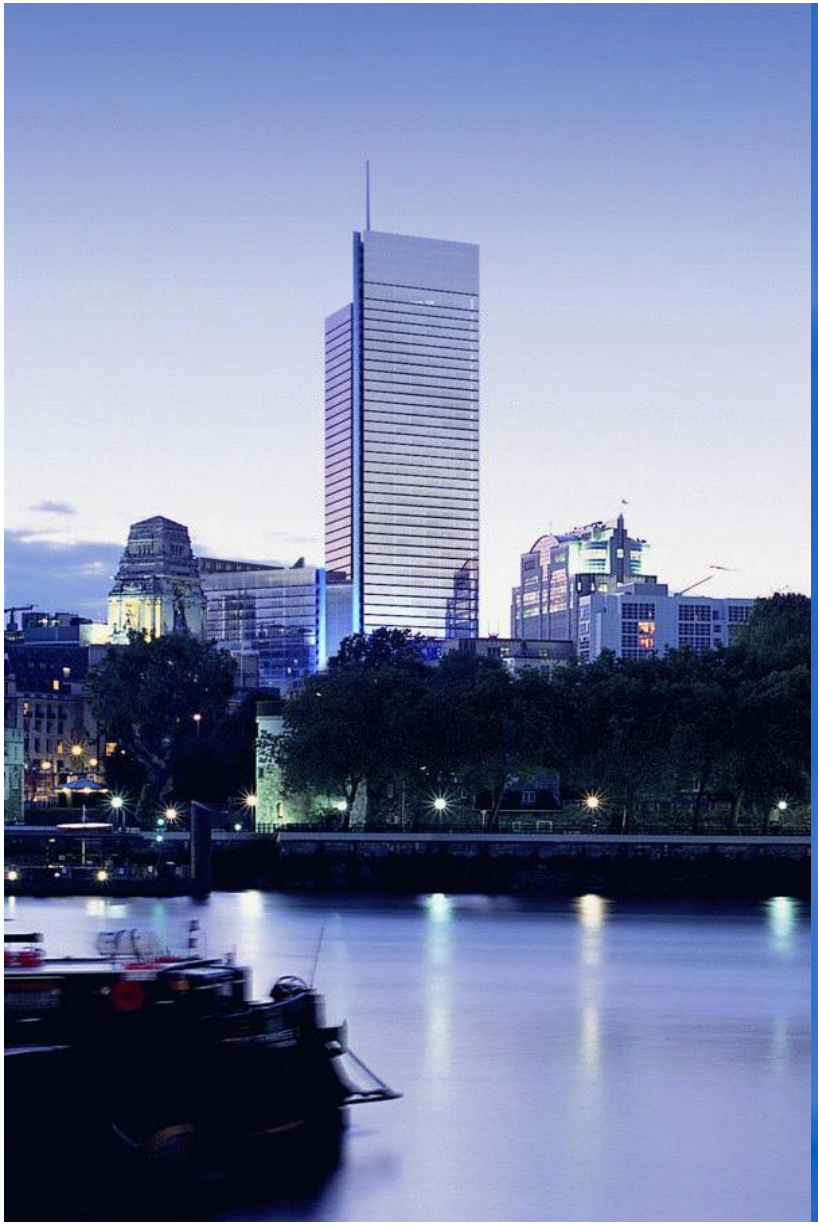
FORS Seminar 2004

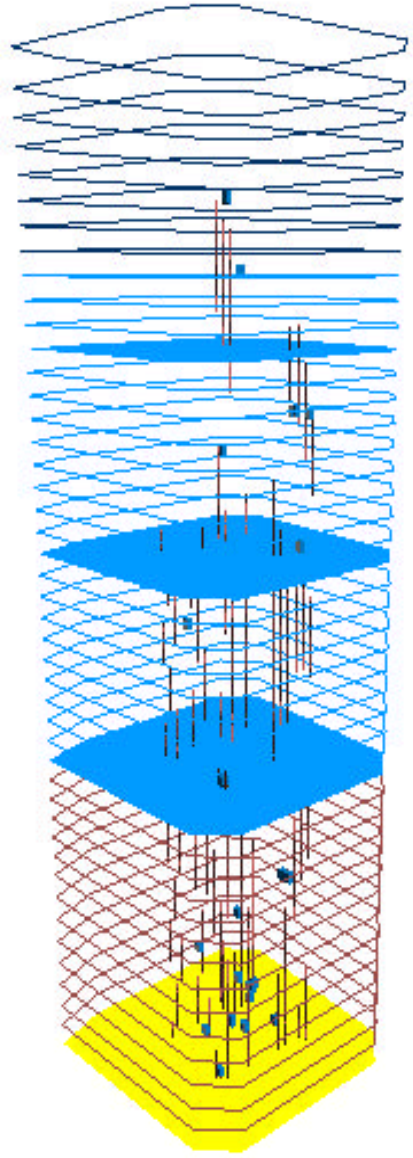


Elevator Simulation and Control

Dr. Marja-Liisa Siikonen
KONE Elevators

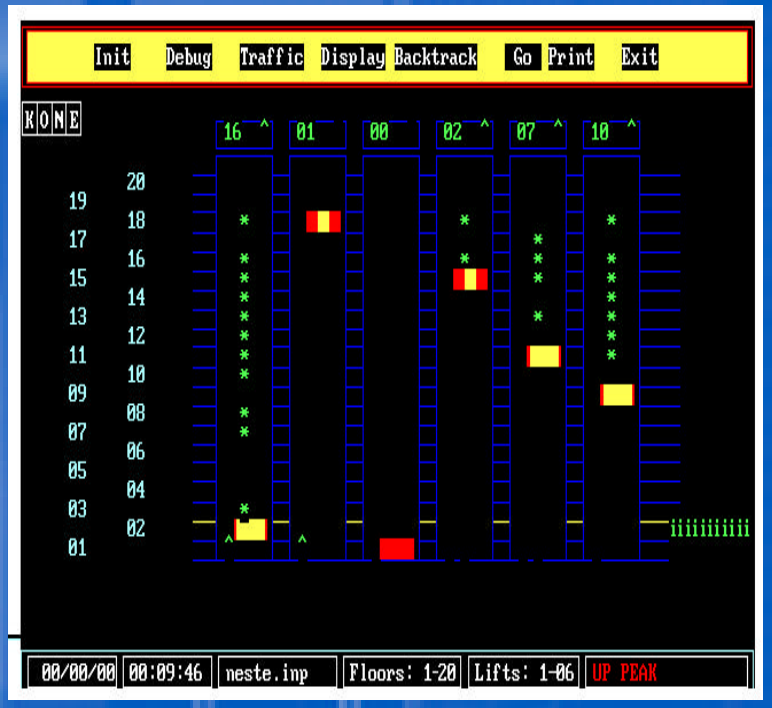
25.11.2004

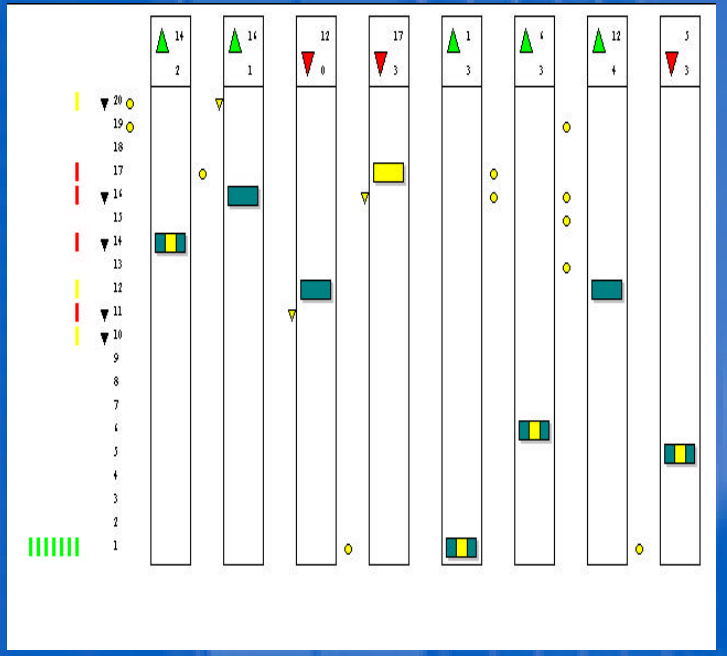
- Background
- Building Traffic Simulator
- Latest Group Control Developments



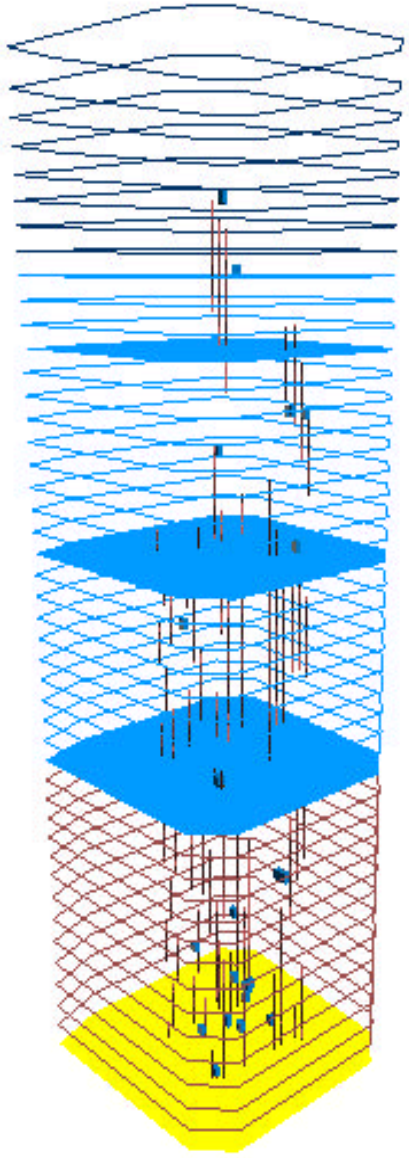
Personal Computer Based Simulators

- In 1980's simulator software moved to PCs
  - generic or "real" group control software
  - simulations 10-100 times faster than real time
  - one elevator group simulated at a time



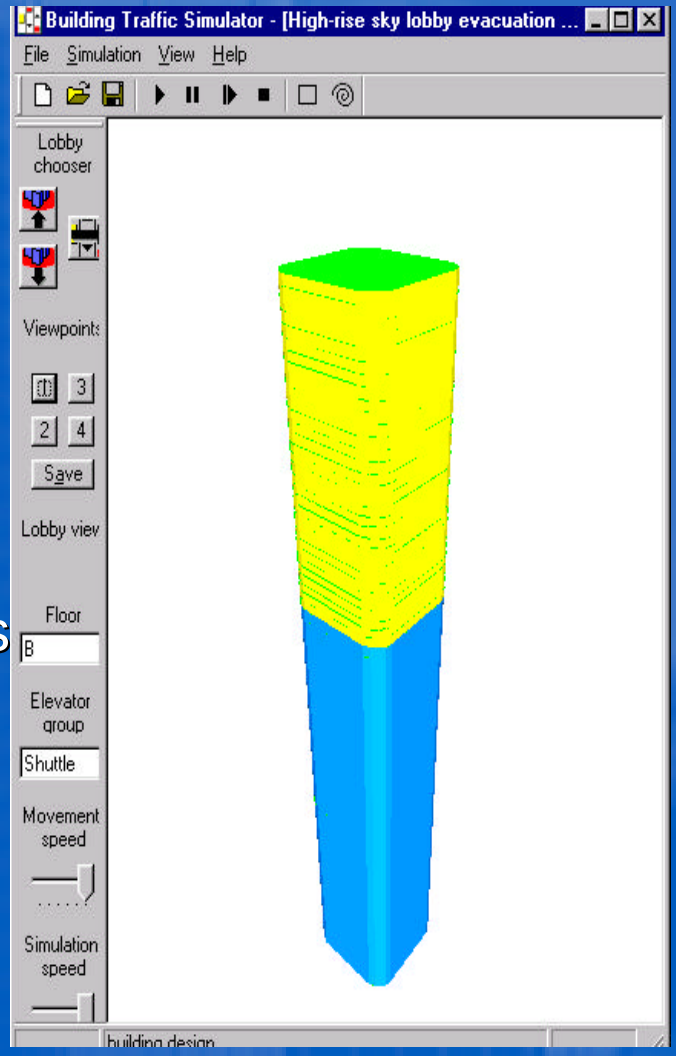


- Background
- Building Traffic Simulator
- Latest Group Control Developments
- **Example Simulation**

