Chapter 7: Why intelligent destination groups perform better

Summary: This chapter explains why and how "Intelligent destination" group controls enable best-possible performance. Understanding the purpose of "selected floors" patterns, the data structures enabled by the patterns, the artificial experience system and the new method for performance calculations will help to appreciate the data and logic of the following chapters.

Introduction

In Chapters 5 and 6 the terms "selected floors", “average RTT Low and High trips” and “Cycle RTT" were used in Comparative Performance Tables (CPT's) without defining their meaning. These terms and the new parameters Average Travel Time in the Car (ATTC) and Average Time To Destination (ATTD) derive from the data structures that facilitate assessment of the performance data of a specific group for all traffic conditions. A CPT is an extract from a calculated data structure.

This chapter will show that the performance potential of each and every group can be made transparent with a calculated data structure. This data structure demonstrates that group performance for all traffic conditions is based on "muscle power" and why and how intelligent destination groups can control their "muscle power" with "brain power".

Calculated data structures are based on the following principles:

- The mathematical basis of a calculated data structure of a specific group is a list of all Door to Door Flight Times (DDFT's) for all possible travel distances. DDFT’s are variable. An intelligent control will use a data structure for heavy traffic conditions that is based on a list with minimum DDFT’s. For medium and light traffic conditions it may use alternative data structures based on lists with slightly longer DDFT’s.

- The calculated data structures of this book are based on "selected floors" patterns, a **rigid** system for assigning service calls (passengers) to specific cars. These patterns enable calculation of average RTT, DC5, TC5 and time-dependent service qualities for all traffic densities. The transport capacities of an intelligent destination group can be increased by reducing the number of floors served. This implies Round Trip Times are reduced to increase transport capacities. Average Waiting Times increase but Average Travel Times in the Cars are reduced. These methods enable calculated data structures to disclose the **relativity of group performance data** for all traffic conditions.

In this book the CPT format is used to present performance data for modes of car operation (options) that satisfy a specific traffic density (s). **The selection of the preferred option** may be influenced by customer preferences in respect of shorter waiting times or earlier arrival at destination.

This chapter concerns itself with UP traffic only because **efficient UP traffic is the basis of the efficiency for all traffic conditions**. The following chapters will explain why and how calculated- and operational (recorded) data structures are used to create intelligent group control systems that enable best possible performance under all traffic conditions.

Service qualities

Intelligent destination group controls enable service denial to anyone and/or any number of floors. The analysis of service denial with "selected floors" patterns disclose that shorter Round Trip Times cause a reduction of the Average Travel Time in the Cars that exceeds the theoretical minimum AWT increase! The same analysis discloses that a **specific UP transport capacity** (DC5) can be delivered with decreasing numbers of passengers in the cars. This implies that intelligent destination groups can bring **UP going passengers to their destinations <u>earlier</u> in cars that are <u>less full</u>.** These characteristics are proved mathematically in chapter 15.

These characteristics can be used to improve the efficiency and service qualities of any group. When new buildings are planned on the basis of "intelligent destination" controls groups may have smaller cars reducing the building volume required for elevators and their energy consumption. These groups will deliver better time-dependent service qualities and higher transport capacities.

The service qualities of groups consist of TWO main categories:

- UP and DOWN transport capacities
- Time-dependent service qualities.

During periods of heavy UP and DOWN traffic best-possible performance is defined by the **preferred balance** between above mentioned categories. During medium and light traffic conditions best-possible performance is defined by the preferred balance between the time-dependent service qualities AWT, ATTC and ATTD. Intelligent destination group controls allows customer preferences to influence this balance.

"Selected floors" patterns

The patterns for "selected floors" are basic elements of the calculated data structure that provides the data of CPT's. The pattern below shows how a group can reduce the number of floors served whilst **distributing its transport capacities and service qualities evenly over all floors** of a building or building zone.

