JÜLICH
FORSCHUNGSZENTRUM

Conception, development, installation and evaluation of a real time evacuation assistant for complex buildings

Workshop on Pedestrian Models

10 - 12 April 2014, EPFL Lausanne, Suisse

Civil Security and Traffic

Jülich Supercomputing Centre

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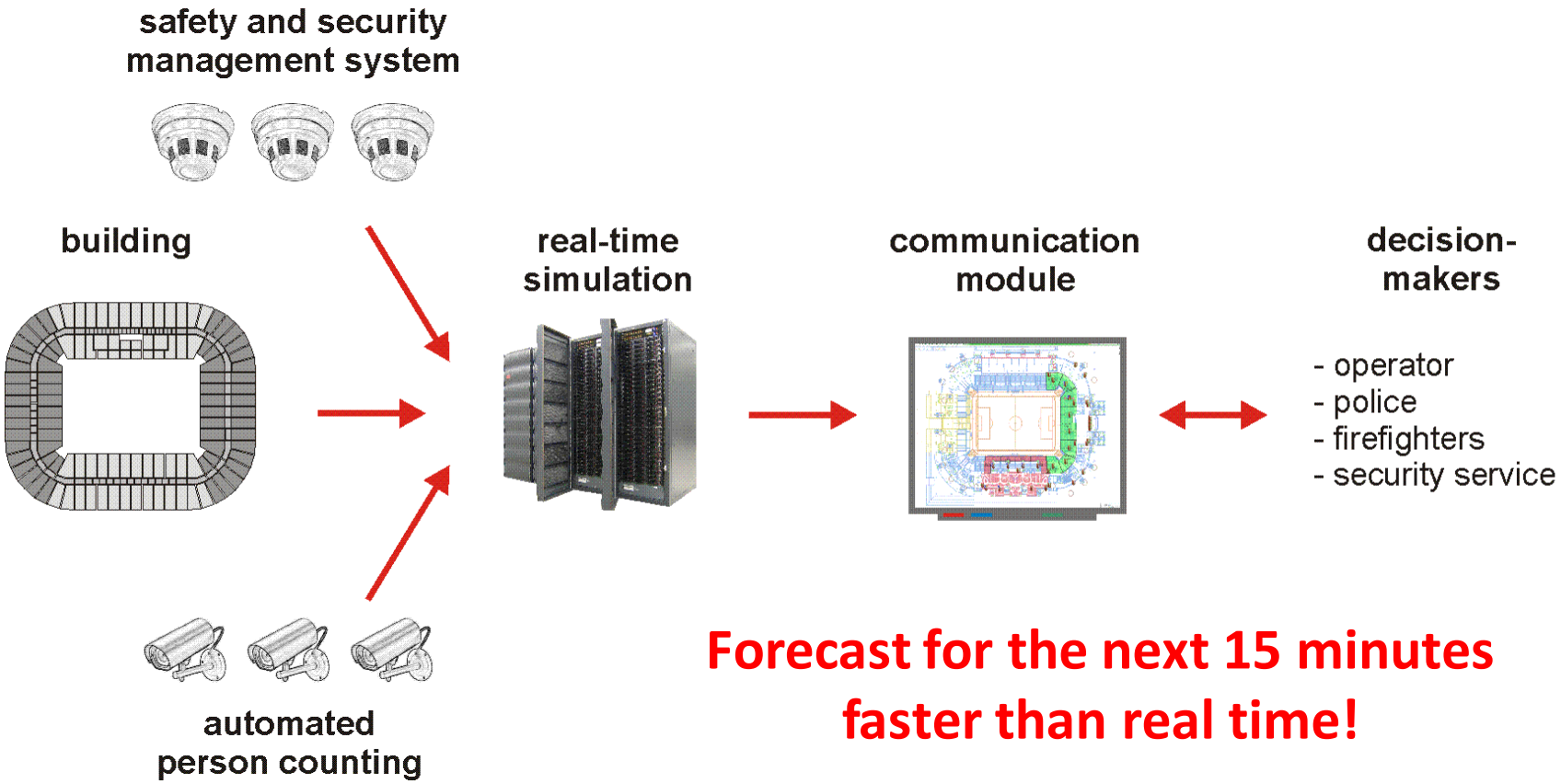
Overview

- Motivation and framework
- Design and installation
- Modelling
- Evaluation / Validation
- Outlook

Motivation and framework

- Improving safety at mass events
  - Monitoring of pedestrian streams
  - Forecast of congestions
- Collection of empirical data
- Information management in crisis
  - Integration of different data sources
  - Dissemination of information

