ANALYTICS ON INDOOR MOVING OBJECTS: A STUDY ON RFID BASED AIRPORT BAGGAGE HANDLING SYSTEM

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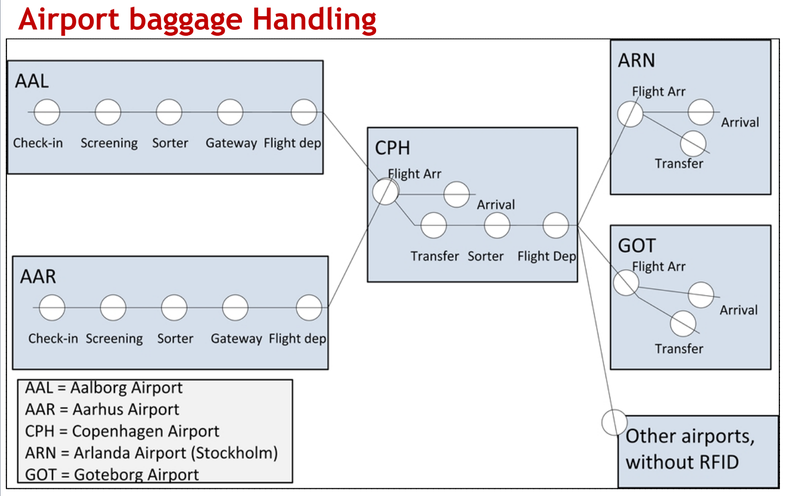
Introduction and Motivation

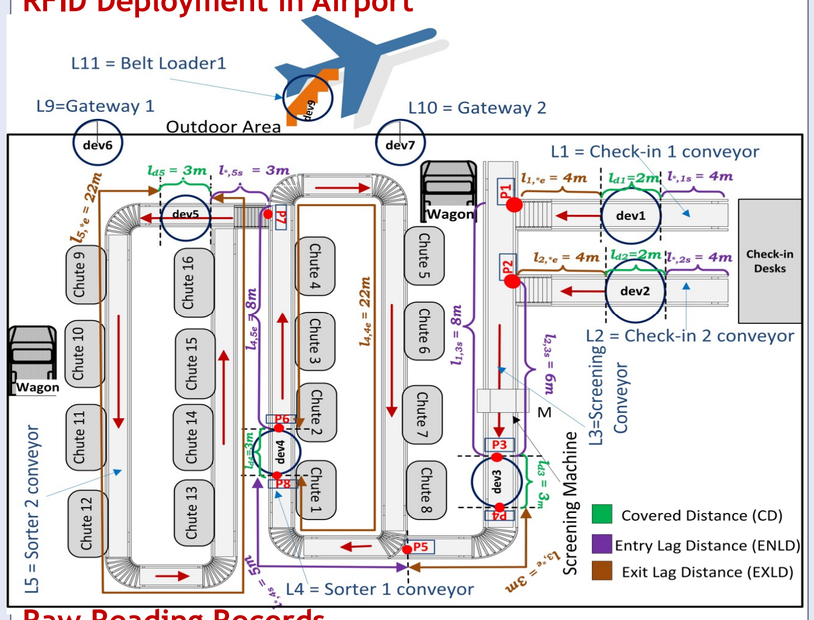
Data Source: http://www.sita.aero/content/baggage-report-2012

RFID Based Airport Baggage Handling

Airport baggage Handling



RFID Deployment in Airport



Raw Reading Records

Rid	Obj	Dev	t
r1	o1	dev1	4
r2	o1	dev1	5
r3	o1	dev3	15
r4	o1	dev3	17
r5	o1	dev3	18
r6	o1	dev4	26
r7	o1	dev4	27
r8	o1	dev4	29
r9	o1	dev4	51
r10	o1	dev4	53
r11	o1	dev4	54

Tracking records after eliminating Multiple Readings

Rec	Obj	Dev	t_in	t_out
rec1	o1	dev1	4	5
rec2	o1	dev3	15	18
rec3	o1	dev4	26	29
rec4	o1	dev4	51	54

Data Warehouse Solution

- Easy and fast queries for analysis

Tracking records into stay records [1]