Trip number	1	2	3	4	5	6	7	8	9	10	11	12
	Number of "selected floors" = 11											
Floors served												
12		X	X	X	X	X	X	X	X	X	X	X
11	X		X	X	X	X	X	X	X	X	X	X
10	X	X		X	X	X	X	X	X	X	X	X
9	X	X	X		X	X	X	X	X	X	X	X
8	X	X	X	X		X	X	X	X	X	X	X
7	X	X	X	X	X		X	X	X	X	X	X
6	X	X	X	X	X	X		X	X	X	X	X
5	X	X	X	X	X	X	X		X	X	X	X
4	X	X	X	X	X	X	X	X		X	X	X
3	X	X	X	X	X	X	X	X	X		X	X
2	X	X	X	X	X	X	X	X	X	X		X
1	X	X	X	X	X	X	X	X	X	X	X	
0	X	X	X	X	X	X	X	X	X	X	X	X
	X	"selected floors"					Omitted floors				Ch7dia1	

This pattern for "selected floors" = 11 reduces Round Trip Times (RTT’s) and enables a group to deliver higher transport capacities at the “expense” of longer theoretical minima for Average Waiting Times (AWT’s).

To envisage how a 4-car group with cars A, B, C and D regularly serves all floors please imagine car A departing from floor zero on trip NR 1 to serve floors 1 to 11. The NEXT departing car from floor zero will make trip NR 2, the second NEXT car trip NR 3 and so on. Please note that the NEXT departing car serves the floor omitted by the previously departed car, i.e. **all floors are regularly served by TWO cars** during the average Cycle RTT**.**

When car A returns to floor zero other cars of the group have already departed to make trips NRS 2, 3 and 4 and car A continues with trip NR 5 provided the “brains” have not decided to use a different "selected floors" pattern.

To achieve the desired performance parameters cars do not have to complete the whole pattern. When the "Intelligent destination" group control decides to change the "selected floors" pattern it **immediately affects transportation capacities and time-dependent service qualities.** All floors continue to be served because **each and every "selected floors" pattern serves all floors.**

The patterns below show how a group serving 12 floors can further reduce the number of "selected floors".

Trip number	1	2	3	4	5	6		1	2	3	4		1	2	3		1	2		1	2	3
Number of "selected floors" = 10									**= 9**					**= 8**			**= 6**				**= 4**	
Floors served																						
12		X	X	X	X	X			X	X	X			X	X			X				X
11		X	X	X	X	X			X	X	X			X	X			X				X
10	X		X	X	X	X			X	X	X			X	X			X				X
9	X		X	X	X	X		X		X	X			X	X			X				X
8	X	X		X	X	X		X		X	X		X		X			X			X	
7	X	X		X	X	X		X		X	X		X		X			X			X	
6	X	X	X		X	X		X	X		X		X		X		X				X	
5	X	X	X		X	X		X	X		X		X		X		X				X	
4	X	X	X	X		X		X	X		X		X	X			X			X		
3	X	X	X	X		X		X	X	X			X	X			X			X		
2	X	X	X	X	X			X	X	X			X	X			X			X		
1	X	X	X	X	X			X	X	X			X	X			X			X		
0	X	X	X	X	X	X		X	X	X	X		X	X	X		X	X		X	X	X
	X	"selected floors"						(yellow)	Omitted floors											Ch7dia2		

The patterns for "selected floors" = 11, 10 .... to 7 are called **omitted floor patterns** the patterns for "selected floors" = 6, 5, 4 etc. are called **direct trip patterns**. The pattern "selected floors" = 4 might be used for extremely heavy traffic conditions, or an emergency, however, groups in well designed buildings will not require the use of direct trip patterns for normal traffic conditions. When pattern "selected floors" = 4 is used 3 consecutively departing cars assure regular service to all floors.

The Appendix to this chapter shows the patterns for "selected floors" = 7 and 5.