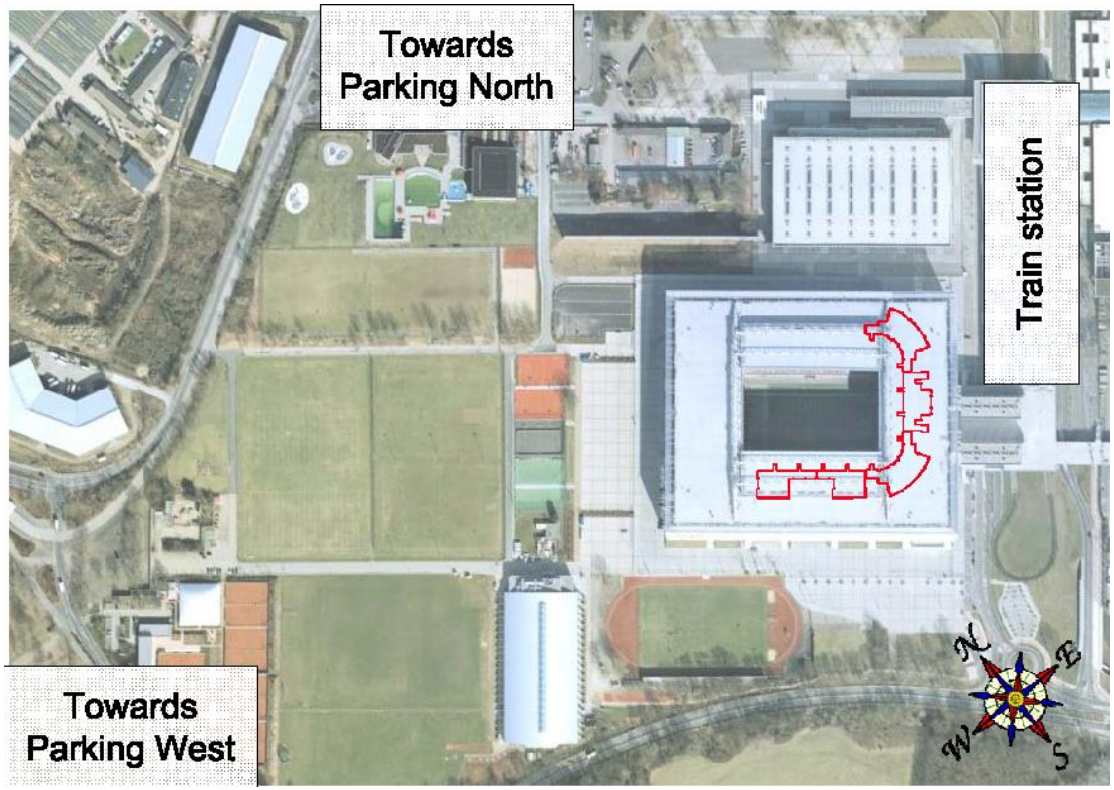
Concept of the evacuation assistant



Forecast for the next 15 minutes faster than real time!

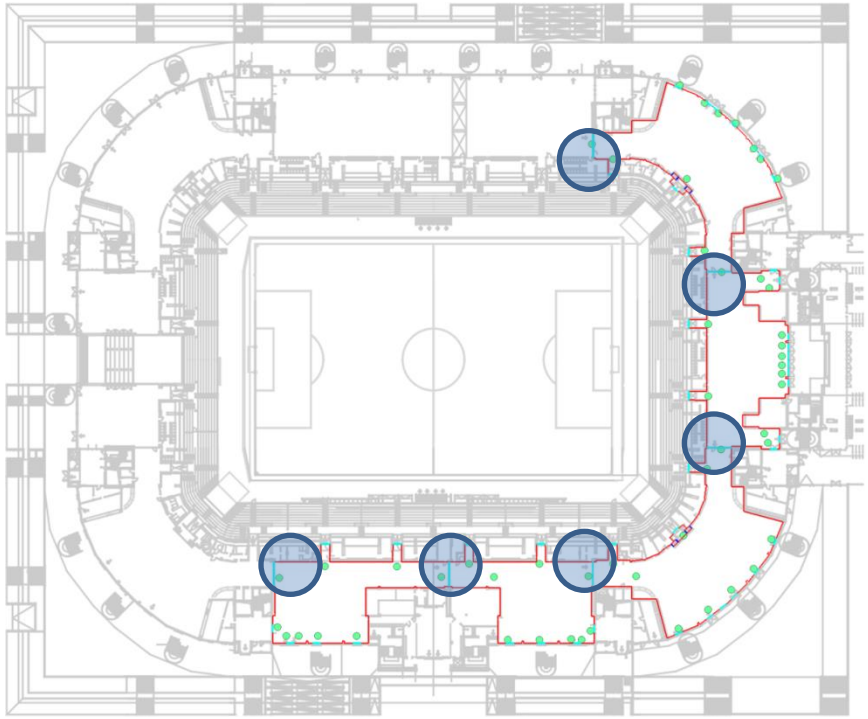
Location

Multifunction arena in Düsseldorf, Germany with a total capacity of ~60000 seats

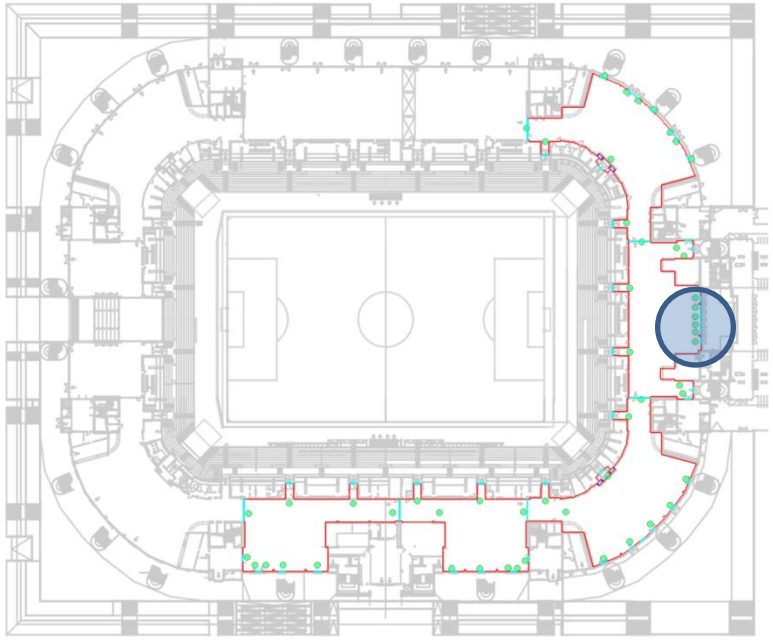


Automatic person counting system

- Mono/Stereo cameras installed by Vitracom AG
- Observation area divided in 15 sections
- Each camera monitors a counting line (exit)
- The passing direction is taken in to account
  - Backward/forward
- Number of person passing each counting line in a specified direction in one minute granularity
- Pedestrians' trajectories not considered