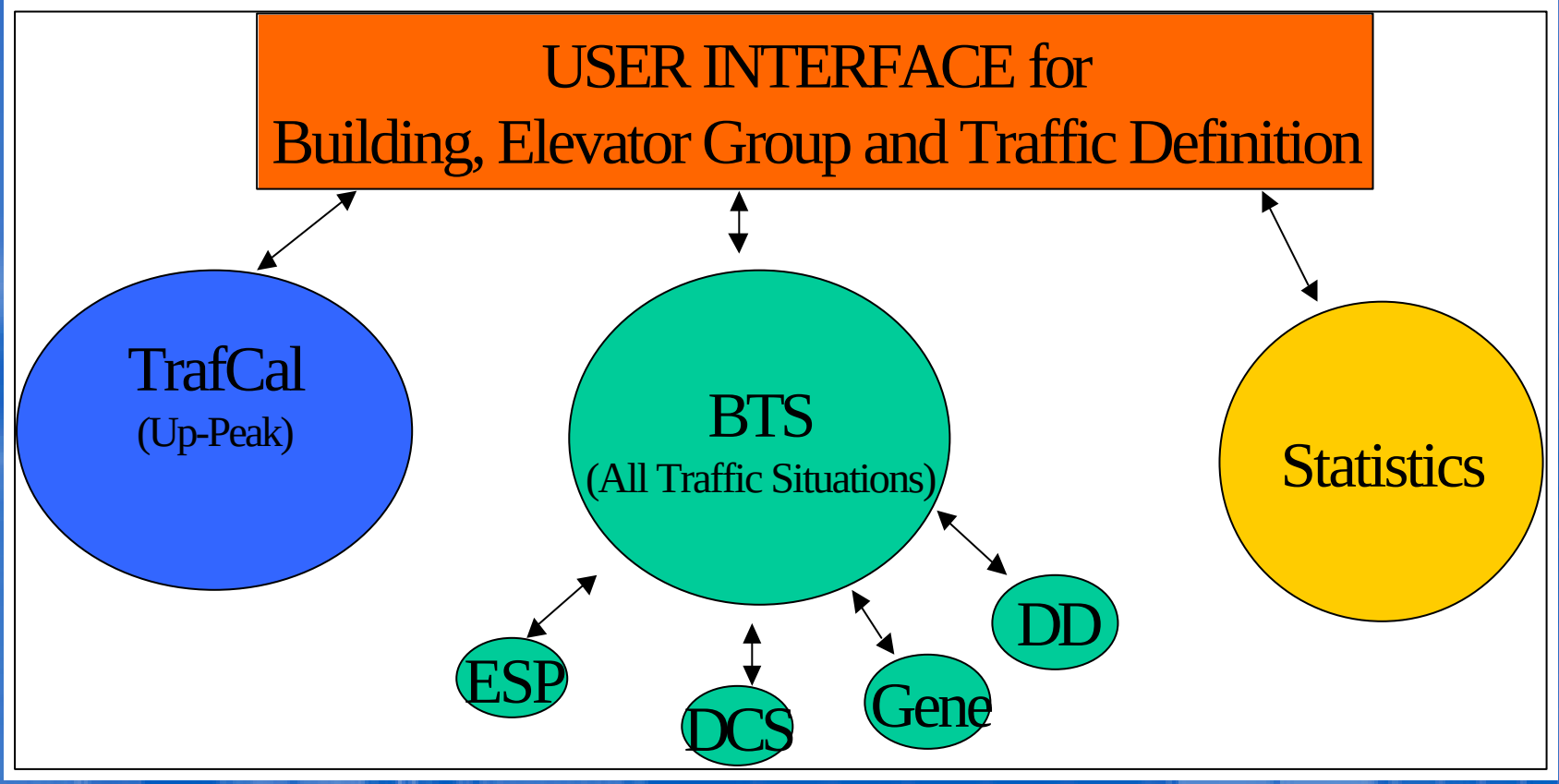


Building Traffic Simulator

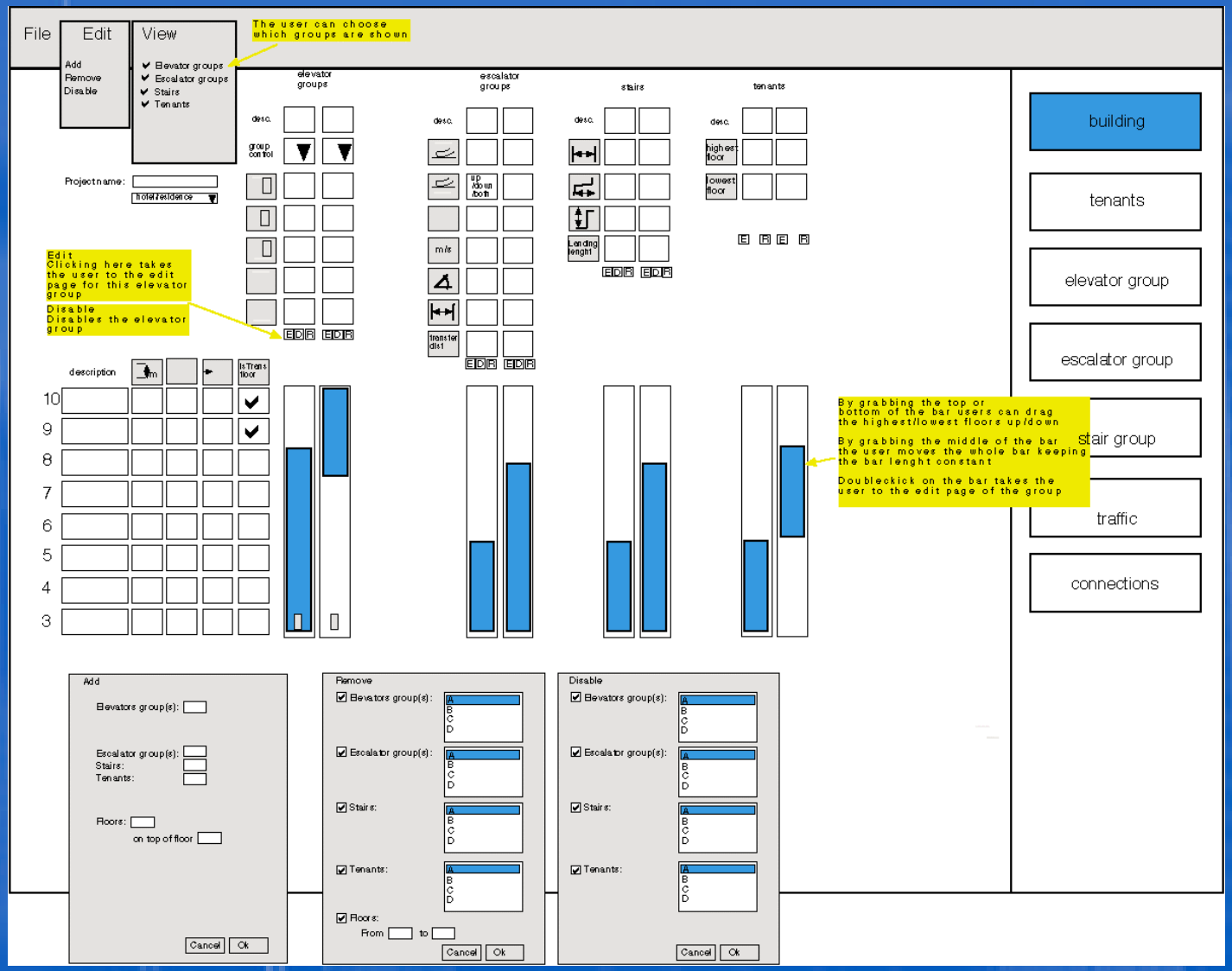
- Tool to simulate several transportation facilities at the same time
  - elevator , escalator and stairs groups
- The whole passenger journey is modeled
  - waiting times of transportation facilities
  - ride times inside the facilities
  - walking times between the facilities
- Window-based architecture
- KONE old and latest group control systems