Comparative Performance Table (CPT's)

In traditional traffic calculations the RTT, DC5 and other service qualities are calculated for defined car loads. Data structures enable a **reversal of this process**, i.e. a calculated data structure can provide all service qualities **for a specific UP traffic density, i.e. for each "selected floors" pattern that can satisfy this traffic density**. This reversal enables insights into the performance data of a group that till now were well hidden by the interdependencies between the characteristics of a specific building, its elevators and traffic conditions.

The CPT below shows for a **constant DC5 of 13.2 %** how service quality data change when the number of "selected floors" is reduced from 12 (all floors) to 11, 10, etc. The ATTC's, ATTD's, RTT's L & H and the car loads all **decline** when the number of "selected floors" is reduced. The Cycle RTT's, Cycle Intervals and theoretical minimum AWT's increase.

The top line for "selected floors" = 12 states the performance data for a group of traditional "collective selective" elevators because the number of "selected floors" is identical with the number of floors served. All incoming passengers are assigned to the car that departs next. The only difference with a real "collective selective" group is destination entry in the lobby instead of in the car. When the number of floors served is reduced to 11 the average number of passengers in the cars that will deliver a DC5 of 13.2 % is reduced from14 to 13.4 and the number of "probable stops" to 7.9. All data change accordingly.

The lines for "selected floors" 11 to 7 show data for omitted floor patterns, the lines for "selected floors" = 6, 5 and 4 state the performance data for the relevant **direct trip patterns.**

Nr flrs served	Top floor	Pop.	Trav.	Contr. speed	Car load	Sel. floors	Prob. stops	Av. RTT L & H	ATTC	Cycle RTT	DC5 4-cars	ATTD	Dep. INT	Cycle INT	AWT
12	12	900	48	2.5	14.0	12	8.5	140.9	55.0	140.9	13.2	72.6	35.2	35.2	17.6
12	12	900	48	2.5	13.4	11	7.9	135.3	52.6	147.6	13.2	71.1	33.8	36.9	18.5
12	12	900	48	2.5	12.8	10	7.4	129.2	50.2	155.1	13.2	69.6	32.3	38.8	19.4
12	12	900	48	2.5	12.0	9	6.8	121.6	47.5	162.2	13.2	67.7	30.4	40.5	20.3
12	12	900	48	2.5	11.2	8	6.2	113.4	44.7	170.2	13.2	65.9	28.4	42.5	21.3
12	12	900	48	2.5	10.7	7	5.7	108.2	42.2	185.4	13.2	65.4	27.0	46.4	23.2
12	12	900	48	2.5	9.3	6	4.9	94.0	38.5	188.1	13.2	62.1	23.5	47.0	23.5
12	12	900	48	2.5	9.0	5	4.3	90.9	36.1	218.2	13.2	63.4	22.7	54.6	27.3
12	12	900	48	2.5	7.6	4	3.6	76.9	32.4	230.7	13.2	61.2	19.2	57.7	28.8
														Ch7dia3	

The above CPT makes the **relativity performance data transparent** for a specific UP traffic density. A CPT is an extract of a calculated data structure that disclose the group specific options and relevant performance data that will satisfy the momentary- or anticipated UP traffic density.

Well designed groups should not require the use of direct trip patterns, i.e. for planning new buildings omitted floor patterns should be able to satisfy all traffic conditions. A real intelligent destination control will use control of the permitted number of stops for UP and DOWN trips, because this enables a further improvement of performance as we will see next. However direct trip patterns may be useful for emergencies or when groups in extremely under-elevatored buildings are modernized with intelligent destination controls.

Performance evaluation

At this point it is important to realize that the service quality data of CPT’s have **different qualities**. The RTT L & H, ATTC, and DC5 can be qualified as reliable because they are based on average RTT's for specific traffic conditions.

