Passenger Rebooking - Decision Modeling Challenge

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Introduction

This is a solution to the DMN Community challenge from October/2016. This solution is strictly based on the **DMN specification**, compliance level 3. It can be executed using the **Drools open source engine** and it can be imported into **Trisotech**'s DMN Modeler for editing/authoring.

Problem statement

Flight	From	To	Dep	Arr	Capacity	Status
UA123	SFO	SNA	1/1/07 6:00 PM	1/1/07 7:00 PM	5	cancelled
UA456	SFO	SNA	1/1/07 7:00 PM	1/1/07 8:00 PM	2	scheduled
UA789	SFO	SNA	1/1/07 9:00 PM	1/1/07 11:00 PM	2	scheduled
UA1001	SFO	SNA	1/1/07 11:00 PM	1/2/07 5:00 AM	0	scheduled
UA1111	SFO	LAX	1/1/07 11:00 PM	1/2/07 5:00 AM	2	scheduled

Name	Status	Miles	Flight
Jenny	gold	500000	UA123
Harry	gold	100000	UA123
Igor	gold	50000	UA123
Dick	silver	100	UA123
Tom	bronze	10	UA123

RULES

1. Alternate flight must depart from the same place as the cancelled flight
2. Alternate flight must arrive at the same place as the cancelled flight
3. Alternate flight must depart after the cancelled flight
4. There must be room on the alternate flight
5. Passenger status determines who gets allocated first

Results

Jenny is confirmed on UA456 departing SFO at 1/1/2007 19:00:00 arriving SNA at 1/1/2007 20:00:00
Harry is confirmed on UA456 departing SFO at 1/1/2007 19:00:00 arriving SNA at 1/1/2007 20:00:00
Igor is confirmed on UA789 departing SFO at 1/1/2007 21:00:00 arriving SNA at 1/1/2007 23:00:00
Dick is confirmed on UA789 departing SFO at 1/1/2007 21:00:00 arriving SNA at 1/1/2007 23:00:00
Tom could not be rebooked