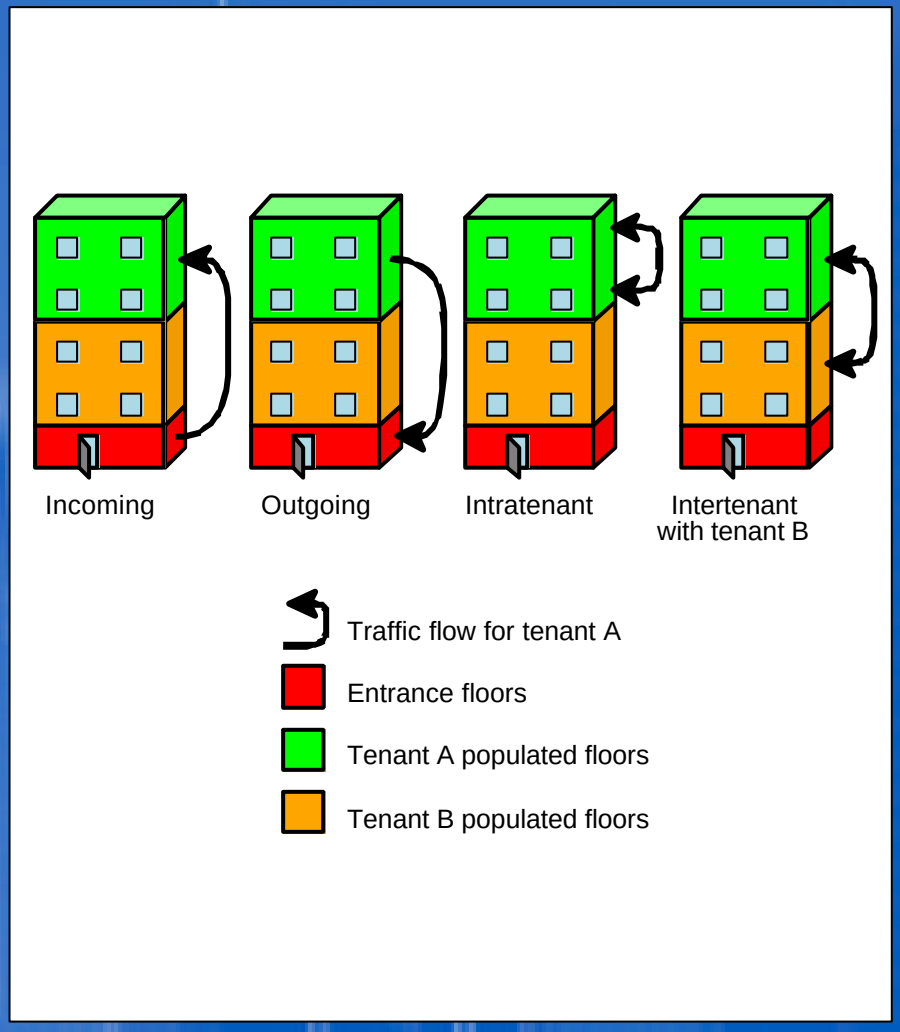
System Architecture



Data Definitions



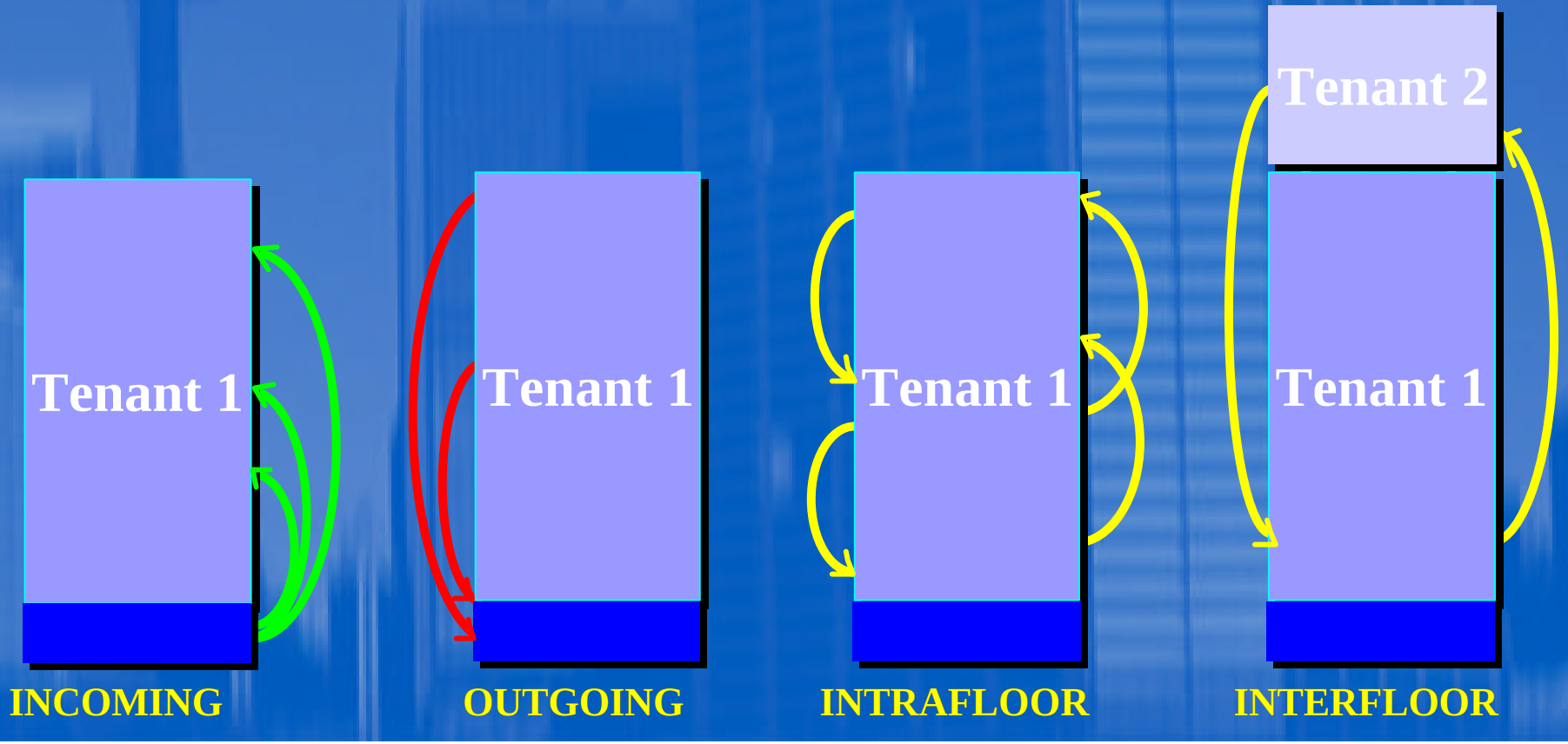
Tenant Traffic



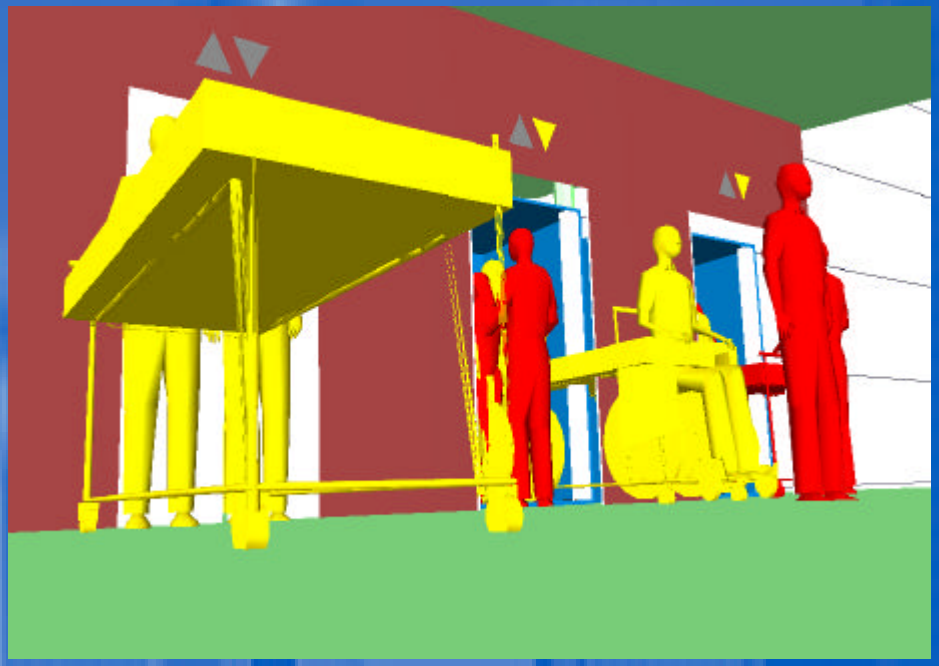
- Traffic flow depends on *location*
- Building divided vertically to *tenants*
- Separate traffic definition for each tenant

Human Circulation

- Passengers generated randomly taken into account
  - Four traffic components
  - Arrival rate according to the time of day
  - Population distribution in the building



Passenger Groups

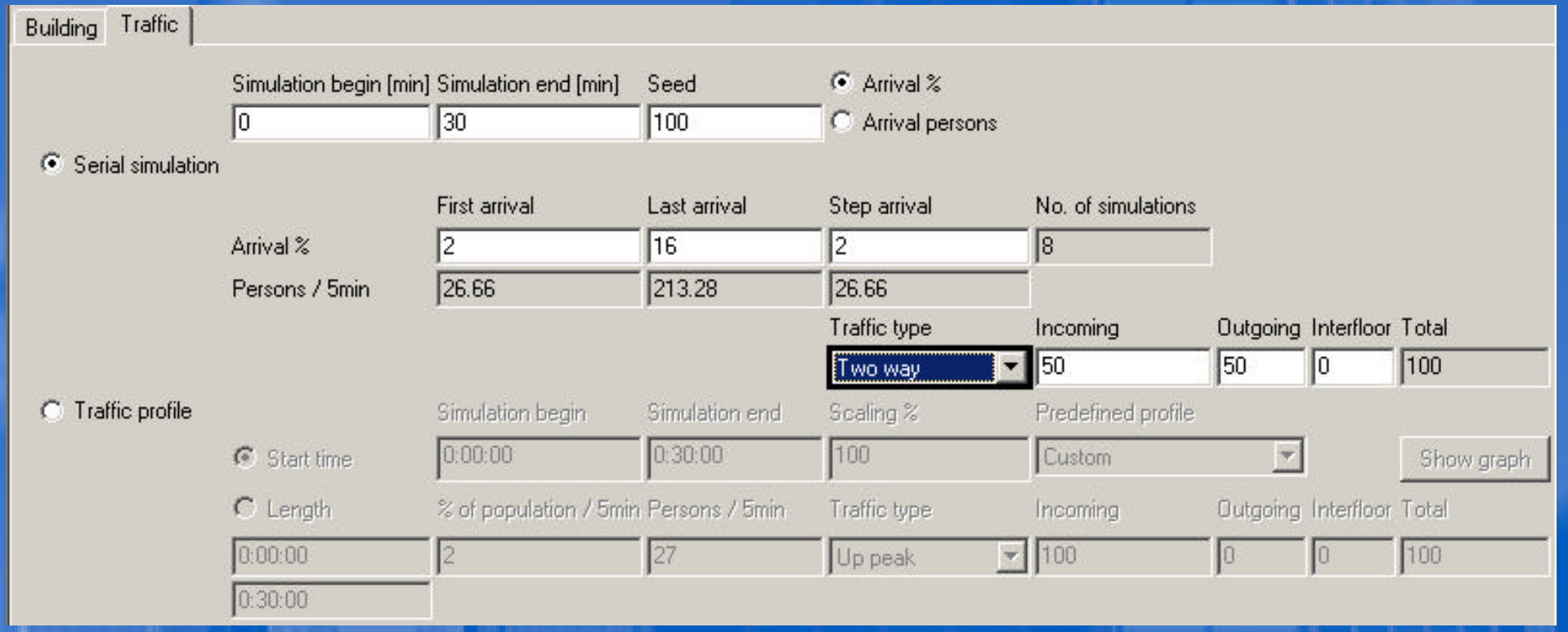


- **Passengers divided into *passenger groups***
  - **Adults**
  - **Children**
  - **People with shopping trolleys**

Passenger Group Characteristics

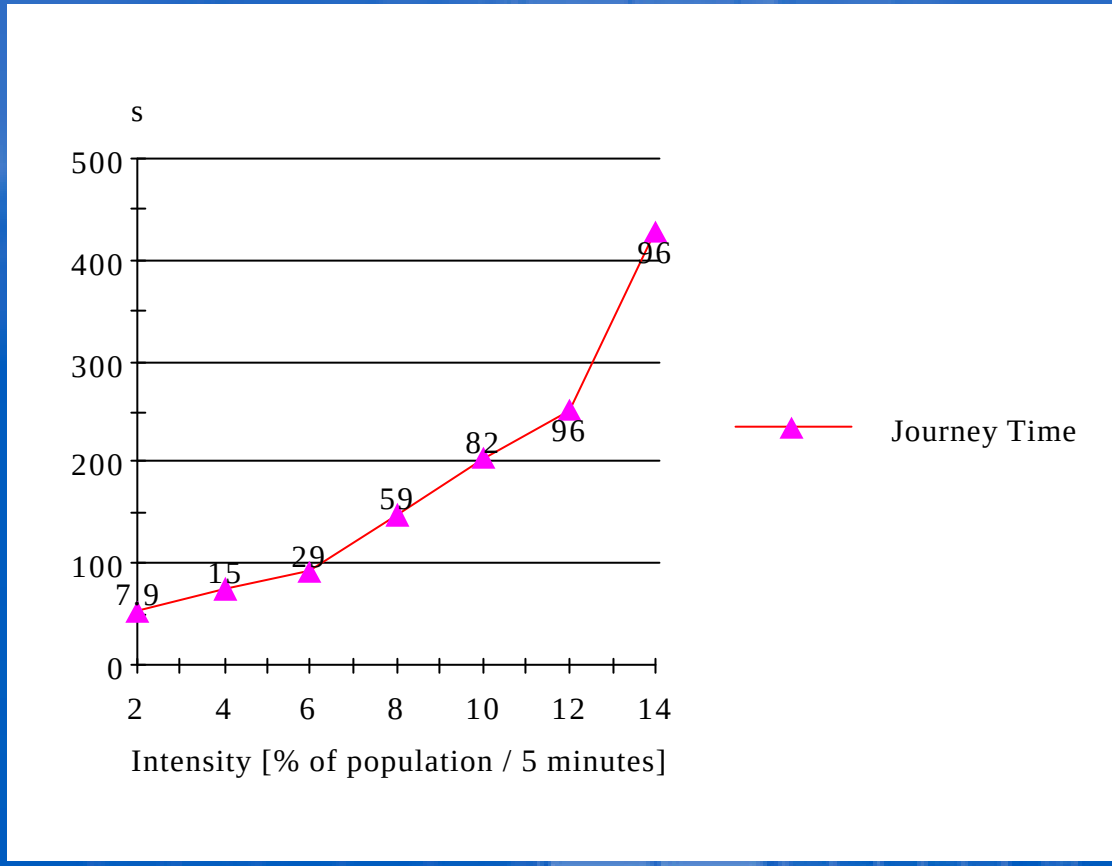
- **Physical charateristics:**
  - **Walking speed**
  - **Space demand**
  - **Transfer time through doors**
- **Behavioural characteristics**
  - **Avoiding massive queues**
  - **Preferring elevators for long trips**
  - **Descending staircases more probable than ascending**

