Chapter 10: Traffic simulation

Summary: Traffic simulation supports the planning of groups of elevators. For groups with intelligent destination controls it will enable contractual guarantees for efficiency and service qualities. The guaranteed service qualities can be validated by the group itself after completion. The inherent relativity of group characteristics makes configuration decisions a logical and simple process. Customer requirements in respect of time-dependent service qualities define group configuration. This know-how will reduce the need for traffic simulation.

Remark (Mai 2013)
In recent years the author wrote a few articles about intelligent destination group controls. This has motivated him to write a new version of this Chapter.

Traffic simulations and Traffic calculations

These methods have much in common and it is useful to understand their different roles. Traffic calculations, i.e. performance calculations, enable accurate calculations of Round Trip Times for a specific group and traffic conditions. These accurate data allow us to speculate about average waiting times, average travel times in the cars and times to destination. A Round Trip Time is a **value** of a group performance parameter that primarily depends on group configuration and secondly on the ability of the specific group to control the efficiency of car operations.

Traffic simulation also discloses Round Trip Times for a specific group and traffic conditions; however, it does much more because it also provides all time-dependent service data for all passengers. This implies simulation allows evaluation of the **quality** of group performance parameters. For example, the waiting time of each passenger during a period with specific traffic conditions defines the average waiting time for all passengers and the **bandwidth** of these waiting times. The bandwidth is a quality parameter because it shows the consistency of waiting times. A waiting time that fluctuates between zero and 100 seconds does not signify high quality.

The average travel time in the cars and its bandwidth, the average number of passengers in the cars and its bandwidth, are other examples of service **quality** parameters.
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Traffic simulations and traffic calculations disclose the same values for round trip times because these values are determined by the configuration of a specific group. A single simulation or calculation cannot disclose whether or not the group's configuration is efficient. The Comparative Performance Tables introduced by this book disclose and compare the performance and efficiency of groups with **different configurations**. This method disclosed the influence of configurations on group performance and enabled the discovery of the inherent relativity of group characteristics.

Artificial traffic

Artificial traffic can be defined as a list(s) with hundreds or thousands of passengers that are **identified by a number**. In addition to the id number the traffic lists state:

- The time a passenger makes a call for service
- The floor on which the service call is made
- The destination of the passenger.

Artificial traffic lists can be used for traffic simulations with any group control system. If the group control is a destination-type system the call is registered as a destination entry, for a traditional control the call is registered as an UP or DOWN call as defined by the positions of the call entry floor and the destination.

Artificial traffic is the input for each traffic simulation. This chapter will show readers that traffic simulation is a simple process that yields data that define the value and the quality of performance parameters for specific traffic conditions. These data facilitate contractual performance guarantees.

Traffic simulation systems

A real group can be used as a simulator if a computer program can play the role of artificial passengers. Via an interface this program enters service calls into a real group in accordance with the data of an artificial traffic list. The real group moves cars and doors as required for the artificial traffic and records all data. The computer also mimics other actions or situations caused by real passengers, for example providing artificial car load data, door open periods, or operation of floor buttons in the car etc. The monitoring and reporting system of the intelligent group records and analyzes all data and reports the desired service quality parameters.

This simulation program could be a function of intelligent destination group controls. It would be a **re-play module** for the traffic lists that were used as the basis for performance guarantees.

A simulation system without the restrictions of a real group may consist of a **real group control system** in combination with a simulator that mimics the drive system, and the cars and doors of a group. This simulator is a system that can be adapted to represent any group configuration. This type of simulator would also be a **real-time simulator**, i.e. a one hour traffic list will require a one hour simulation period.

The alternative for a real-time simulator is a high-speed simulation system, i.e. a computer program that can mimic the configuration of a group and a specific group control system. These systems will be able to produce traffic simulation data in minutes or seconds for traffic lists that represent several hours of traffic. It is obvious that high-speed traffic simulation systems are much more complex than a real-time simulator. This chapter will explain why this type of simulator is not an essential or a recommended tool for group planning.

Traffic density patterns

The UP and DOWN traffic densities in buildings vary all the time, however, the traffic density patterns of whole days or specific periods of days may well be very similar. For this reason it is important that an intelligent group controls have the ability to learn and analyze the traffic density patterns of the specific building that is served by a specific group. These systems provide intelligent group controls with artificial experience that supports their ability to predict traffic trends.