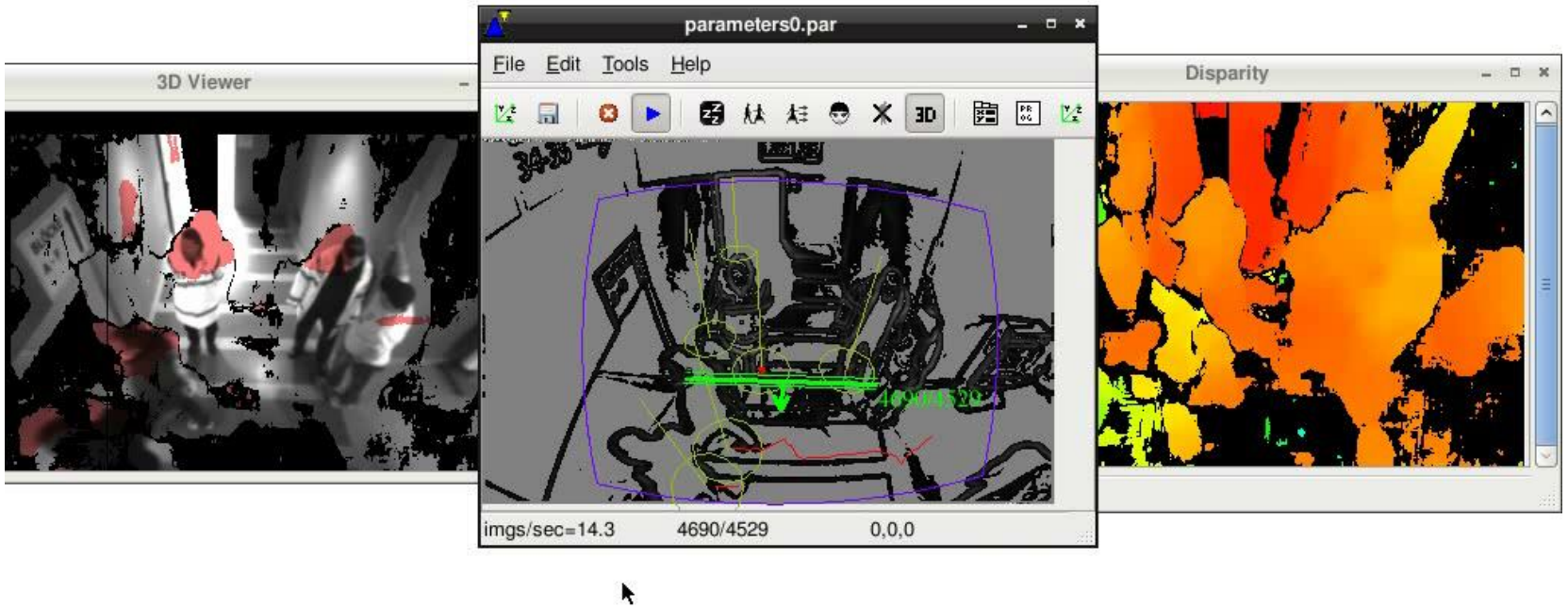


Automatic person counting system



*Courtesy Vitracom AG

Data processing

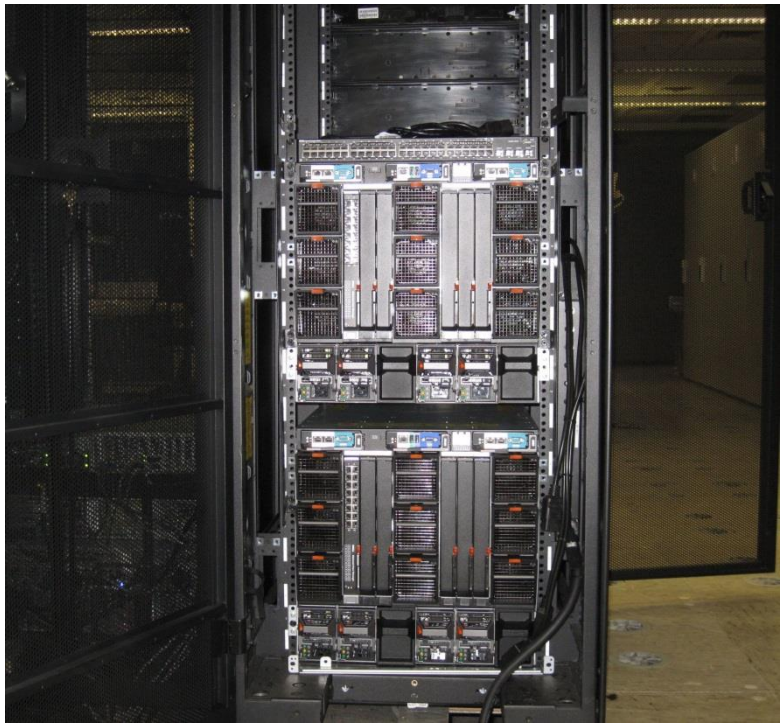


Only the number of pedestrians passing the counting line is given out

*Courtesy Vitracom AG

Simulation cluster

- Cluster for real time simulation and processing of the data
- 312 cores



Communication module

Modelling

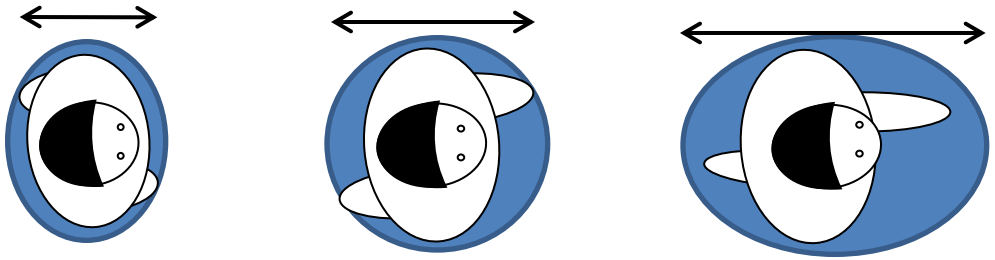
Generalized Centrifugal Force Model

- Equation of motion

$$m_i \ddot{\vec{R}}_i = \vec{F}_i = \overrightarrow{F_i^{\mathrm{drv}}} + \sum_{j \in \mathcal{N}_i} \overrightarrow{F_{ij}^{\mathrm{rep}}} + \sum_{w \in \mathcal{W}_i} \overrightarrow{F_{iw}^{\mathrm{rep}}}$$