Serial simulation

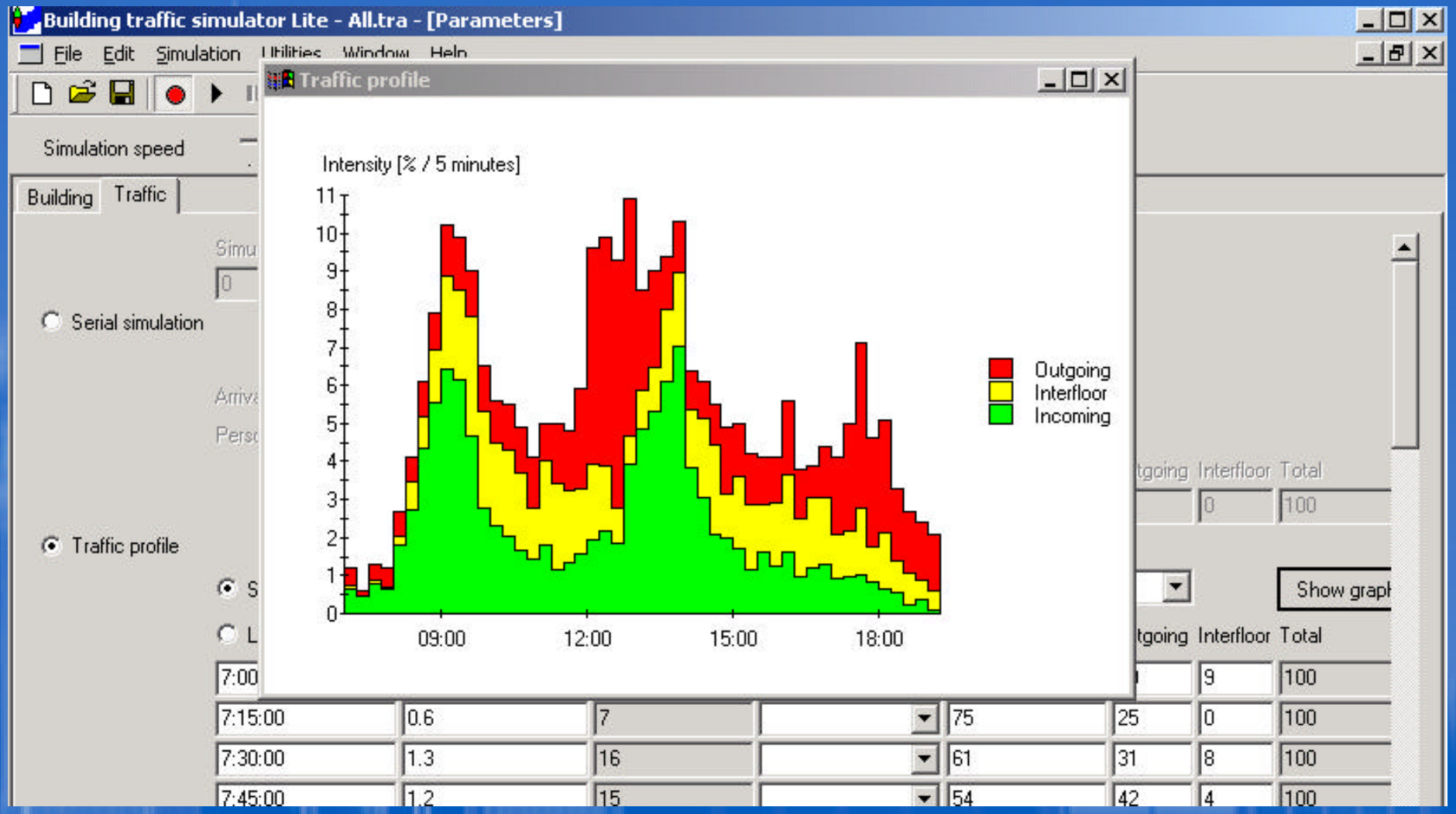


Result types: Serial statistics

- Serial statistics
  - One data point per simulation

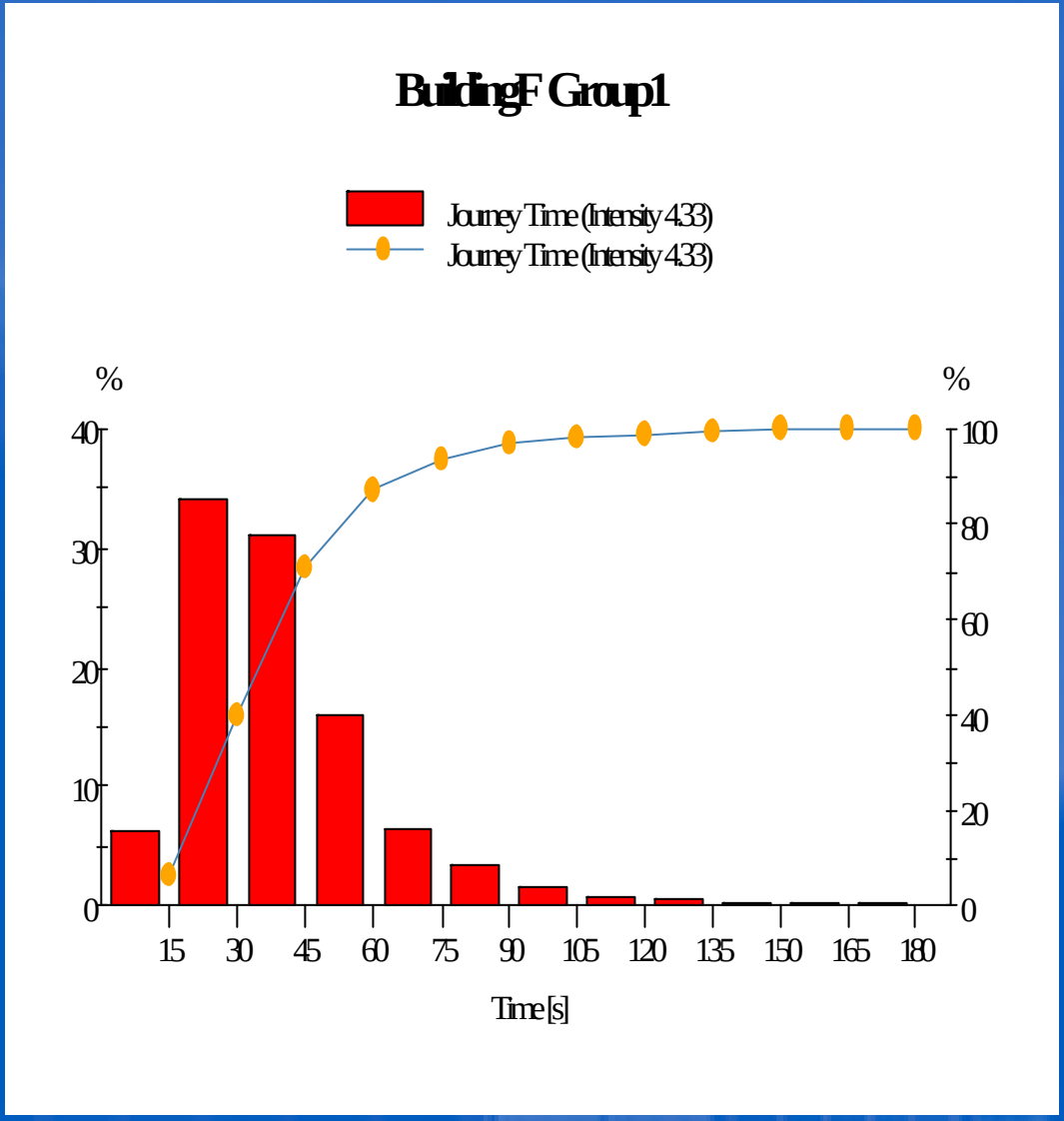


Traffic Input Profile



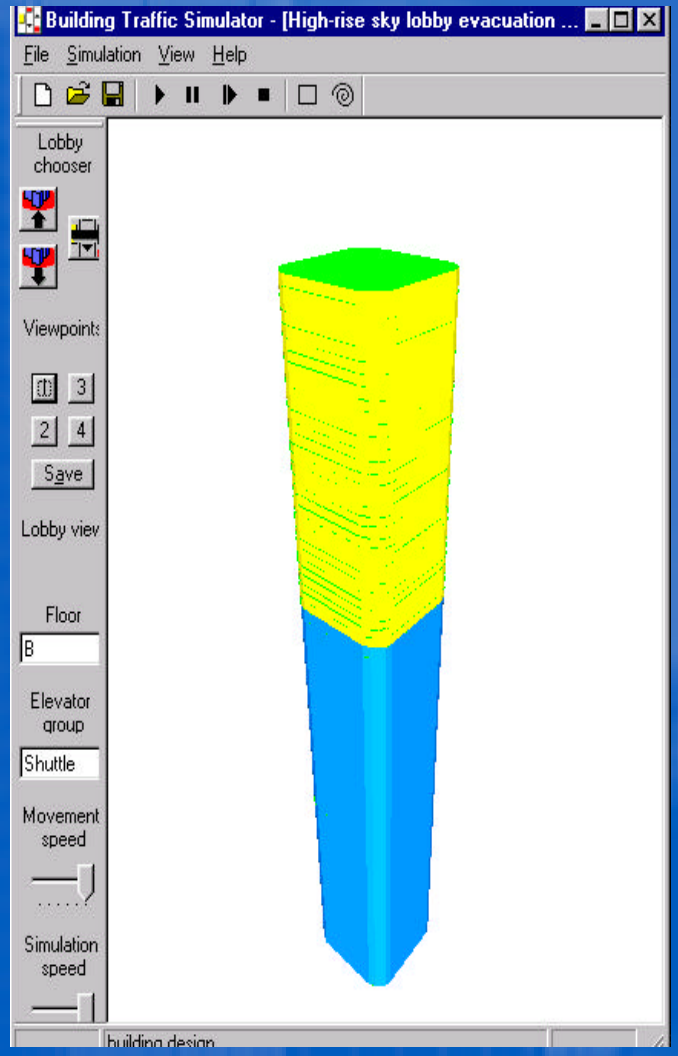
Statistics result types: Histogram

- Percentage of items (e.g. waiting times) for certain traffic intensity
- Cumulative percentage

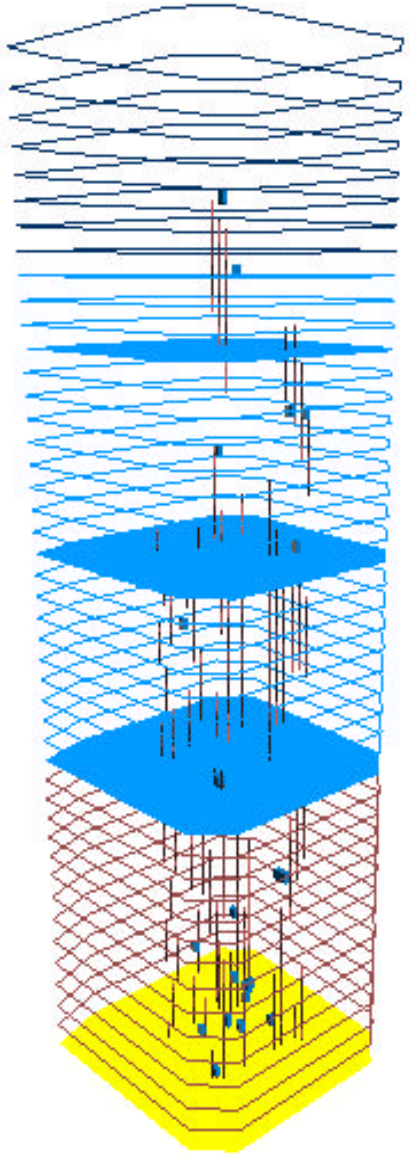


Use of Building Traffic Simulator

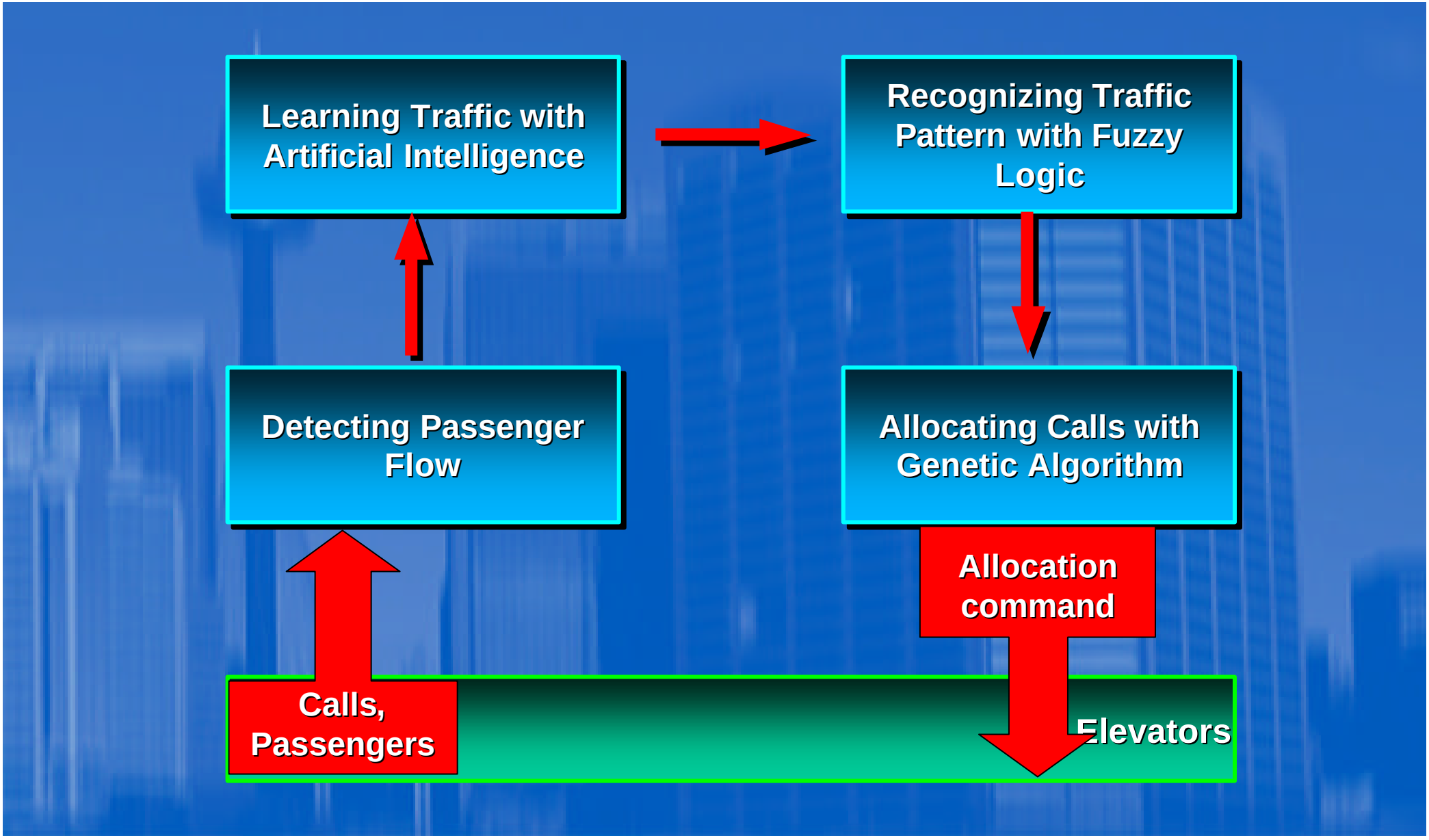
- Customer projects
- Group control development and testing
- Research



