Chapter 9: Artificial experience system

Summary: A group of intelligent destination elevators must accumulate “artificial experience” to make reasonably accurate predictions of traffic conditions for the next 5 minutes. These data enable setting the permitted numbers of stops and performance targets at the start of each UP or DOWN trip. Monitoring, recording and analysis of traffic data will yield patterns of the behavior of the building- and floor populations that provides this experience. The correlation between predicted- and momentary conditions enables the sensory abilities of the group control system. Monitoring supports the building management information system with data of traffic densities, floor populations, elevator service qualities etc.

Introduction

A group of intelligent destination elevators must have data about the UP and DOWN traffic densities that are generated by the population of the building that is served by a specific group. Although the traffic densities of a specific building vary greatly during each day, the daily traffic density patterns of a specific building are very similar. This similarity enables groups with intelligent destination controls to make reasonably accurate predictions of traffic trends. Early last century this was the task of elevator attendants and their supervisor. Their intelligence and know-how assured that a group could improve its efficiency during periods of heavy traffic. These abilities were lost when attendants were abolished.

Intelligent destination groups control both transport capacities and time-dependent service qualities by setting the permitted number of stops for each UP and DOWN trip relative to anticipated UP/DOWN traffic densities. When intelligent destination elevators anticipate a change in traffic conditions they will adjust their performance potential before its onset.

The settings for anticipated traffic conditions also define the correlated car loads. Consequently the control system has the ability to check predictions and to adjust its settings for the next departing car if necessary. The monitoring of traffic data and their analysis has been given the name: artificial experience system.

Traffic monitoring

This chapter will show that traffic monitoring can provide accurate data of traffic flows, service calls and other data that reflect the behavior of the population. Also the "muscle power" data of a specific group, i.e. the DDFT’s over all possible travel distances, are disclosed by traffic monitoring. The "muscle power" data in combination with patterns for modes of car operations define the calculated data structure of groups with intelligent destination controls. The data obtained from monitoring, recording and analyzing car operations are retained in the operational data structure. The format of these data structures will be very similar. The calculated data structure is well defined in this book. The operational data structure should be seen as the group’s memory of its car operations in the past and its headings will be somewhat different. Please note that car operations continuously produce performance data just like an endless series of traffic simulations. The calculated- and the operational data structures are the basis of the artificial intelligence system.

Chapter 9: Artificial experience system

This chapter describes in detail traffic density- and population monitoring. Other systems such as a round trip data base and a service call data base and relevant patterns are outlined to indicate how the objectives of the artificial experience system might be realized.

Objectives of monitoring- and analysis of traffic data

Groups with intelligent destination controls require a monitoring and data recording system that enables analysis of traffic periods in the past. Long term statistical analysis of traffic conditions will be the main data source for the artificial experience system of intelligent destination elevators.

The main objectives of monitoring and analysis are:

- To create and maintain traffic density patterns that enable the system to make reasonably accurate predictions of traffic densities during the next 5 minutes

- To investigate correlation between:
    - traffic density- and service demand patterns
    - number of floors served and/or "selected floors" patterns and service qualities in a manner that is independent of the calculated data structure

- To create a data and information system for building managers

This chapter describes the types of data to be recorded, methods for data recording and how anticipated traffic conditions, performance targets and momentary data can be used to optimize car operations.

Types of data to be recorded

The types of data to be monitored and recorded can be defined in categories as follows:

- Data that result from the behavior of the building population
- Data controlled by the "muscle power" and/or "brain power" of the group
- Outside influences that may influence elevator traffic. For example the weather, a strike of public transport, interruptions of the power supply, etc.

Round trip data base

Traffic happens when cars transport passengers. The recording of the movements of cars and their loads, destinations etc. will provide intelligent destination elevators with a valuable source of information in respect of traffic patterns, i.e. the behavior of the population, the demand for service and the service qualities of a group. The following list is an example of the data that might be recorded in a round trip data base.

- A consecutive trip number for each round trip of each car on each day / date
- The permitted number of stops for the UP and the DOWN trip, or the
- Direct trip pattern used during extreme traffic conditions
- Additional stops/destinations caused by INTERFLOOR traffic

- Targets for: RTT, Departure- and Cycle INTERVAL , AWT, ATTC, ATTD and numbers of passengers UP and DOWN
- Floor designations of all stops and the reversal floor
- All departure- and arrival times (The departure times will be the time doors start closing and arrival times the time when the doors are fully open)
- Carload at each departure (= carload at next arrival)
- Number and designations of <u>assigned floors</u> at each departure
- The number of service calls received for each assigned floor prior to departure of the assigned car.

The objectives of this data base and the other data bases mentioned in this chapter are:

  - Analysis of traffic conditions in the specific building served by a group.
  - Compilation of an operational data structure and the creation of traffic density patterns and such other patterns as intelligent destination controls may need for best-possible response under all traffic conditions.
  - Quality control of all service qualities. For example the evaluation of the bandwidth of time-dependent service qualities during specific periods.
  - To provide interfloor traffic data.
  - Evaluation of outside influences, for example weather conditions, on traffic density patterns.