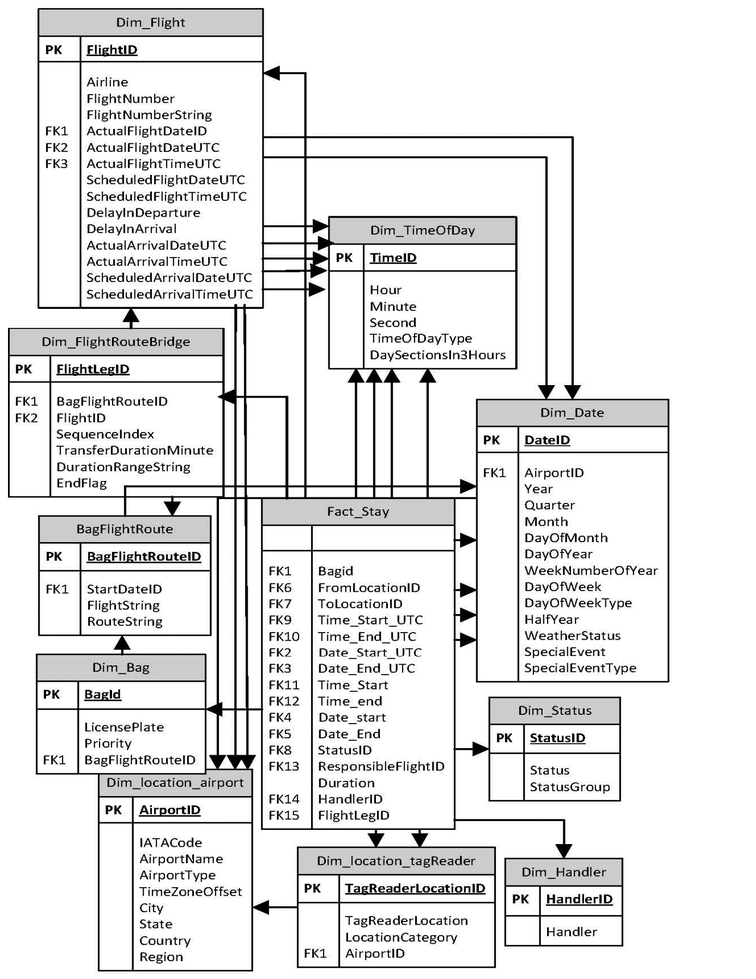
Tracking records

Bagid	Location	Time In	Time Out
B1	L1	1	1
B1	L3	4	5
B1	L4	7	8
B1	L10	19	20
B1	L11	30	31

Stay records

Bag Id	From Location	To Location	Time Start	Time End	Duration
B1	L1	L3	1	4	3
B1	L3	L4	4	7	3
B1	L4	L10	7	19	12
B1	L10	L11	19	30	11
B1	L11	L11	30	31	1

Data Warehouse Design



Many to Many relationship between Flight and Bag

Bag-Flight Bridge Table

BagID	FlightID	Sequence
B1	F1	1
B1	F2	2
B2	F1	1
B2	F2	2
B3	F1	1
B4	F1	1
B5	F1	1
B6	F1	1
B6	F2	2

Bag-Flight-Route Bridge Table

BagFlightRouteID	FlightID	Sequence
1	F1	1
1	F2	2
2	F1	1

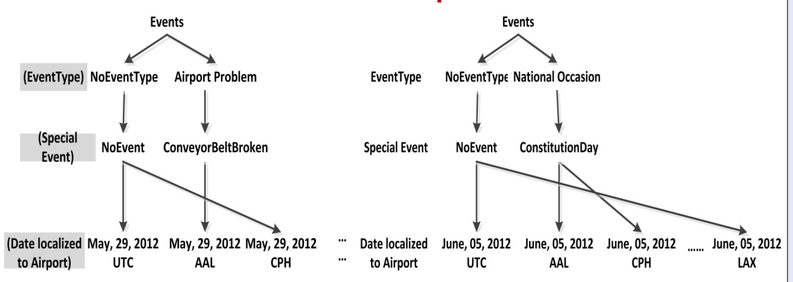
Bag-Flight Route Table

BagFlightRouteID	FlightString	RouteString
1	F1–F2#	AAL-CPH-ARN#
2	F1#	AAL-CPH#

Bag Table

BagID	BagFlightROuteID	Other Attributes
B1	1	...
B2	1	...
B3	2	...
B4	2	...
B5	2	...
B6	1	...