- Background
- Building Traffic Simulator (BTS)
- Latest Group Control Developments
  - Forecasts, Fuzzy Logic
  - Genetic Algorithm
  - Destination Control

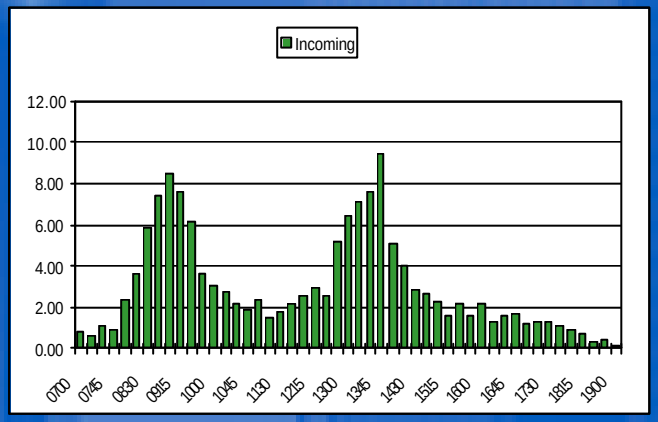


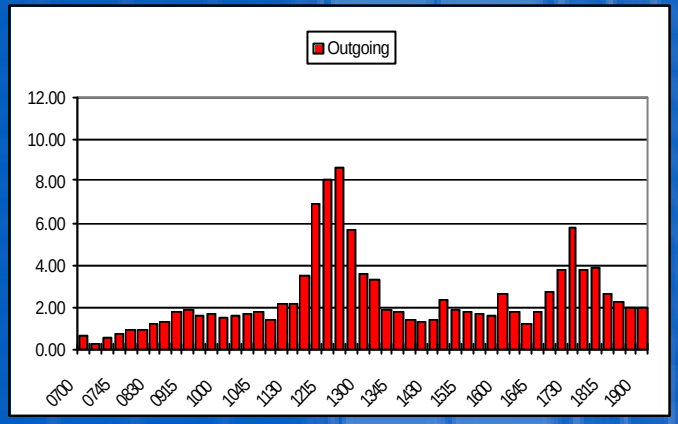
Control Architecture

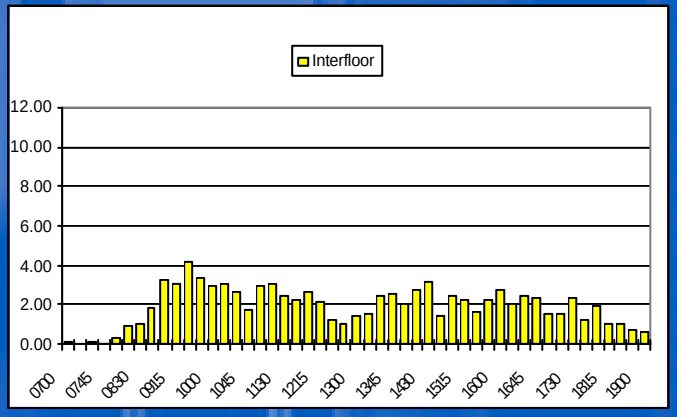


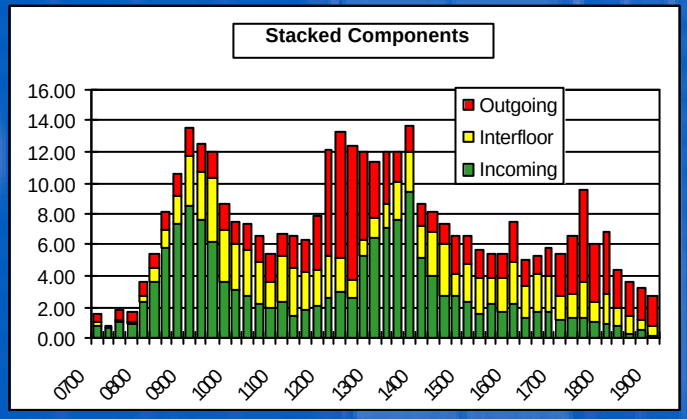
Forecast traffic during a Day

Tour Europe, Paris
Passenger Arrival Rate
(% of Population in 5 minutes)

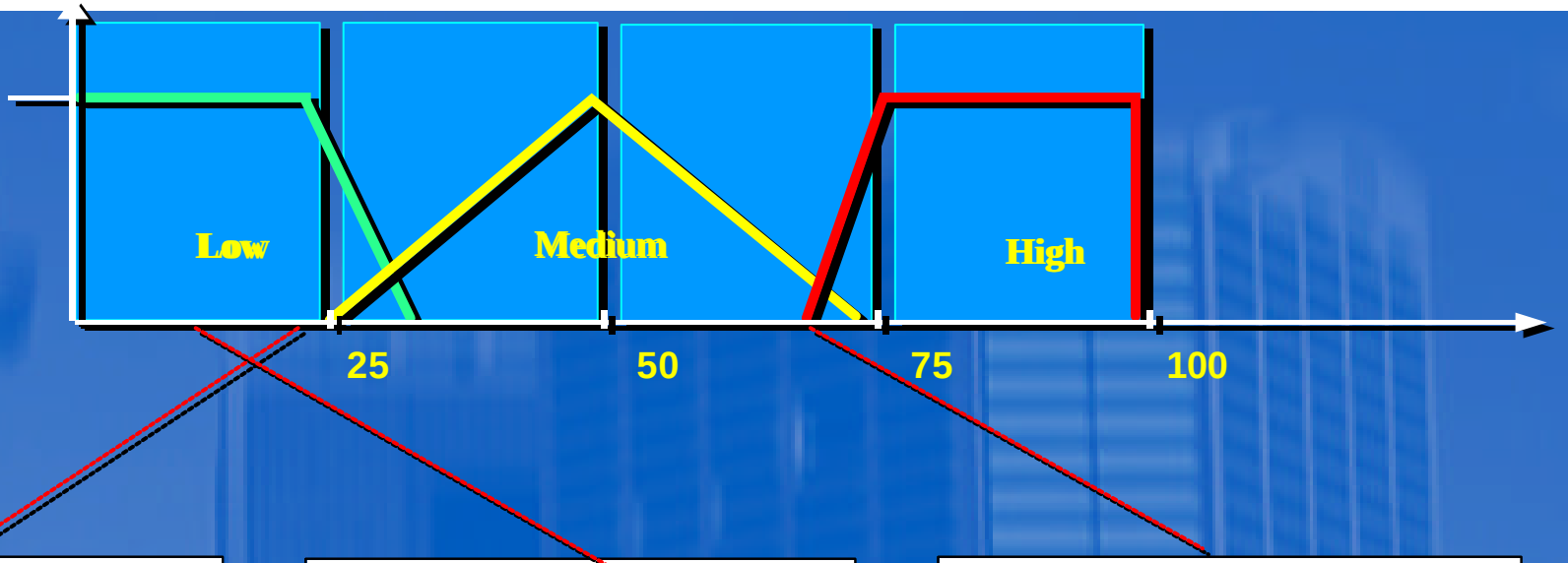


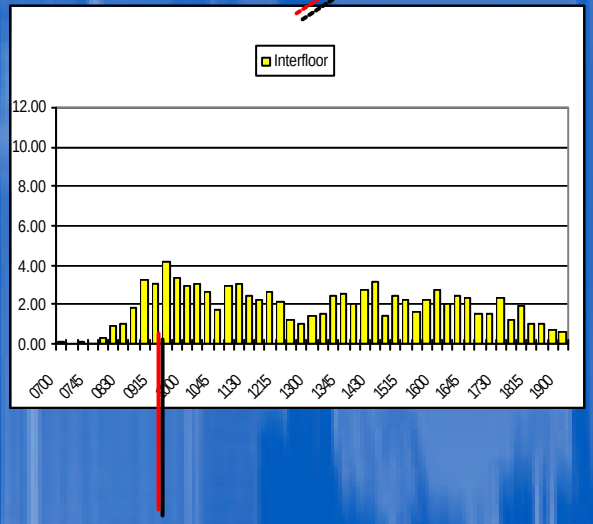




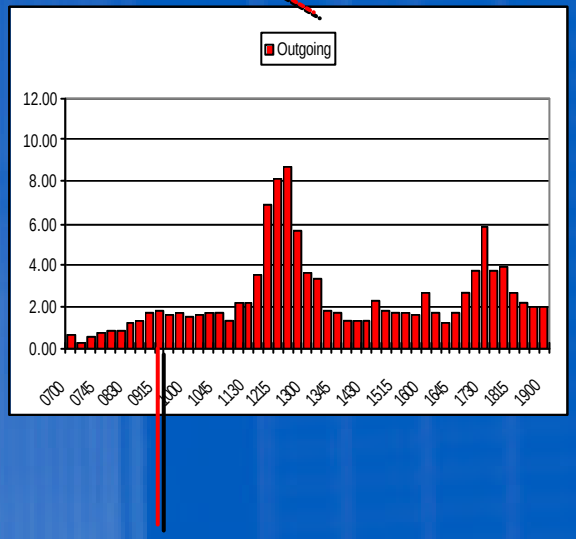


Traffic Pattern Recognition

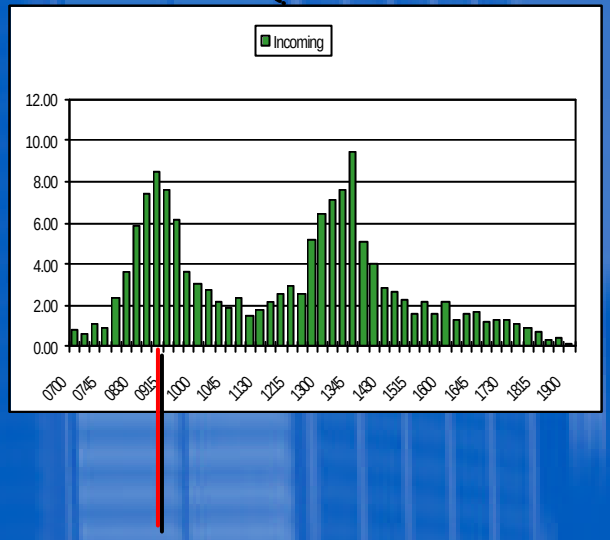




9:15 INTER-FLOOR TRAFFIC 3.2%
3.0/13.5 = 23 % OF TOTAL

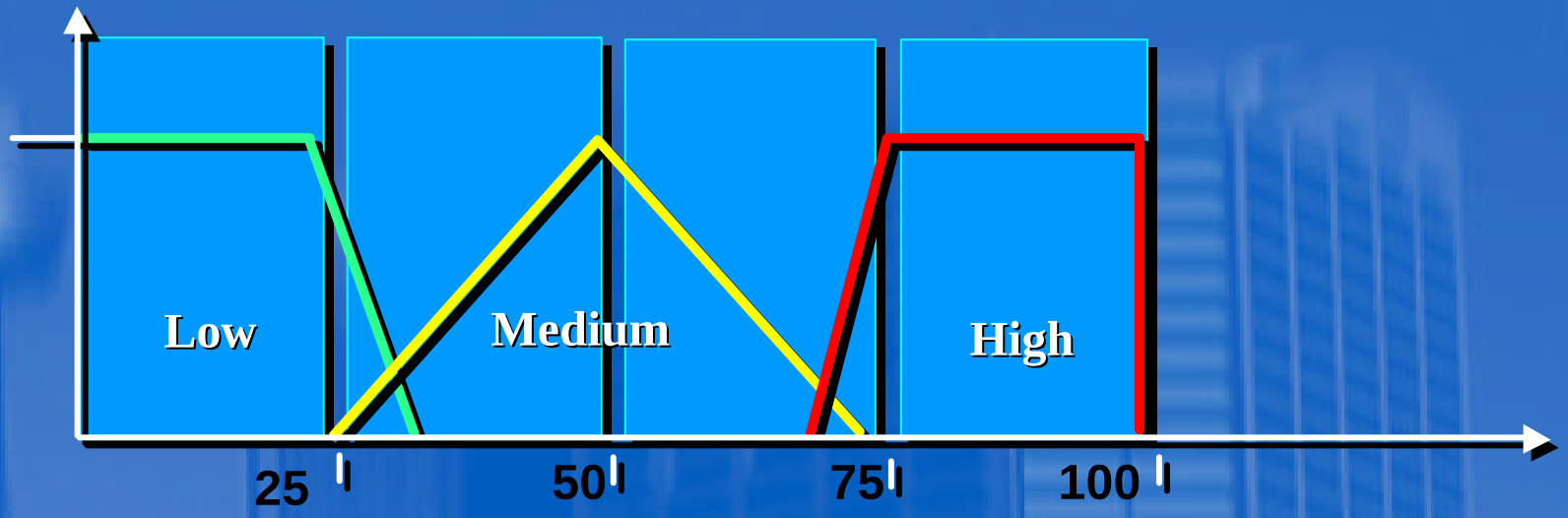


9:15 OUTGOING TRAFFIC 1.8%
1.8/13.5 = 12 % OF TOTAL



9:15 INCOMING TRAFFIC 8.7%
8.7/13.5 = 65 % OF TOTAL

Forecast with Fuzzy Rules



IF	Intensity	= Heavy	AND
	Incoming traffic	= High	AND
	Outgoing traffic	= Low	AND
	Interfloor traffic	= Low	