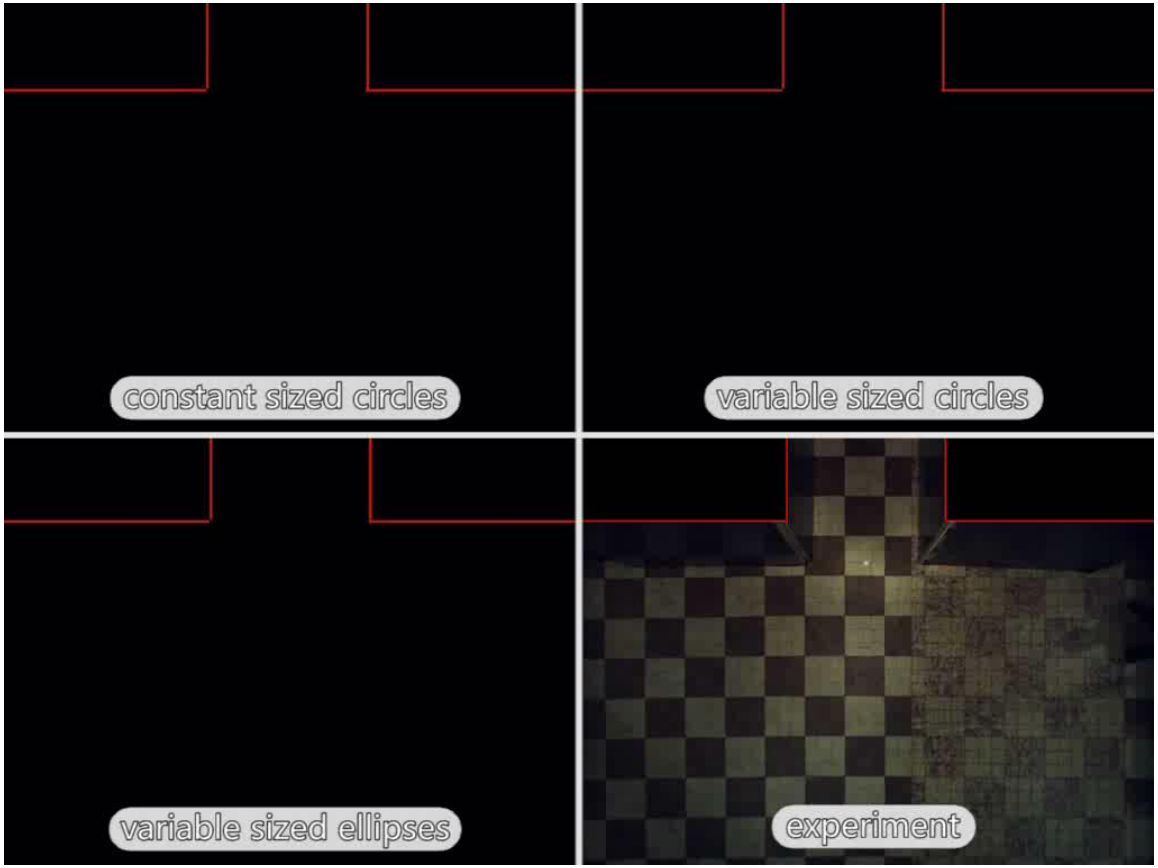
- Velocity dependent space requirement

$$d(v) = a + b \cdot v$$

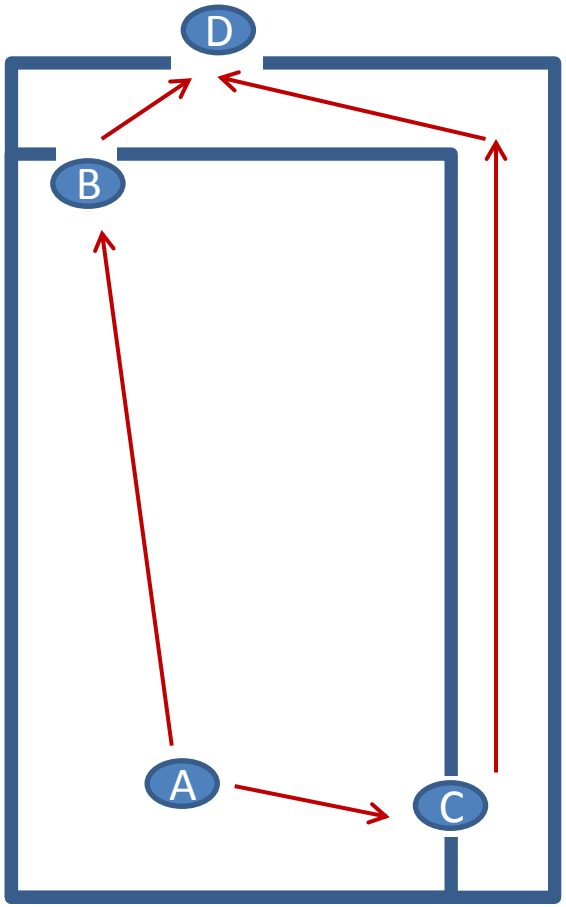


”Generalized centrifugal force model for pedestrian dynamics”, Chraibi et al, Physical Review E 82, 046111 (2010)

Simulation with specific target (the exit)



Route choice



Quickest path based on visibility

- Travel time

$$t(\vec{x}_i,\vec{n}_j)=\begin{cases}\dfrac{\|\vec{x}_i-\vec{x}_j\|}{\|\vec{v}_i\|}+\dfrac{\|\vec{x}_j-\vec{n}_j\|}{\|\vec{v}_{ja}\|}, & \text{if a reference } \vec{x}_j \text{ was found}\\ \dfrac{\|\vec{x}_i-\vec{n}_j\|}{\|\vec{v}_i\|}, & \text{if } \vec{n}_j \text{ is free}\end{cases}$$

$\vec{v}_{ja}$ is the average velocity of the reference over the observation time

