0.00014332	0.0915
CodaT.Queue	0.04046939	0,01	0.02104750	0.05911443	0.00000303	0.1521

Figure 8: Hourly queue waiting time with 8 available security control checkpoint

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Coda A.Queue	8.6206	1,91	4.5711	13.5705	0.00	130.00
coda Bd.Queue	0.01828298	0,02	0.00254316	0.08871395	0.00	3.0000
coda4.Queue	1.1504	0,21	0.8008	1.6249	0.00	17.0000
coda5.Queue	1.0865	0,22	0.6043	1.5284	0.00	19.0000
coda6.Queue	1.0870	0,20	0.6886	1.4993	0.00	19.0000
Codabus.Queue	0.06060394	0,01	0.04453302	0.0970	0.00	4.0000
CodaT.Queue	1.5202	0,39	0.7064	2.2537	0.00	48.0000

Figure 9: Number of users in queue with 8 available security control checkpoint

In this new context, we remark that the queue waiting time at the checkpoint is noticeably reduced and in confirmation of what previously developed we found for the check-in desks the values similar to the ones previously found.

6. CONCLUSION

This paper documents our study and development in creating a knowledge-based simulation system to predict check-in counter resource requirements at airports. Results generated by this knowledge-based simulation system are then used by a constraint-based scheduling system that generates a schedule for daily check-in counter allocation.

The results obtained through Arena provide queue average values and waiting times as well as the related minimum and maximum peaks in relation to the number of resources left open in the model.

We obtained, in this step analysis, a quantitative model that represent the airport passenger flow before boarding. The immediate use of this structure is to study the check-in desks numbers and the related security checkpoint numbers in different time interval.

Next phase is to optimize the model, and then to figure out the check-in desks and security control checkpoint best combination able to minimise costs.

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