Traffic pattern = Up Peak

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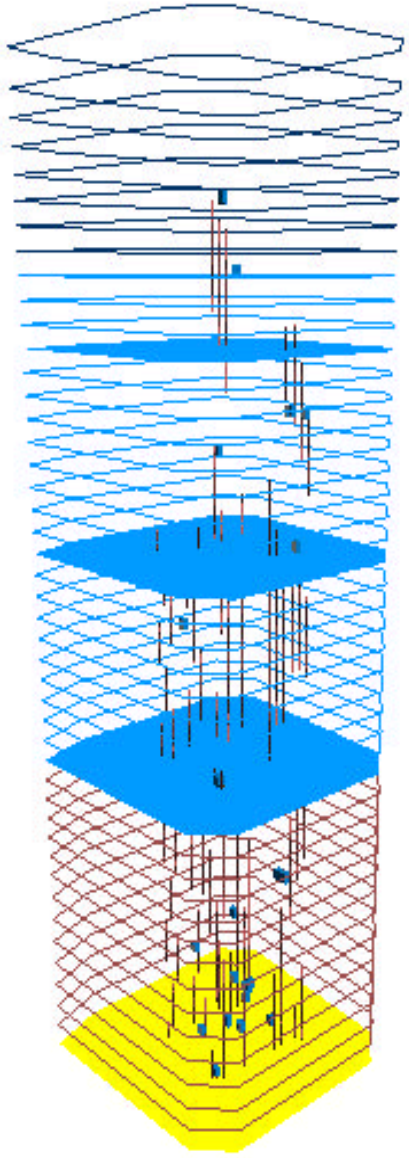
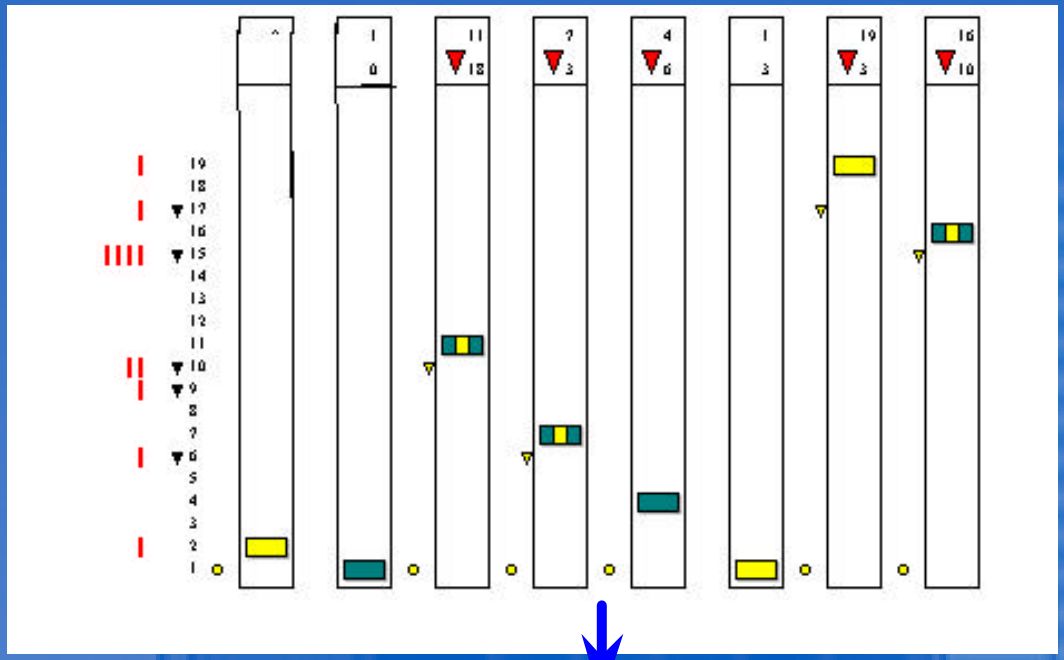


Example Building



Genetic Algorithms

Optimal Routes

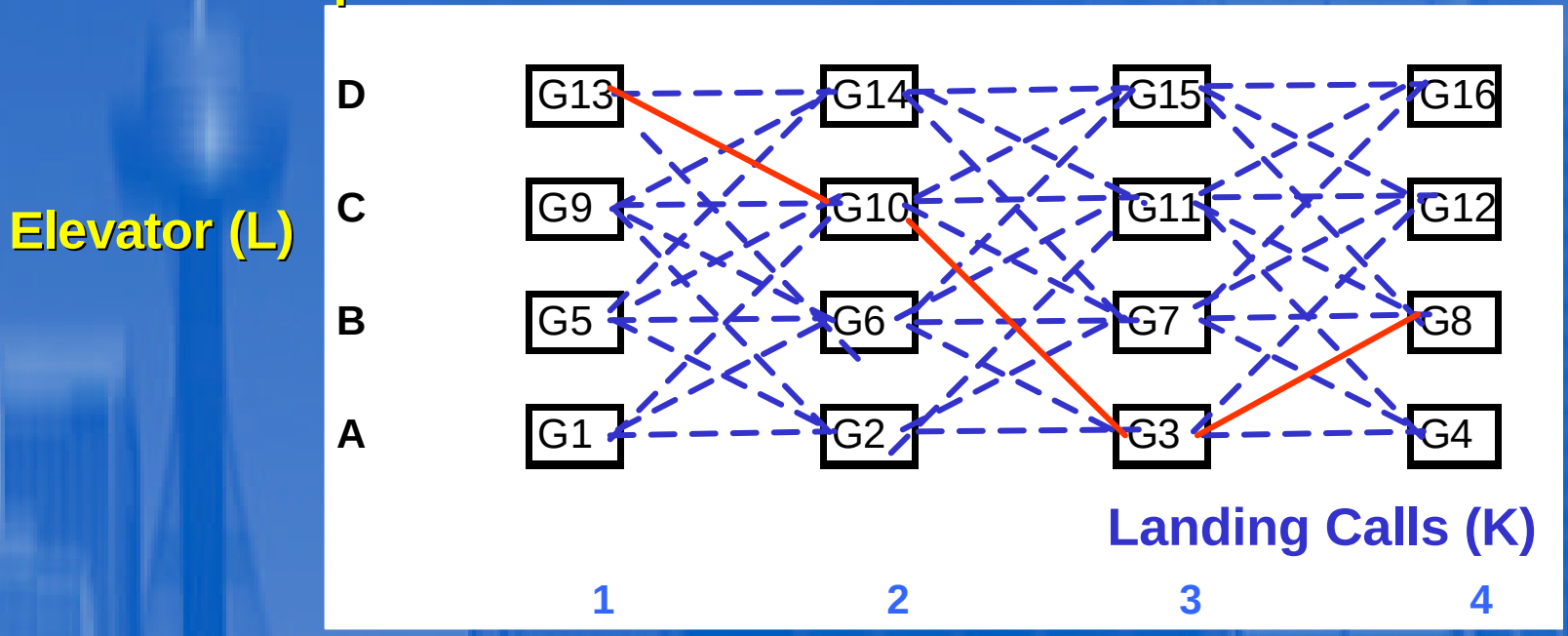
Max. 40 Landing Calls

$8^{40} = 10^{36}$ Routes

Calculation of 8^{19} routes takes 4600 years if one route took 1 ? s

Genetic Algorithm

Genetic Algorithm = Guess- Cross Over - Inheritance - > Optimal Solution



$L^K = 4^4 = 256$ Chromosomes

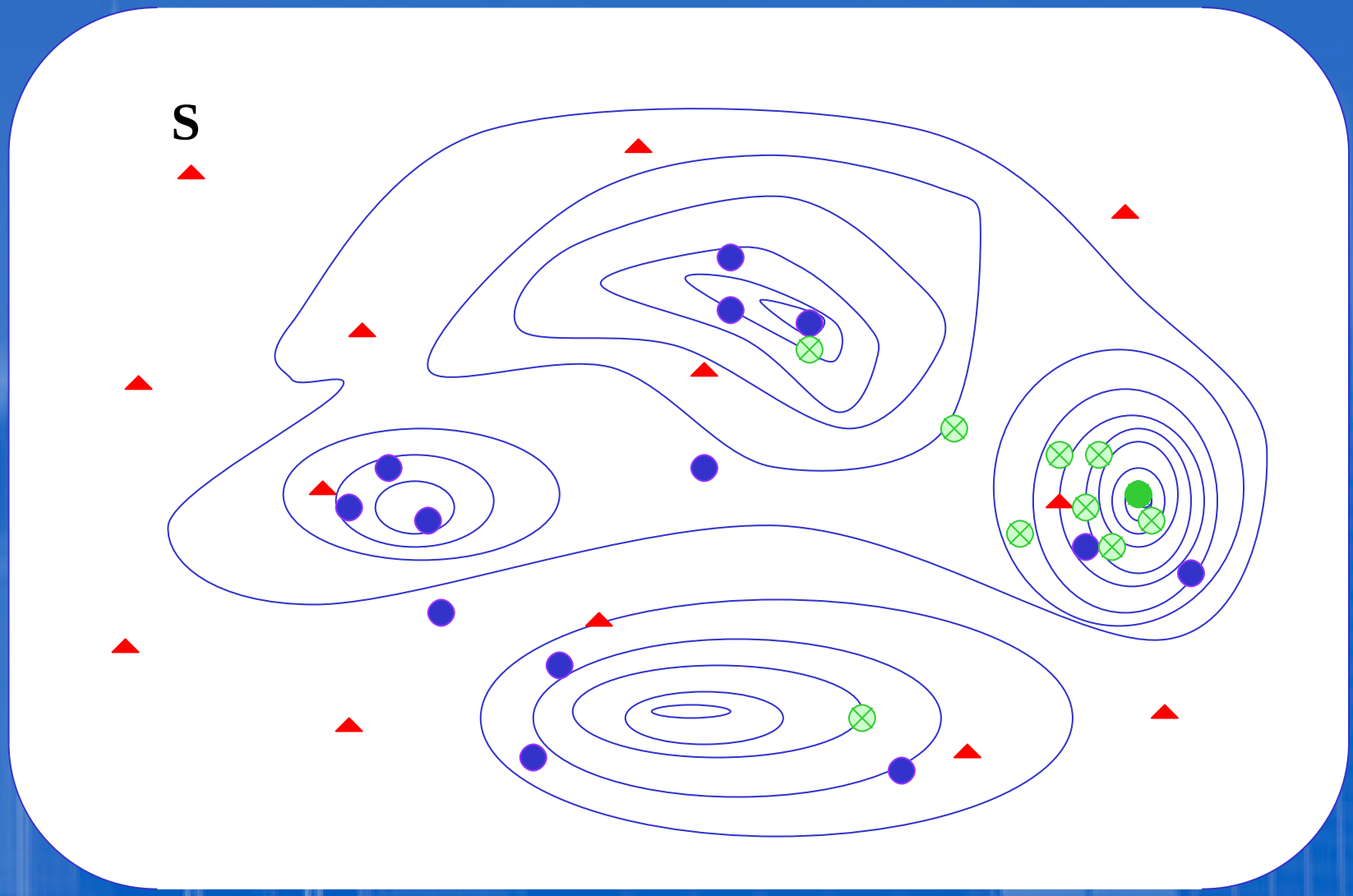
G1-G2-G3-G4

G1-G2-G3-G8

...