The INTERVAL and AWT data of the top line ("collective selective" performance) must be qualified as misleading for reasons mentioned in the previous chapter. However, **the quality of INTERVAL- and AWT data of "intelligent elevators" will be much better** because their RTT’s will be systematically minimized and equalized.

The declining ATTC, ATTD and average car load in above CPT indicate that large contract loads are not essential for high transport capacities. The following chapters will show that groups with more but smaller cars can substantially improve all service qualities including AWT’s.

All CPT’s of this book are based on **rigid adherence to "selected floors" patterns**, however, real intelligent destination group controls will most of the time not operate on the basis of rigid adherence to patterns. Rigid adherence to patterns is not desirable for traffic conditions that can be satisfied with omitted floor patterns. Time-dependent service qualities will improve if the group limits the number of UP stops by setting a maximum number of **permitted destinations/stops** for the NEXT UP trip in relation to the anticipated UP traffic density. This method has following benefits:

- Passengers are served on a **"First come first served"** (FCFS) basis, i.e. **service denial, if any, is delayed till the last possible moment**. Denied passengers will be assigned to the NEXT car.
- The number of "probable stops" in CPT’s can be used as an indicator for the number of permitted stops. The column car load may now be seen as an indicator for the probable number of passengers. Intelligent destination controls will learn from their operational data structure (the recorded data structure or memory) the true relationship between permitted numbers of stops, traffic densities, car loads (number of passengers) and all other service qualities.
- The consistency of RTT’s and departure INTERVALS is enhanced when cars make the same number of stops. Consequently control of the maximum number of stops for each UP and DOWN trip will improve the quality of the RTT bandwidth and all time-dependent service qualities.

For extremely heavy traffic conditions or emergencies the use of direct trip patterns may be necessary. Groups in extremely under-elevatored buildings may need to use direct trip patterns for heavy traffic after conversion to intelligent destination controls.

The CPT’s of this book are based on rigid adherence to "selected floors" patterns. This implies that for all calculations the reversal floors are defined. The "first come first served" method implies that reversal floors are not defined. Fortunately the reversal floor level has little influence on RTT's. A one floor change in the reversal floor level will affect the RTT by less than two seconds. One stop more or less affects the RTT by at least ten seconds. Control of the number of permitted stops will support minimizing and equalizing the Round Trip Times of groups with intelligent destination controls.

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Terminology

The following defines the terms used for evaluating the performance for UP traffic **on the basis of rigid adherence to "selected floors" patterns**.

Trips that serve the top floor are called **High trips**. All other trips are called **Low trips**. In the pattern "selected floors" = 11 trip NR 1 is a Low trip, trips NRS 2 to 12 are High trips. The total time required for all 12 round trips divided by 12 yields the **average RTT L & H**. The **departure INTERVAL** from floor zero is RTT L & H divided by the number of cars in the group. During all 12 round trips all floors are served 11 times and we can say the 12 trips consist of **11 Cycles**. The total time required for all 12 round trips divided by 11 yields the average **Cycle RTT**. The **Cycle INTERVAL** is the Cycle RTT divided by the number of cars in the group. The **purpose of the Cycle INTERVAL is calculation of the theoretical minimum AWT** = Cycle INTERVAL divided by TWO.

Calculations on the basis of rigid adherence to "selected floors" patterns imply worst possible assumptions for service denial to passengers. This means the calculated group data structure provides conservative performance data. The **operational data structure** will be based on data from real car operations with the "first come first served" method and other rules outlined in this book. It is the group's memory of real car operations. The formats of the calculated- and the operational data structures will be highly similar. Both will allow extraction of Comparative Performance Tables and the modules described in this book. The calculated data structure provides intelligent destination controls with data that provide these groups with basic intelligence from the start of operations. Their operational data structure will probably become the more important data structure of these groups. Please note that the calculated- and the operational data structures of a group will complement and check each other.

Artificial intelligence

The artificial intelligence system of intelligent destination controls consists of two key elements:

- The learning- and traffic prediction system
- Their calculated- and operational data structures.