The change is taken if the *cba* is greater than a given threshold

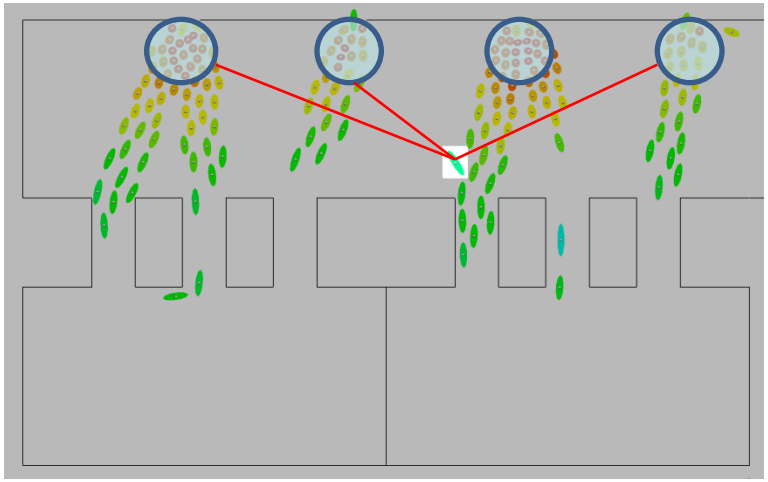
- Gain

$$g(\vec{x}_i,\vec{n}_j)=\frac{1}{t(\vec{x}_i,\vec{n}_j)}$$

g_1 is the actual choice

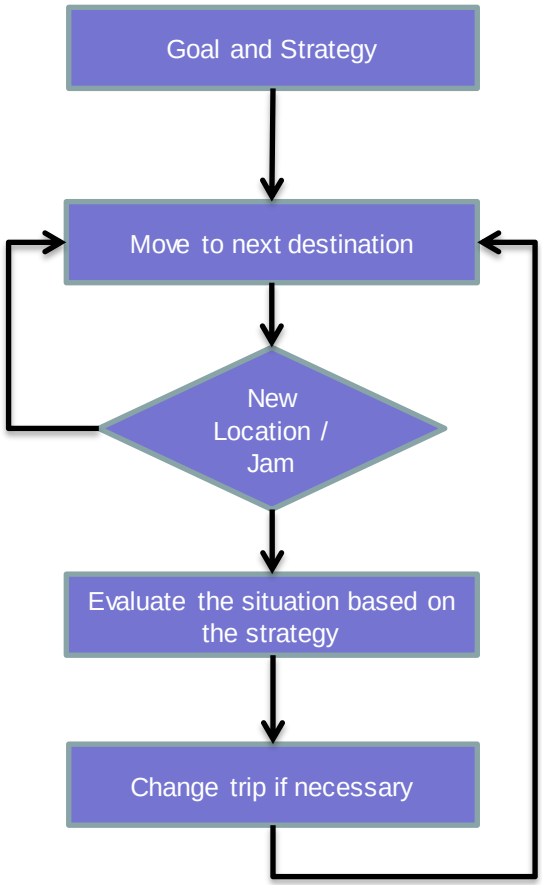
- Cost benefit analysis

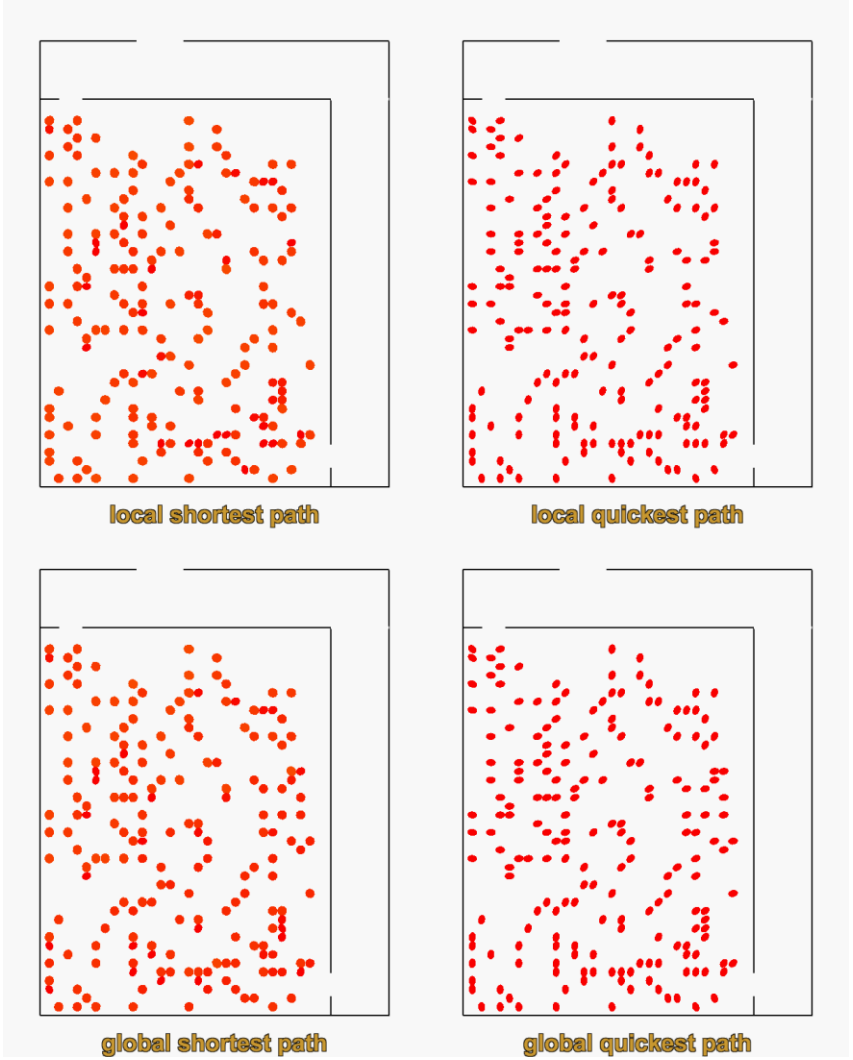
$$cba(g_1,g_2)=\frac{g_1-g_2}{g_1+g_2}$$



Kemloh et al. "Modelling dynamic route choice of pedestrians to assess the criticality of building evacuation ", 2012, ACS.