Example of Date Localization



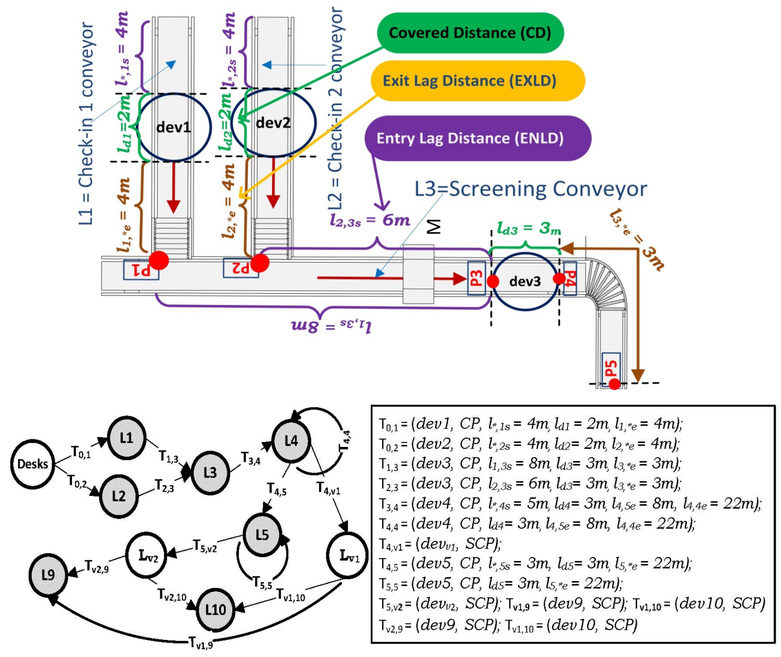
Finding Dense Locations

Defining Density

$$d_i = \frac{n_i}{\Delta t \times capacity(l_i)} \times 100\%, \text{ where } \Delta t = t_{end} - t_{start}.$$

- Useful for finding overloaded locations
- Tracking records do not provide when did an object enter and exit a location.
- Need to map the tracking records before hotspot query
- More topological detail need to be captured.

Modeling and Mapping for Constrained Path Space [2]



- Use eq (1) (2), (3) and node type of a location for calculating the appropriate ***time$_{start}$ and time$_{end}$*** from tracking record.

$$Speed := \frac{CD(dev_x)}{(time_{out} - time_{in})} \quad (1)$$

$$time_{start} := time_{in} - \frac{ENLD}{Speed} \quad (2)$$

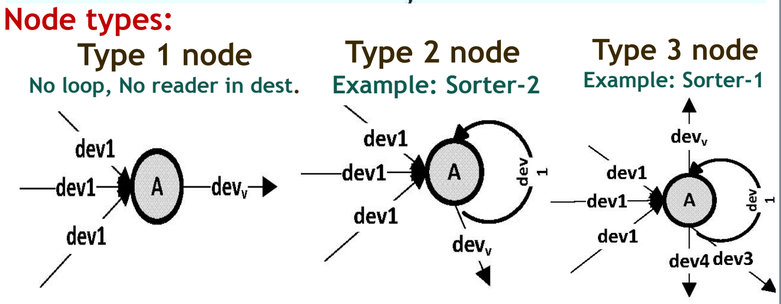
$$time_{end} := time_{out} + \frac{EXLD}{Speed} \quad (3)$$

Node types:

Type 1 node — No loop, No reader in dest.