G13-G14-G15-G16

GA Searching Method



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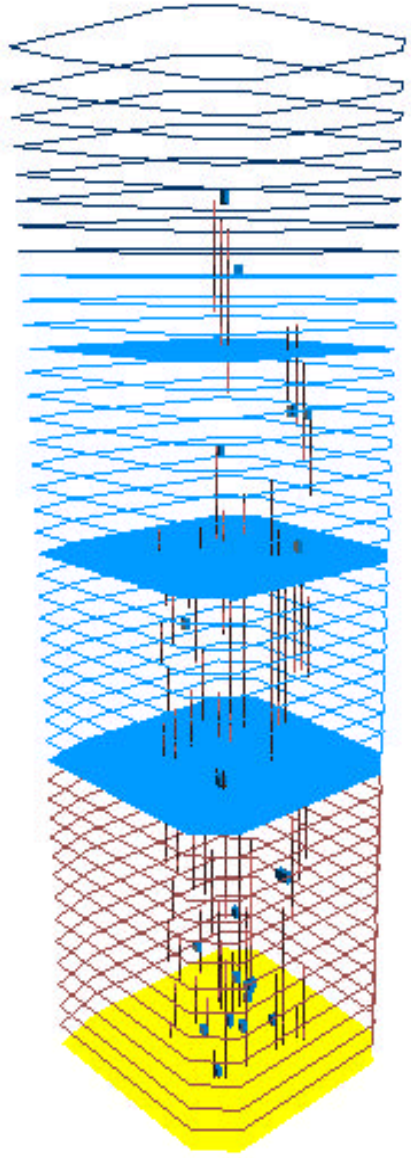


Normal hall call buttons…

With normal hall call buttons control system gets information of

- *Floor where call was given*
- *Call Direction*

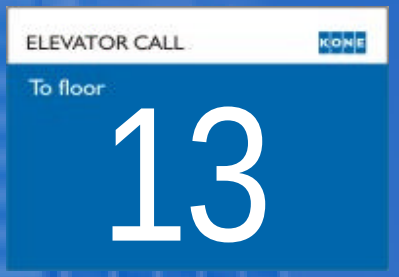
KONE DESTINATION CONSULTATION SYSTEM

Elevator Call

STEP 1

The user inputs the destination floor into keypad

The screen confirms the requested floor number



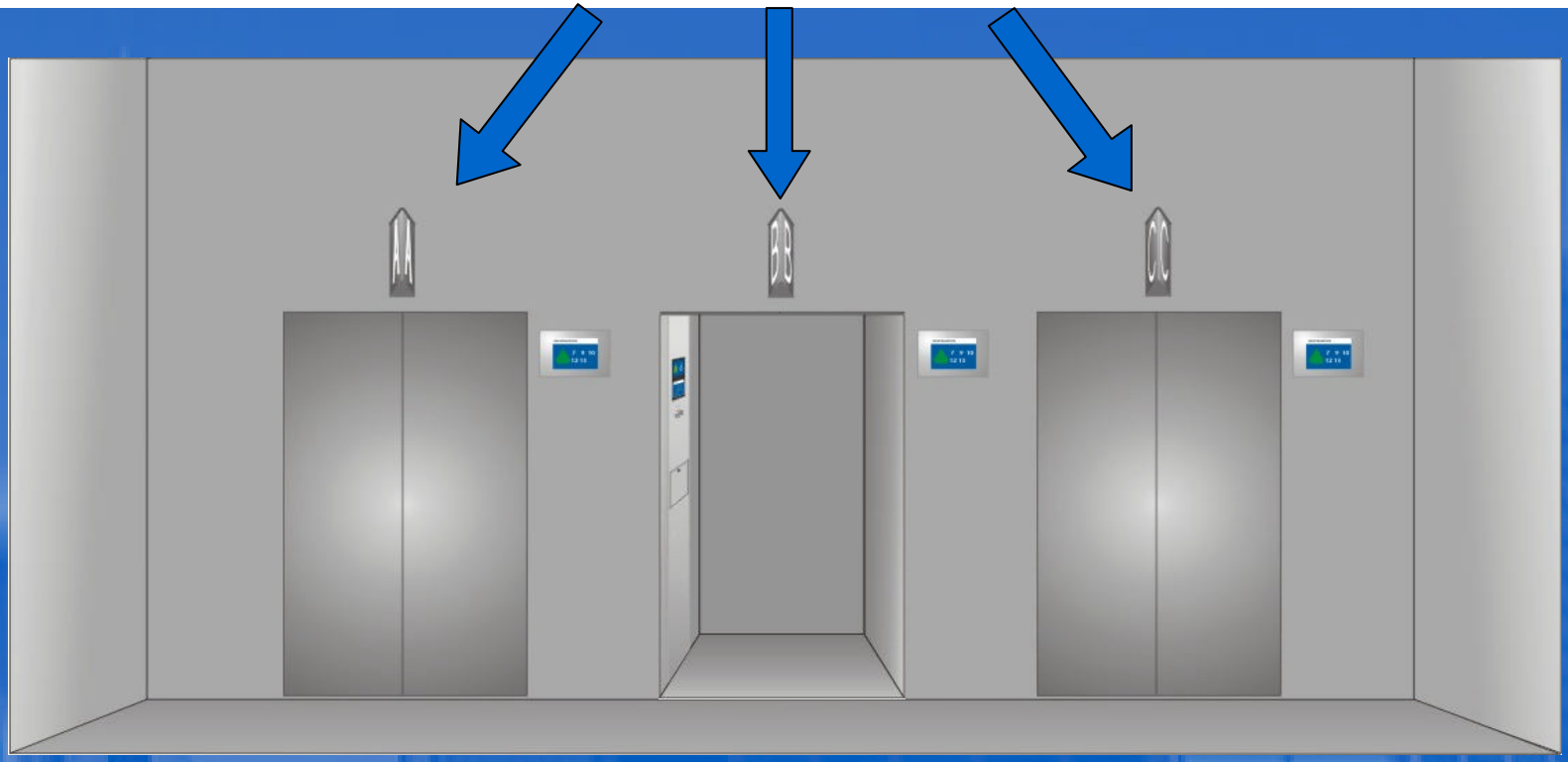
STEP 2

The display screen indicates the assigned elevator

Guidance

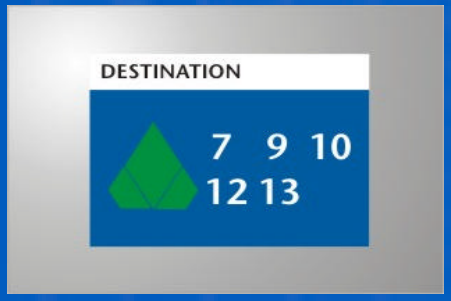
STEP 3

Elevator are identified by letters. User walks to the assigned elevator.



STEP 4

Elevator identifier blinks and makes a gong sound when the car arrives at the landing (sound and light features are optional)

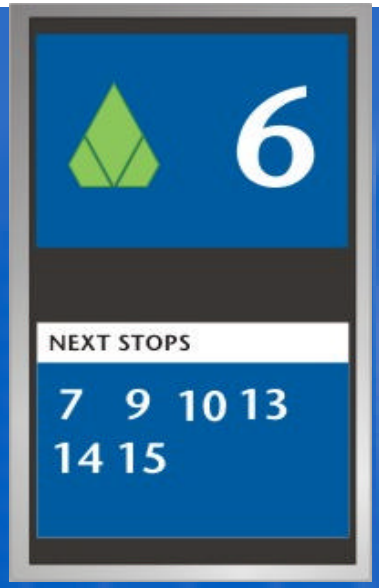


STEP 5

Destination indicator confirms the destination floors

NOTE: Destination indicator can be also placed on door transom

Inside a Car



STEP 6

Upper display indicates elevator position, direction arrow and elevator mode

Lower display indicates the allocated stops of passengers already inside the car as well as the landing calls to pick up new passengers

Hidden keypad

Alarm, door close and door open buttons

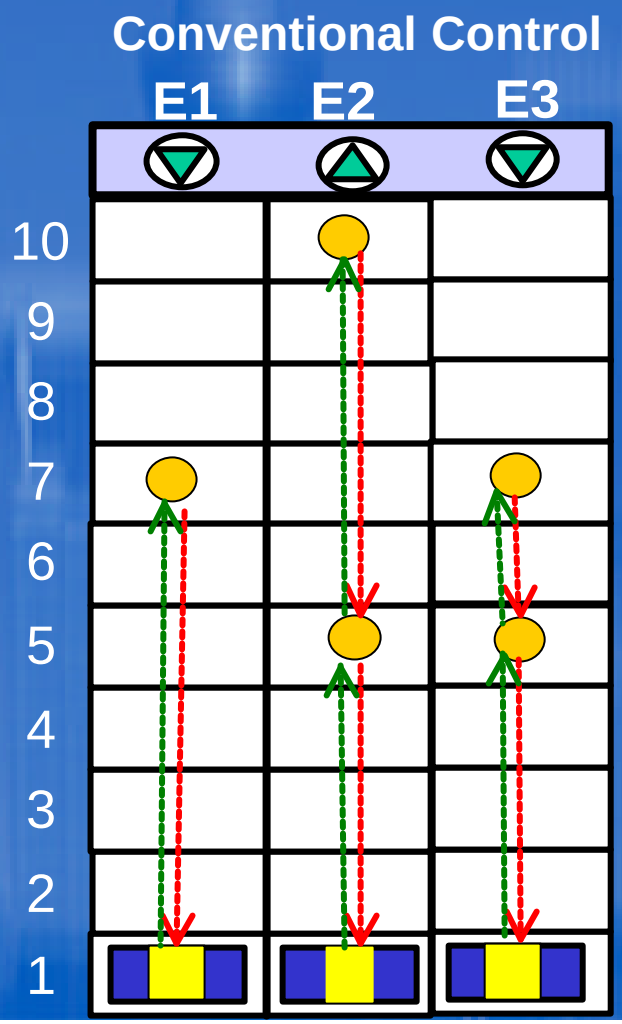
KONE DCS…

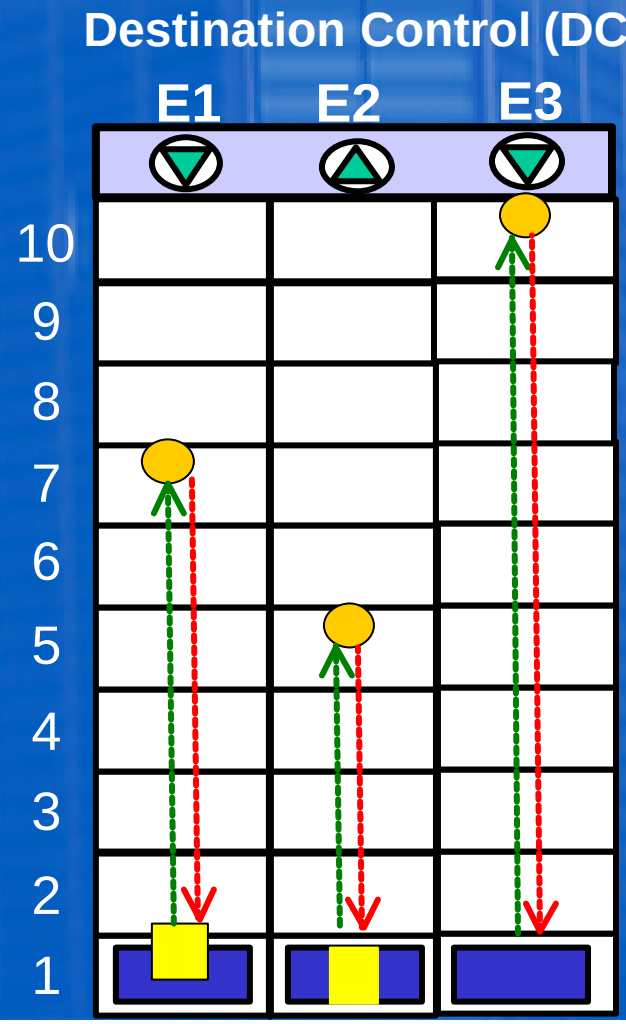
With destination control the control gets information of

- *Passenger arrival floor*
- *Passenger destination floor*
- *Number of people at each floor*