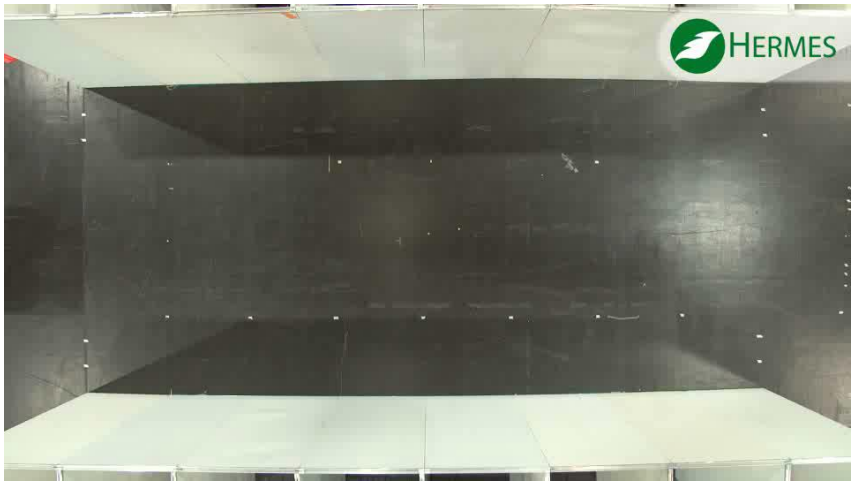
Business logic



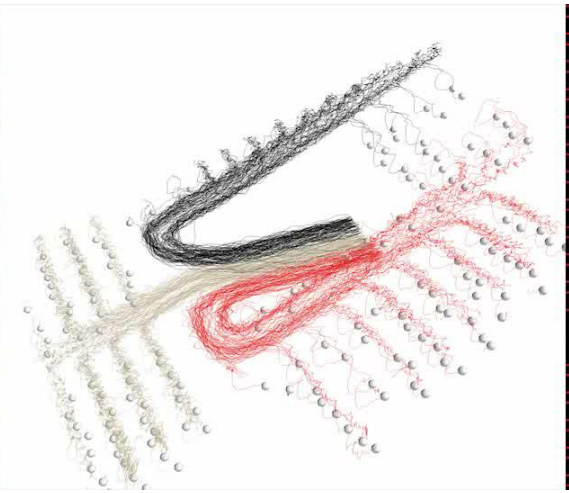