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Traffic density patterns can be recorded in existing buildings. Know-how of realistic traffic patterns is useful for making **artificial traffic lists** with hundreds or thousands of passengers. The making of traffic lists is a simple task if we divide a one hour simulation period in, for example, twelve periods of 5 minutes. Subsequently we assume for each 5 minute period a traffic density - in percent of the building population - for the following types of traffic:

- UP traffic from floor zero to random upper floors
- DOWN traffic to floor zero from random upper floors
- UP and DOWN traffic between random upper floors (INTERFLOOR traffic)

One hour of traffic simulation consisting of 12 periods of 5 minutes can be defined by 36 percentages. The percentages for each 5 minute period can be converted into numbers of passengers for the **assumed population**. A simple computer program can convert the number of passengers for each 5 minute period and for each type of traffic in a mini-traffic-list with random timing of service calls within each 5 minute period and random floor designations in accordance with the relevant traffic type definitions. Thereafter the artificial traffic list for one hour is compiled from the 36 mini-lists and sorted in accordance with service call timing.

Elevator contractors, consultants or architects can create a repertoire of traffic density patterns that reflect the typical traffic conditions that occur in tall buildings. In combination with population estimates for a proposed building these patterns will enable the efficient production of many traffic lists. When mobile phones are used for direct communication between passengers and intelligent controls the recording of traffic patterns will be simplified.

Group configurations

The configuration efficiency of a group must be checked **before** traffic simulation.

The discovery of the inherent relativity of group characteristics has greatly simplified configuration decisions because it disclosed that the relationship between the number of cars in a group and the number of floors served is decisive for all time-dependent service qualities. This implies that customer requirements in respect of time-dependent service qualities define group configurations. Please remember that even traditional groups with more and smaller cars can substantially improve time-dependent service qualities (Chapter 6). For groups with intelligent destination controls a few simple performance calculations can determine configuration efficiency, i.e. the relationship between the number of cars, the number of floors served, and the minimum contract load, that will satisfy customer requirements in respect of time-dependent service qualities.

When the configuration of a specific group for a specific building is decided traffic simulation will confirm the value and the quality of group performance parameters. If the optimal configuration would be a 5 or 6-car group with small contract loads it could be that the building planners would decide to serve one additional floor. This would imply an increase of the contract load and worse time-dependent service qualities. Please note that also in this case the planning procedure remains an exact process that is controlled by the building planners and delivers service qualities that can be contractually guaranteed.

The poor efficiency of traditional groups with 6-large-cars is an example of group planning that was done before the inherent relativity of group characteristics was known.

Typical configurations

Intelligent destination controls enable the use of more and smaller cars. For a 4-car group the optimal contract load is about 1200 KG because for this configuration all service qualities will be the best possible in combination with minimal space- and energy requirements and lowest costs. Groups with five or six cars may have cars that are even smaller.

This does not mean that intelligent destination controls promote the use of groups with small cars. Cars can be as big as a customer may like. Large cars imply surplus transport capacity and even greater passenger comfort; i.e. the comfort of more car space in addition to best possible time-dependent service qualities.

Validation of guaranteed service qualities derived from simulation

When the service qualities of a specific group for specific traffic conditions are contractually guaranteed the monitoring and reporting system of an intelligent group will report the real traffic densities for any traffic period and the relevant service qualities. Building owners may appreciate to have such confirmation earlier, i.e. before a building is fully occupied. This is not a problem because the completed group can be used as a simulator. The traffic lists used for simulations and guarantees can be re-played with the completed group.

Demand for traffic simulation

Until now the insecurity in respect of time-dependent service qualities has caused much demand for traffic simulation. The inherent relativity of group characteristics has simplified configuration decisions and will reduce the need for simulation. Demand will probably be further reduced when completed groups with intelligent destination controls prove their efficiency in new and existing buildings day after day.

This also means that high speed traffic simulators are not essential. Even large international elevator contractors can satisfy their need for traffic simulations with one or two real-time simulators. High speed simulators will be costly and have to be adapted if group controls are modified. Making sure that high speed simulations always yield exactly the same data as the re-play of traffic lists, or real time simulation, may be a tricky problem.

Performance comparisons of group controls

Architects and consultants can request traffic simulation data for identical groups from different elevator contractors on the basis of identical traffic lists. It is obvious that this practice will facilitate comparison of the efficiency and performance of proprietary group controls.