Boosting Effect in Up-Peak

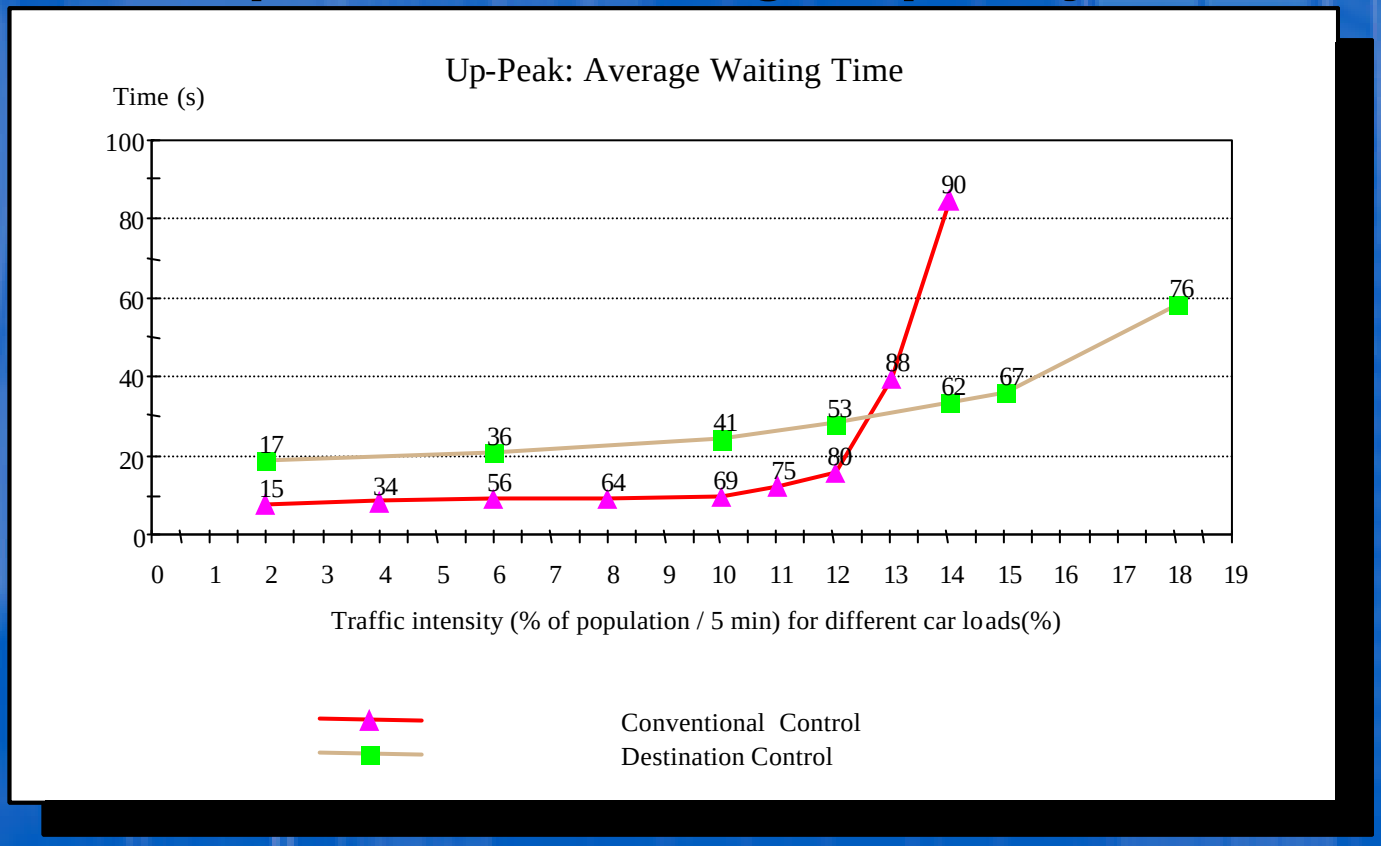
- With DCS passengers with the same destinatination floors gathered in the same car -> less stops





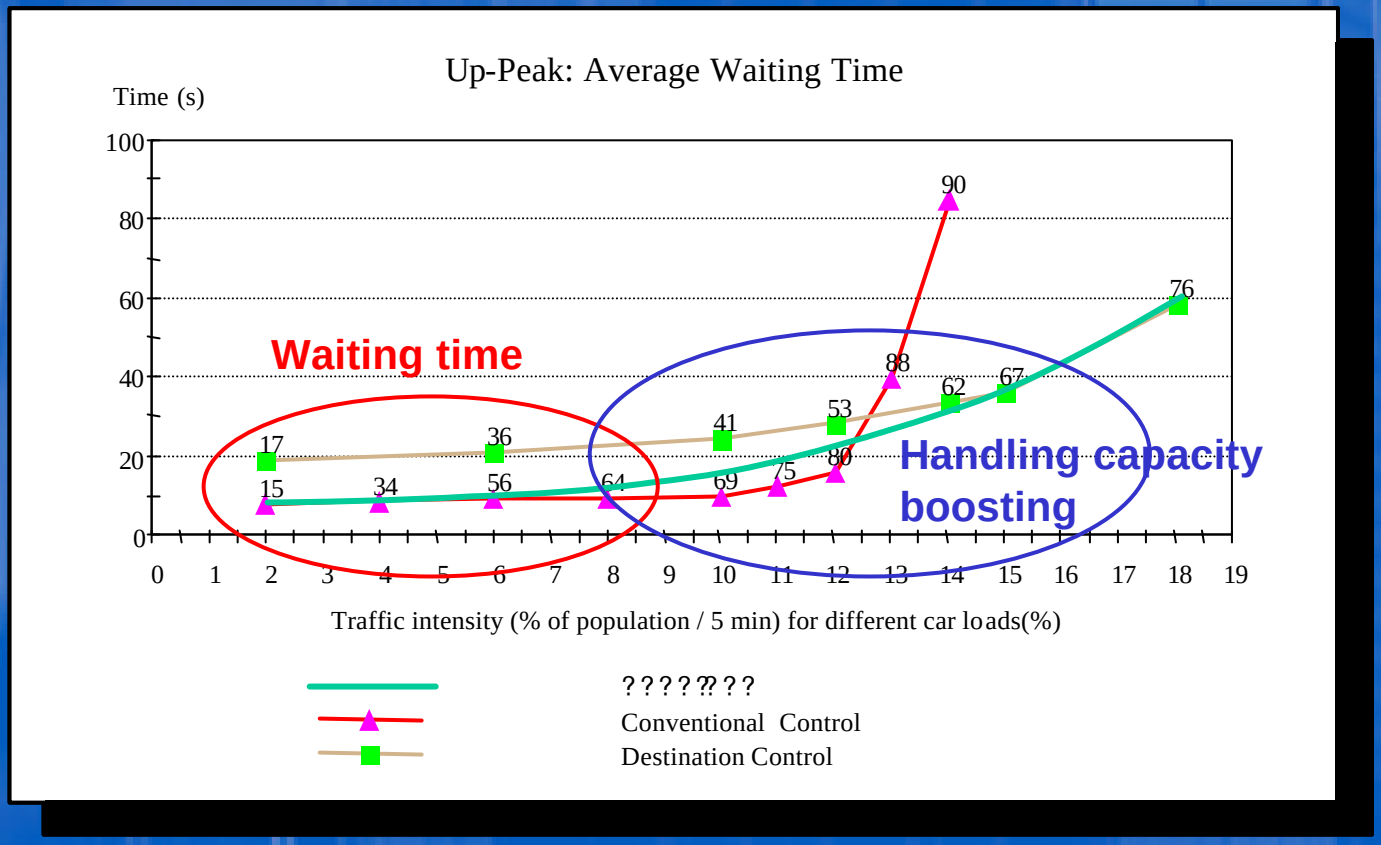
Up-Peak Waiting Times Conventional Control vs. DCS

- With destination control less stops during Round Trip
  - Shorter Round Trip Times
  - More Up-Peak Handling Capacity



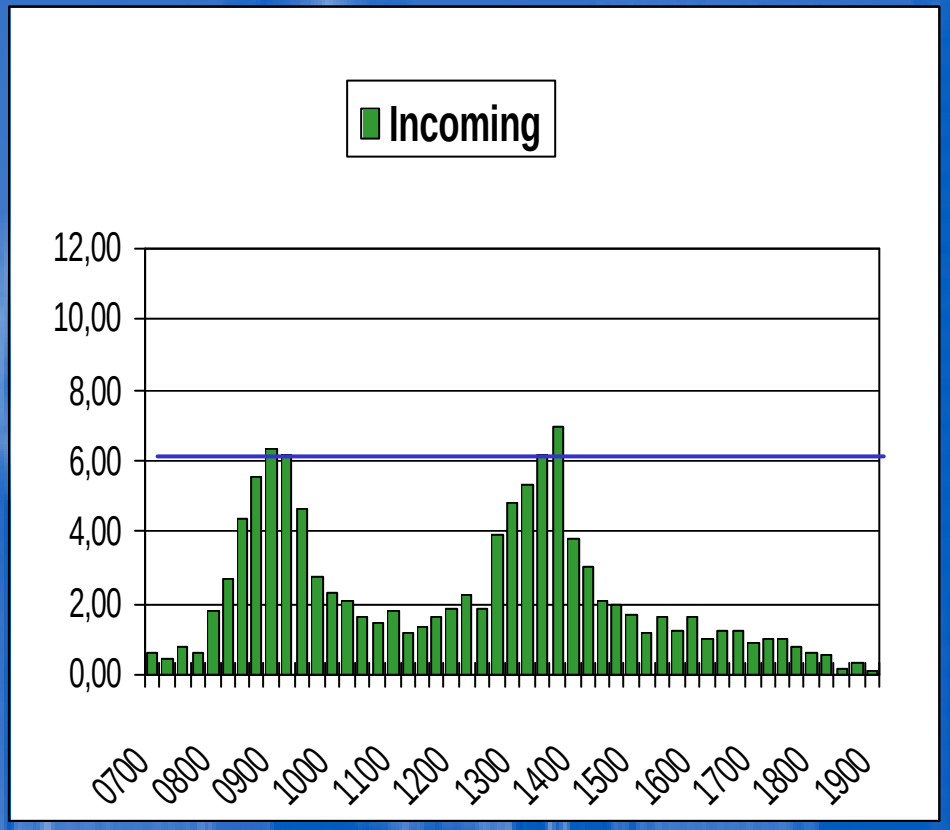
KONE DCS

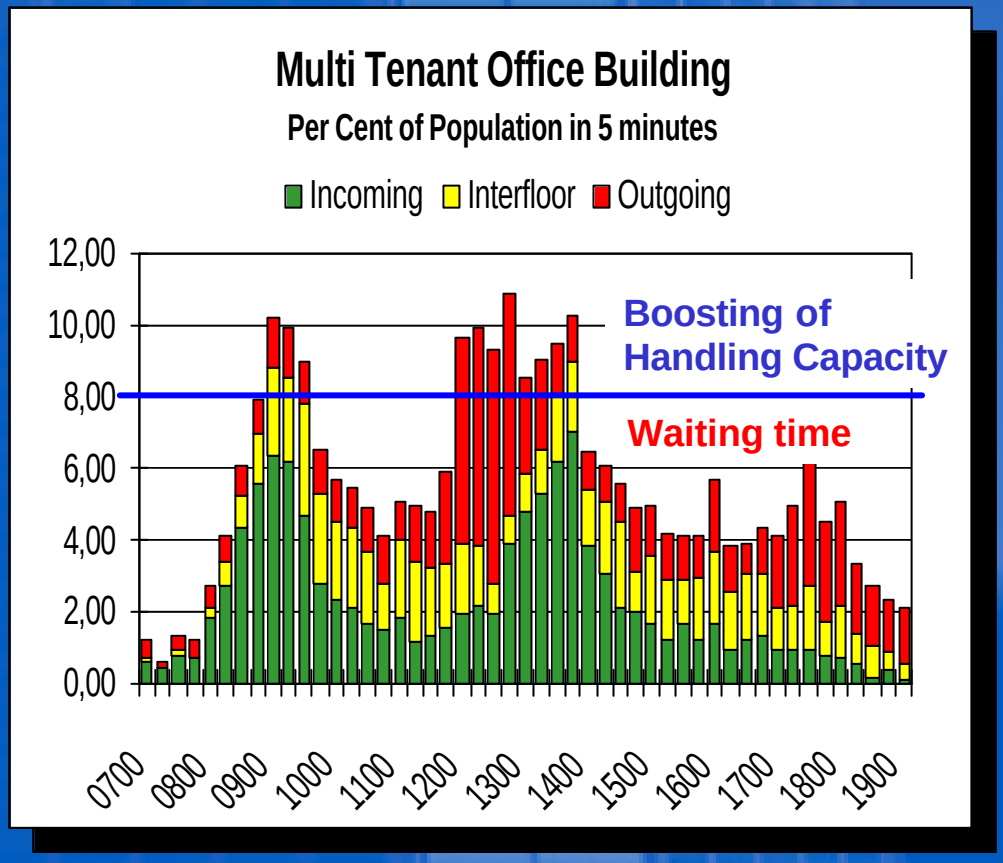
- KONE DCS Changes the optimisation algorithm based on the traffic intensity
  - during light traffic waiting times become shorter



New Planning Concept
Measured Daily Traffic

- Morning up-peak used in elevator planning





The heart of your building™