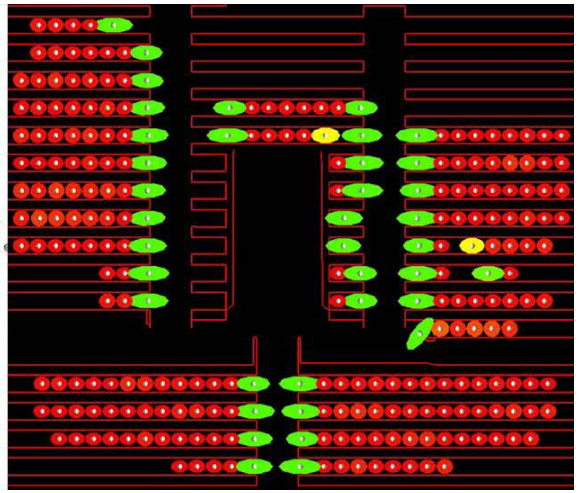
Validation

Experiments

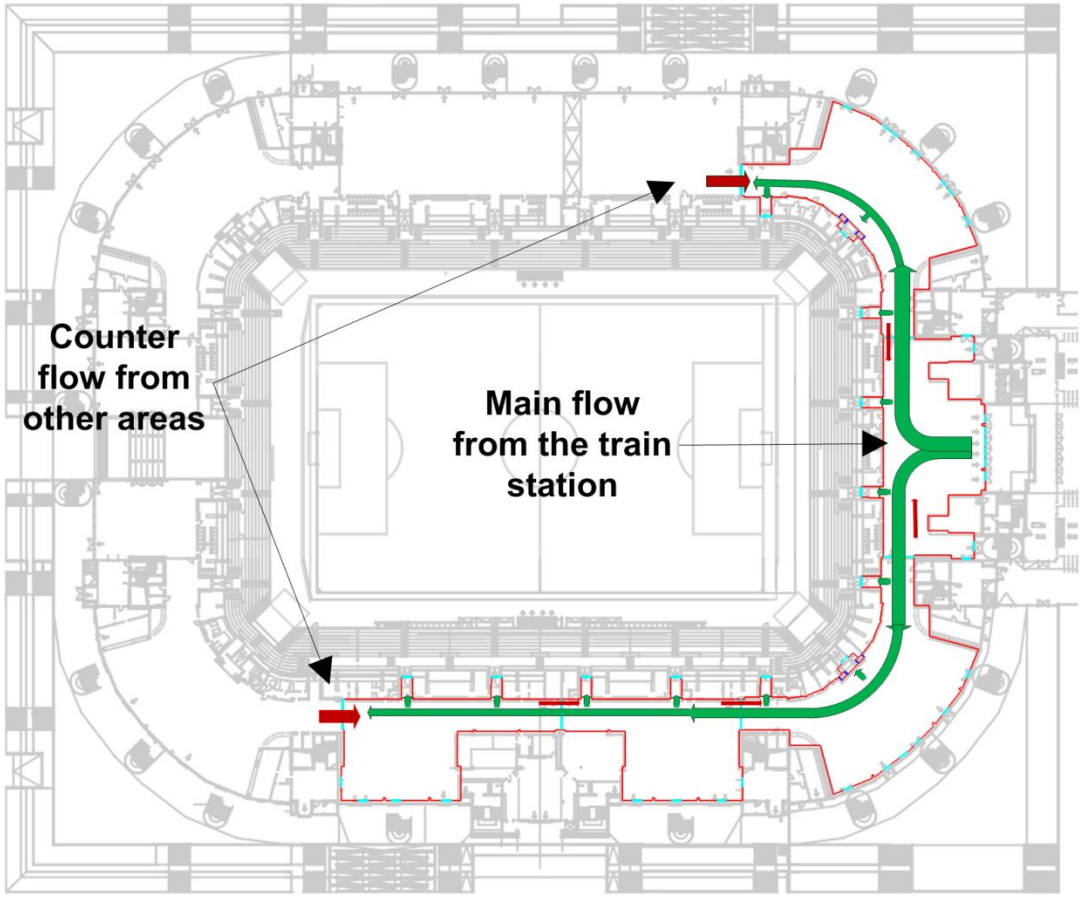


Analysis and simulation