This chapter shows only a small part of the calculated data structure. In other chapters we will expand this data structure to demonstrate that the entire performance potential of any group is defined by its "muscle power" and can be controlled by its "brain power".

These systems enable many innovations that will greatly improve the performance and service qualities of groups of elevators. For example: For each round trip the group control can set a time plan on the basis of the permitted number of UP stops and the permitted number of DOWN stops. The anticipated numbers of UP and DOWN passengers are included in this time plan. Minimizing and equalizing RTT's will be a permanent control objective to minimize and equalize waiting times.

The ability to control performance will enable elevator contractors to provide contractual performance guarantees, including time-dependent service qualities, for specific traffic conditions. In this connection please also refer to chapter 10 (traffic simulation) for more details.

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Transparent performance calculations

The term “traffic calculations” is used for calculation of performance parameters of "collective selective" groups. This book uses the term **“performance calculations”** because traffic cannot be calculated, traffic happens.

RTT calculations for each round trip are in fact a simple addition of the Door to Door Flight Times (DDFT’s) of all trips between floors during a round trip plus an **assumed time allowance** for passengers boarding and leaving the cars.

Please imagine an elevator making a round trip with several stops but without transporting any passengers. Doors open on arrival and **close again immediately afterwards**. It is obvious that under these circumstances the RTT is the sum of all DDFT’s. Real elevators have a minimum dwell time on each floor of for example one or two seconds to enable passengers to commence entering or leaving a car. When passengers are between the doors photocells or other devices prevent premature door closing.

All RTT calculations of this book are based on the total of all DDFT’s of a specific round trip plus an assumed standard time of 2 seconds per passenger for car entry and exit that includes the minimum dwell time on floors. Chapter 13: “Transparent performance calculations” gives a detailed description of the calculation method. The design of this standard performance calculation method was in fact the first step towards the discovery of relativity by the author.

Data used by real groups

The calculated data structure of a real group will not use calculated DDFT’s or assumed “time costs” for passenger entry and exit, "probable stops" etc. They will use realistic data derived from statistical analysis of group operations. Comparison of the calculated data structure with the operational data structure will disclose performance improvements on account of application of the permitted number of stops and "first come first served" methods, avoidance of too short waiting times etc.

Appendix: Patterns "selected floors" = 7 and 5 for a group serving 12 floors.

Edits:
29.11.2011: Minor edits on page 4.

Appendix: Patterns "selected floors" = 7 and 5 for a group serving 12 floors.

Trip number	1	2	3	4	5	6	7	8	9	10	11	12
	Number of "selected floors" = 7											
Floors served												
12		X		X		X	X		X		X	X
11		X		X	X		X		X		X	X
10		X		X	X		X		X	X		X
9		X	X		X		X		X	X		X
8		X	X		X		X	X		X		X
7	X		X		X		X	X		X		X
6	X		X		X	X		X		X		X
5	X		X		X	X		X		X	X	
4	X		X	X		X		X		X	X	
3	X		X	X		X		X	X		X	
2	X	X		X		X		X	X		X	
1	X	X		X		X	X		X		X	
0	X	X	X	X	X	X	X	X	X	X	X	X

X "selected floors" | (yellow) Omitted floors | Ch7dia4

Trip number	1	2	3	4	5	6	7	8	9	10	11	12
	Number of "selected floors" = 5											
Floors served												
12			X		X			X		X		X
11			X		X		X			X		X
10		X			X		X			X		X
9		X			X		X		X			X
8		X		X			X		X			X
7		X		X			X		X		X	
6		X		X		X			X		X	
5	X			X		X			X		X	
4	X			X		X		X			X	
3	X		X			X		X			X	
2	X		X			X		X		X		
1	X		X		X			X		X		
0	X	X	X	X	X	X	X	X	X	X	X	X

X floor served | (yellow) floor not served | Ch7dia5