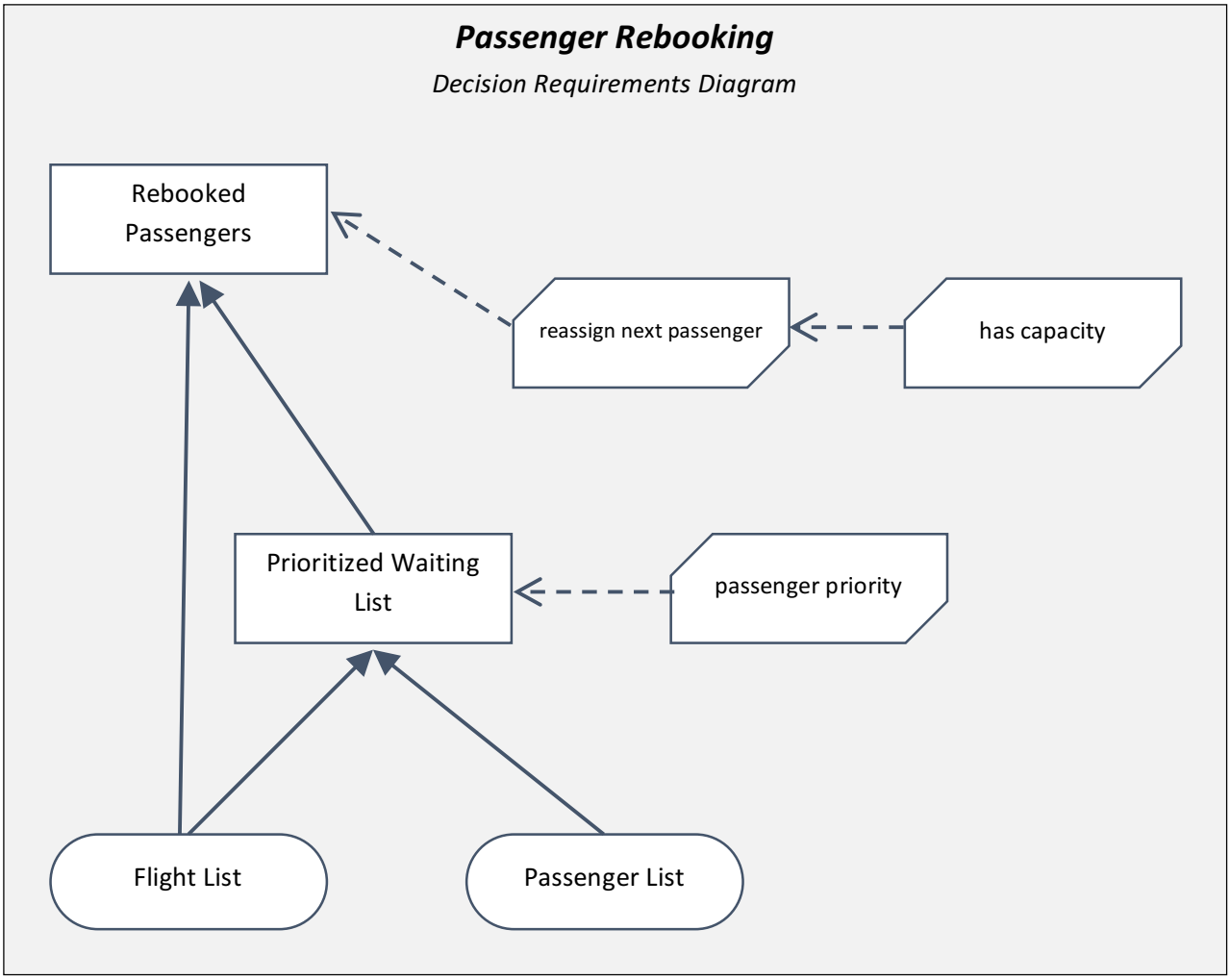
Solution

Following the DMN standard, the high-level solution is modelled in a DRD (Decision Requirements Diagram) that is presented below. Each node of the diagram is then explained in the following pages.

Input Nodes

This problem statement defines two lists of input data:

- A list of flights, represented by the “Flight List” input node; Each flight contains all the flight attributes, as defined in the problem statement (i.e., flight number, from, to, etc)
- A list of passengers, represented by the “Passenger List” input node; Each passenger contains all the passenger attributes as defined in the problem statement (i.e., name, status, etc)



Prioritized Waiting List Decision

From the input data, the first decision finds the list of passengers from cancelled flights and sorts them in priority order, per the rules provided in the problem statement. This decision is modelled as a boxed context:

Prioritized Waiting List	
Cancelled Flights	`Flight List[ Status = "cancelled" ].Flight Number`
Waiting List	`Passenger List[ list contains( Cancelled Flights, Flight Number ) ]`
`sort( Waiting List, passenger priority )`	

The first entry in the context uses a filter to find all the flights for which the status is "*cancelled*" and for each of those flights returns its "*Flight number*". The result is a list of "*Flight Numbers*" that is assigned to the variable "*Cancelled Flights*".

The second entry in the context also uses a filter to find all the passengers that were booked on the cancelled flights. This time, the filter uses a FEEL function named "*list contains()*" that returns true if the list passed as the first parameter ("*Cancelled Flights*" in this case) contains the element passed as the second parameter ("*Flight Number*" in this case). The result of this filter will be a list of all the passengers from the "*Passenger List*" that were booked into cancelled flights, and will assign that list to the variable "*Waiting List*".

The final box in the boxed context is called result box and contains the expression that will be evaluated to produce the result of this decision. In this case, it is a call to another FEEL function called "*sort()*". The "*sort()*" function will sort the "*Waiting List*" based on the "*passenger priority*" criteria (the second argument to the function) and will assign the resulting sorted list to the decision (i.e., the "*Prioritized Waiting List*" variable). The "*passenger priority*" criteria is modelled as a Business Knowledge Model and explained next.

Passenger Priority Business Knowledge Model

The passenger priority for flight rebooking is defined by a composite criterion as per the problem statement. Basically, passengers with a higher status have priority ("gold" has priority over "silver" and "bronze", etc) over passengers with a lower status. The problem statement is not clear on what happens if two passengers have the same status, but it is assumed that in this case, the passenger with a higher mileage will have priority.

This rule can be modelled in several ways, including FEEL expressions, decision tables or a combination of both.

In this case, a decision table is used, as it is typically considered to be more user friendly. It is modelled as a Business Knowledge Model node that receives two passengers as parameters and returns a boolean result of "true" if passenger 1 has priority over passenger 2, or false otherwise.

passenger priority				
(Passenger1, Passenger2)				
U	Passenger1.Status	Passenger2.Status	Passenger1.Miles	Passenger1 has priority
	gold, silver, bronze	*gold, silver, bronze*		true, false
1	*gold*	*gold*	> Passenger2.Miles	true
2		*silver, bronze*	-	true
3	*silver*	*silver*	> Passenger2.Miles	true
4		*bronze*	-	true
5	*bronze*	*bronze*	> Passenger2.Miles	true

Rebooked Passengers Decision

After creating a prioritized waiting list of passengers, the "Rebooked Passengers" decision reassign the passengers to new flights, depending on availability. It does that by invoking the Business Knowledge Model "reassign next passenger".

The decision itself then returns a list of all the reassigned passengers as the solution for the problem.