A group of intelligent destination elevators will probably not need a separate traffic simulation system because as mentioned earlier the group itself is an excellent source of information in respect of performance data.

This book does not attempt to provide all details of an artificial experience system. It describes the role of an artificial experience system in an intelligent destination group control.

In the future panels for destination entry in the lobbies will probably be abolished, i.e. each passenger will communicate directly with the group control. This will provide groups with perfect data in respect of demand for service and traffic densities. Communication with individual passengers will make it easy to inform passengers in case a change of the assigned car is unavoidable.

Passenger "service calls"

Intelligent destination elevators will record in a **service call data base** each call for service. The term "each call" requires further definition because <u>service calls from a specific floor for the same destination</u> may be placed several times during a specific INTERVAL. Intelligent destination elevators will register each **first service call** in a daily data base as follows:

- The time of the service call
- Floor designation from where call is placed
- Destination requested
- Assigned car and round trip number
- Number of repeat calls from the same floor after the first call and before the assigned car departs

The time of arrival and departure of the assigned car is recorded in the Round Trip data base. Analysis of the Round Trip- and Service Call data bases will yield demand patterns as described under the heading Data Analysis, data for waiting times, travel times in the car and times to destination.

The service call data base enables making **service demand patterns for <u>each 5 minute period</u>** of every day as follows:

- Number of calls from floor zero for trips to specific upper floors
- Total number of calls from floor zero for trips to all upper floors
- Number of calls from upper floors for trips to higher upper floors
- Number of calls from specific upper floors for trips to floor zero
- Total number of calls from all upper floors for trips to floor zero
- Number of calls from upper floors for trips to lower upper floors except floor zero

Statistical analysis of these service call patterns will yield average patterns that will greatly help the “brains” to make forecasts in respect of service calls. These patterns also will help building managers to investigate the type and origins of traffic PEAKS.

Statistical analysis of service call patterns in combination with population and traffic density patterns will undoubtedly show that correlations exists. Such correlations will enable the **traffic prediction module** of intelligent destination controls to check predictions with momentary trends in respect of service call frequencies.

Evaluation of service qualities

Analysis of the Service Call data base **and** the Round Trip data base will deliver the following data in respect of **each and every service call**:

- The waiting time till arrival of the assigned car
- The travel time in the car to destination
- The total time to destination (waiting- plus travel time)
- The carload after each departure
- The average carload during the trip to destination of each passenger
- The average carload during each round trip

When lobby networks are used that can register the arrival of each passenger intelligent destination elevators will be able to deliver exact data in respect of the AWT, ATTC and ATTD of each individual passenger and statistics and **bandwidth graphs** for these data over any period.

Without lobby networks analysis of the <u>carload data</u> will enable assessment of the approximate number of passengers per service call and the approximate average waiting time per passenger. These methods will enable intelligent destination elevators to deliver service quality statistics that are superior to data presently available from existing group controls.

"Muscle power" data

Chapter 9: Artificial experience system

Modern elevators monitor several data that reflect whether or not sub-systems are functioning correctly. If, for example, the round trip data base is extended with the data below it can support technical monitoring as well.

- Time doors start to close
- Time doors are fully closed and locked
- Time car starts acceleration
- Maximum speed reached during each trip
- Time car reaches maximum speed
- Time car starts deceleration
- Time car doors start to open
- Time car floor is level with target floor
- Time car doors fully open, i.e. the arrival time already mentioned in the round trip data base.

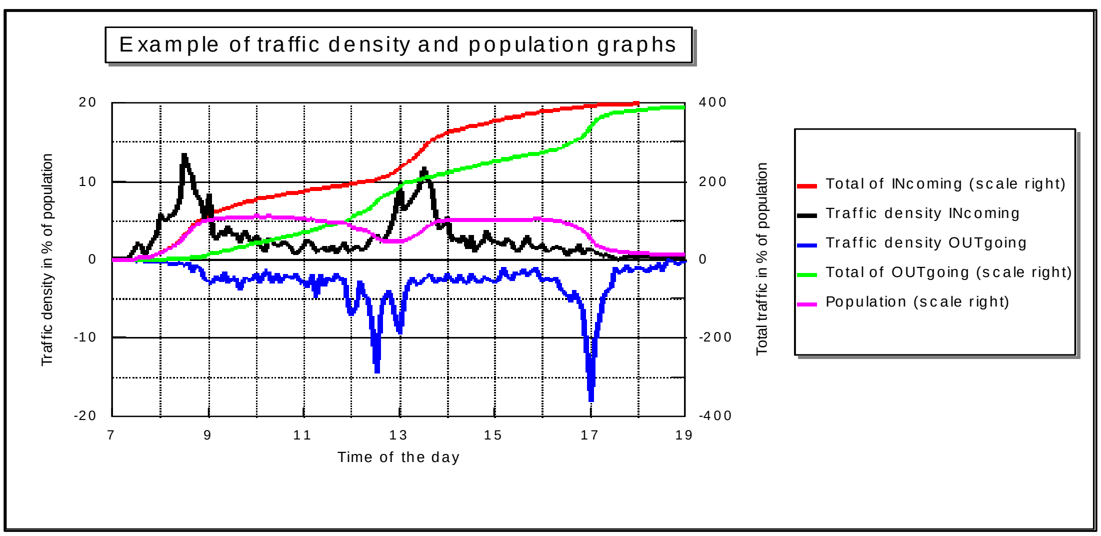
These data allow monitoring of all "muscle power" characteristics.