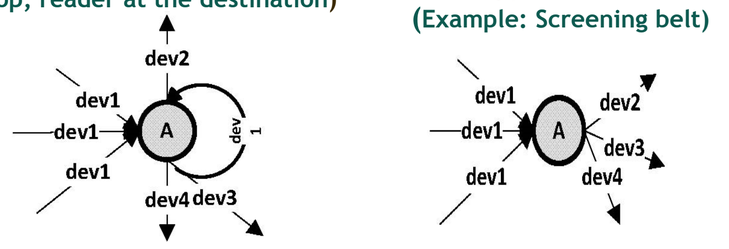
Type 2 node — Example: Sorter-2

Type 3 node — Example: Sorter-1

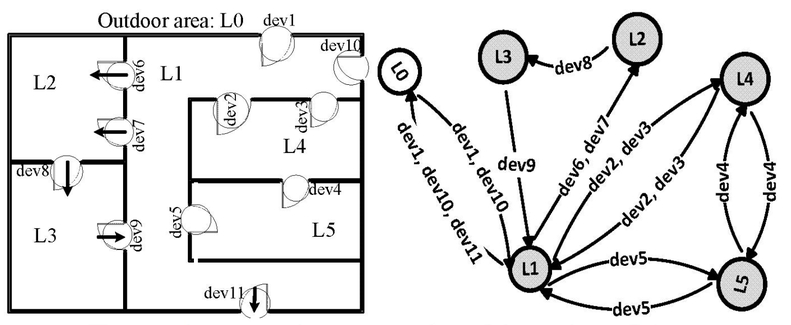


Type 4 node (Loop, reader at the destination)

Type 5 node (Example: Screening belt)



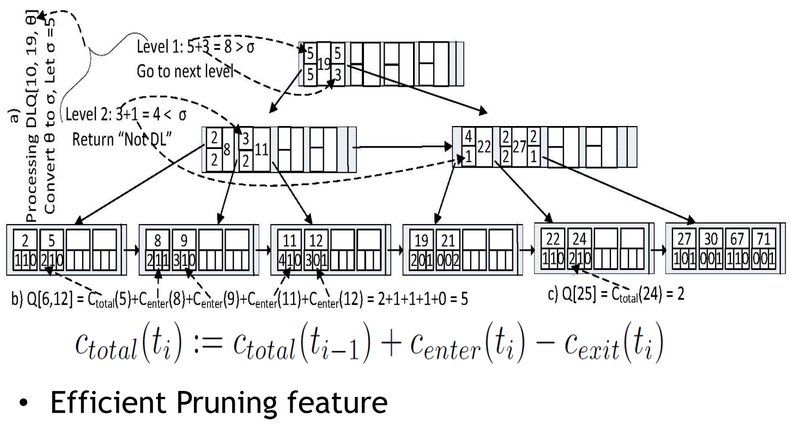
Modeling and Mapping for Semi-constrained Path Space[3]



Example mapping records of location $L1$

MapID	ObjID	LocID	time$_{start}$	time$_{end}$
$r1$	o_1	$L1$	2	7
$r2$	o_2	$L1$	5	11
$r3$	o_{18}	$L1$	8	20
$r4$	o_{15}	$L1$	9	18
$r5$	o_{16}	$L1$	11	20
$r6$	o_{12}	$L1$	67	70
$r7$	o_{19}	$L1$	22	26
$r8$	o_{20}	$L1$	24	29

The DLT-Index for Efficient Query Processing [3]



$$c_{total}(t_i) := c_{total}(t_{i-1}) + c_{enter}(t_i) - c_{exit}(t_i)$$

- Efficient Pruning feature

Other Analytics

- Extract interesting features from the tracking data
- Apply different data mining algorithms to find relations among the features that are highly related for baggage mishandling
- Due to very low ratio of mishandling, the data sets should be re-sampled for learning.
- Outlier mining

References

[1]. T. Ahmed, T. B. Pedersen, and H. Lu. A data warehouse solution for analyzing RFID-based baggage tracking data. In MDM, pages 283-292, 2013.

[2] T. Ahmed, T. B. Pedersen, and H. Lu. Capturing Hotspots for Constrained Indoor Movement. In SIGSPATIAL/GIS, pages 462-465, 2013

[3] T. Ahmed, T. B. Pedersen, and H. Lu. Finding Dense Locations in Indoor Tracking Data, In MDM, 2014 (to appear)

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