Rebooked Passengers	
reassign next passenger	
Waiting List	Prioritized Waiting List
Reassigned Passengers List	[]
Flights	Flight List

The parameters should be self-explanatory, except maybe the "Reassigned Passengers List". This is a list of all the passengers already reassigned. On the first invocation, it starts empty, as one can see above. The empty square brackets ("[]") is the FEEL representation for an empty list.

Reassign Next Passenger Business Knowledge Model

The Business Knowledge Model "`reassign next passenger`" is a recursive function that will reassign all the passengers in the waiting list one by one. It is implemented as a boxed context for simplicity, and the explanation to each entry can be found after the diagram:

<table>
<tr><td colspan="2">reassign next passenger</td></tr>
<tr><td colspan="2">(Waiting List, Reassigned Passengers List, Flights)</td></tr>
<tr><td>Next Passenger</td><td>Waiting List[1]</td></tr>
<tr><td>Original Flight</td><td>Flights[Flight Number = Next Passenger.Flight Number][1]</td></tr>
<tr><td>Best Alternate Flight</td><td>Flights[From = Original Flight.From and
To = Original Flight.To and
Departure > Original Flight.Departure and
Status = "scheduled" and
has capacity(item, Reassigned Passengers List)
][1]</td></tr>
<tr><td>Reassigned Passenger</td><td><table><tr><td>Name</td><td>Next Passenger.Name</td></tr><tr><td>Status</td><td>Next Passenger.Status</td></tr><tr><td>Miles</td><td>Next Passenger.Miles</td></tr><tr><td>Flight Number</td><td>Best Alternate Flight.Flight Number</td></tr></table></td></tr>
<tr><td>Remaining Waiting List</td><td>remove(Waiting List, 1)</td></tr>
<tr><td>Updated Reassigned Passenger List</td><td>append(Reassigned Passengers List, Reassigned Passenger)</td></tr>
<tr><td colspan="2">if
  count(Remaining Waiting List) > 0
then
  reassign next passenger(Remaining Waiting List,
  Updated Reassigned Passengers List,
  Flights)
else
  Updated Reassigned Passengers List</td></tr>
</table>

The BKM receives 3 parameters when it is invoked:

- **Waiting List:** the current list of passengers waiting for reassignment to a new flight
- **Reassigned Passengers List:** the list of passengers already reassigned
- **Flights:** the list of all available flights

The BKM evaluates the following context entries in order:

- **Next Passenger:** retrieves the next passenger to be assigned. It is the first passenger in the waiting list.

- **Original Flight:** retrieves the original flight the passenger was booked into by filtering the `Flights` list and finding the flight whose `Flight Number` is the same as the `Flight Number` of the passenger. A filter on a list returns a new list, so the use of [1] in the expression ensures that the result is a single element, not a list.
- **Best Alternate Flight:** finds the best alternate flight to assign the passenger to, based on the rules defined in the use case. I.e.:
    - the new flight must depart from the same location:
        - `From = Original Flight.From`
    - the new flight must arrive at the same location:
        - `To = Original Flight.To`
    - the new flight must depart after the original flight was scheduled to depart
        - `Departure > Original Flight.Departure`
    - the new flight must be scheduled (i.e., not cancelled)
        - `Status = "scheduled"`
    - the new flight must have a free seat for the new passenger. This condition is checked by invoking the "*has capacity()*" function (see its documentation in the next section for details), passing the flight as the first parameter and the already reassigned passengers list as the second parameter. It returns *true* if the flight still has a free seat for the new passenger, or *false* if it is already full.
        - `has capacity( item, Reassigned Passengers List )`
- **Reassigned Passenger:** creates a new record for the passenger with its new flight number. In case no flight was found matching the requirements in the previous entry, a null value is set on the *Flight Number* attribute.
- **Remaining Waiting List:** calculates the remaining waiting list by removing the passenger that was just reassigned from the original waiting list.
- **Updated Reassigned Passengers List:** updates the reassigned passengers list by appending the passenger that was just reassigned.
- **Result:** finally, the result box checks if the "*Remaining Waiting List*" is not empty, in which case it calls the "*reassign next passenger()*" function again to reassign the next passenger in the "*Remaining Waiting List*". Otherwise, if the list is empty, it just returns "*Updated Reassigned Passengers List*" as the result of the invocation.

Has Capacity Business Knowledge Model

The "*has capacity*" BKM is a simple function that checks if there are still free seats on a flight, considering all the passengers that were already reassigned to that flight.

It receives 2 parameters: the flight to check and a list of all rebooked passengers. It compares the flight remaining capacity with the number of passengers in the "rebooked list" already assigned to this flight. It returns true if there are still free seats or false otherwise.

has capacity
(flight, rebooked list)
flight.Capacity > **count**(rebooked list[Flight Number = flight.Flight Number])