Outside influences

The weather, disruptions of public transport or power failures or strikes may affect elevator traffic. Availability of relevant standardized information will be of help to adjust traffic patterns relative and the operational data structure for special conditions.

Population and traffic density patterns

In Chapter 3: Elevator "muscle power" is mentioned that during door closing the carload is measured. This is a requirement of the drive system to assure a smooth start of the car when the brake opens. **Carload measuring can provide accurate information of the total weight or the number of passengers in the car**. These data enable presentation of traffic density and population graphs as shown below. (The same graphs were shown on page 2 of chapter 2.)



Please envisage counters for each and every floor named IN and OUT. These counters are re-set to zero at mid-night each day. The carload of each and every car departing from **floor zero** after re-set is added to the counter **Building IN**. The carload of each car arriving at floor zero after re-set is added to the counter **Building OUT**. Every 5 minutes the total of the IN counter and the total of the OUT counter is recorded in a **dedicated memory named building population**.

The values of the IN counter that were recorded every 5 minutes give us the RED graph and the values of the OUT counter the GREEN graph. The momentary differential between the counter IN and the counter OUT is the momentary building population, i.e. the PURPLE graph. The increase of the IN counter over the previous 5 minutes represents the UP traffic density of the 5 minute period the BLACK graph and the increase of the OUT counter over the previous 5 minutes represents the DOWN traffic density of the previous 5 minute period the BLUE graph.

These patterns can be made for **any floor X** as follows: The carload at departure is deducted from the carload at arrival (= carload at departure from the previous floor). In case the differential is positive passengers have been delivered to floor X and the positive differential is added to **counter floor X IN.** In case this difference is negative passengers have departed from floor X. The absolute value of a negative differential is added to **counter floor X OUT.** Every 5 minutes the total of the IN counter and the total of the OUT counter is recorded in a dedicated memory named **population floor X**.

The population memories of each floor enable making traffic density and population graphs for each floor of a building served by intelligent destination elevators.

The above graphs do not show the traffic between upper floors. In multi-tenant buildings INTERFLOOR traffic is usually quite small. Analysis of the round trip- and service call data bases will enable Intelligent destination controls to make reasonably accurate statistics of INTERFLOOR traffic data.

These simple methods can be applied immediately for any group in any existing building provided the cars have an accurate load measuring system. Considering the scarcity of information concerning traffic flows in existing buildings it seems that the use of these systems is rare.

The population and traffic density patterns of one or more years can be retained in the group's data storage system to enable **statistical analysis** of traffic patterns for all days of a week or specific days of many weeks or seasonal periods etc. The objective is to define **average patterns** that can be used to make reasonably accurate predictions for traffic densities for the next 5 to 10 minutes.

For building managers the population and traffic density patterns will be of great interest because they will be able to see which floors cause traffic peaks and their timing. With this information they may be able to reduce such peaks in consultation with their tenants. Knowing which floors have high population densities and/or high traffic densities may be a basis for introducing a service cost element in rentals. The air-conditioning system may benefit when data about momentary floor populations are always available. **Intelligent destination elevators will help to make buildings more "intelligent".**

It is obvious that statistical analysis of traffic patterns will be an important feature of intelligent destination elevators. The group's "brain power" can do the analysis at night when the elevators are not busy. The resulting data will be of great interest not only to parties involved in the operation and maintenance of elevators but also to all parties that plan new buildings or the modernization of existing buildings.

Correlation between predicted and momentary traffic conditions

Intelligent destination elevators will be able to make reasonably accurate predictions of traffic conditions on the basis of their artificial experience. Decisions in respect of permitted number of stops or the use of a direct trip pattern for the NEXT departing car will be based on these predictions and the relevant performance data from the operational- and/or calculated data structures. This process will also define target values in respect of carload (number of passengers), RTT, best possible time-dependent service qualities etc. for each round trip.

Comparison of momentary data with predicted carloads and other target data will make intelligent destination elevators "aware" of the differential between predicted- and the momentary traffic conditions. This "sensory" ability enables intelligent destination elevators to adjust their mode of car operation quickly if required.

The following example of a sensory ability will be of interest: The momentary UP traffic density can be deducted from the carload of a specific car departing from floor zero to a specific number of designated floors. The total population of these specific floors is known. The period prior to departure during which passengers were assigned to the departing car is also known. This relationship provides an interesting indication of a momentary UP traffic density.

This interpretation of traffic data will help intelligent destination group controls to collect accurate information about momentary UP, DOWN and INTERFLOOR traffic densities for an entire building or zone and individual floors.