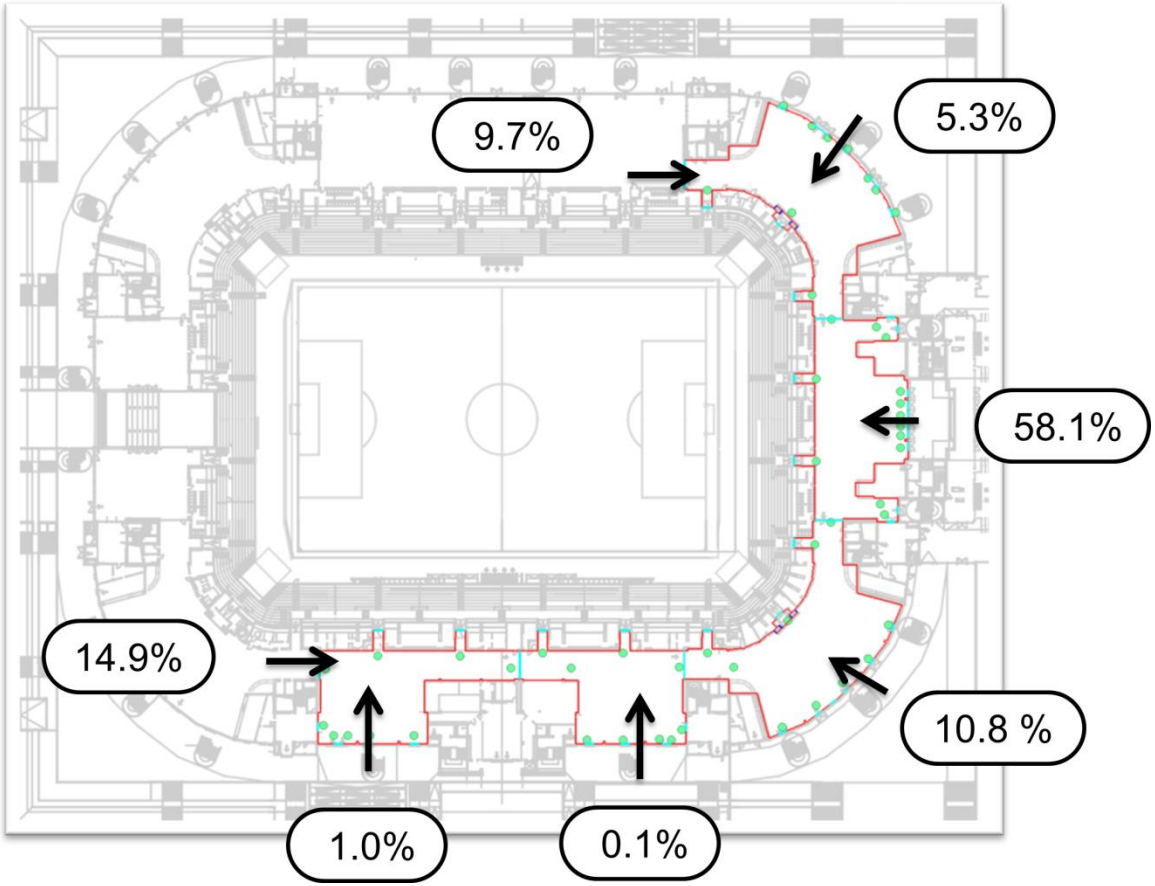




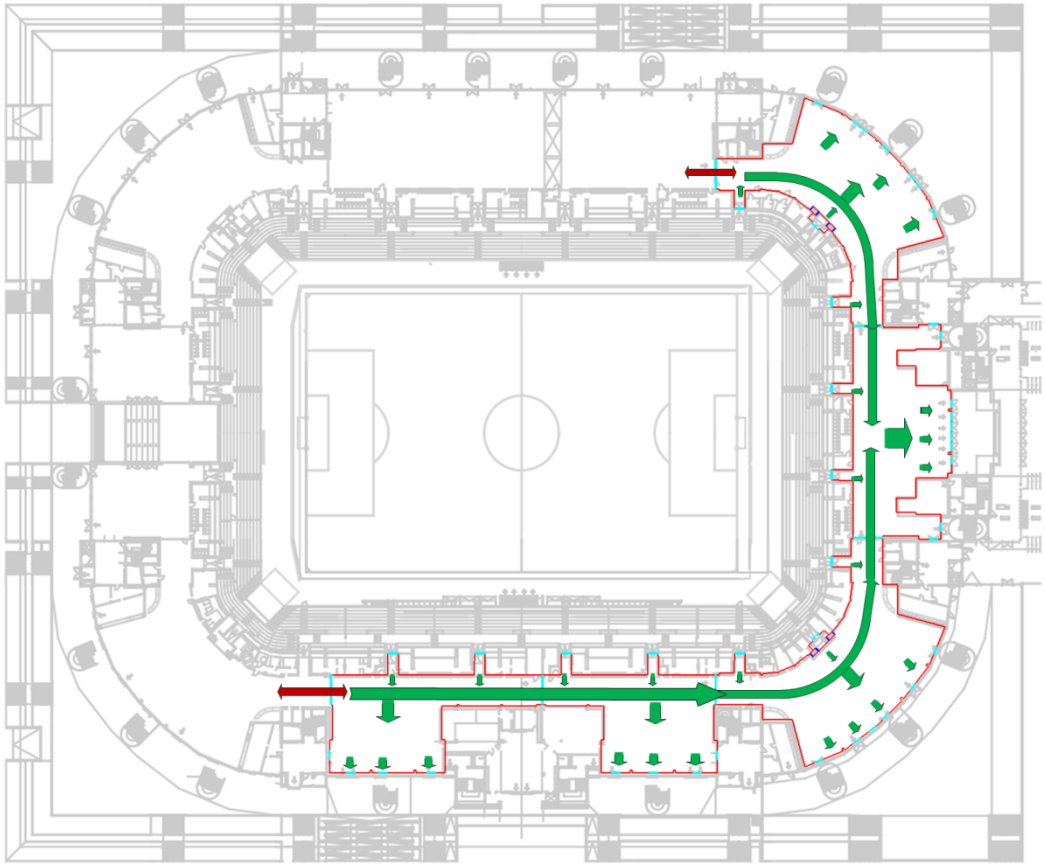
Route choice: beginning of the event



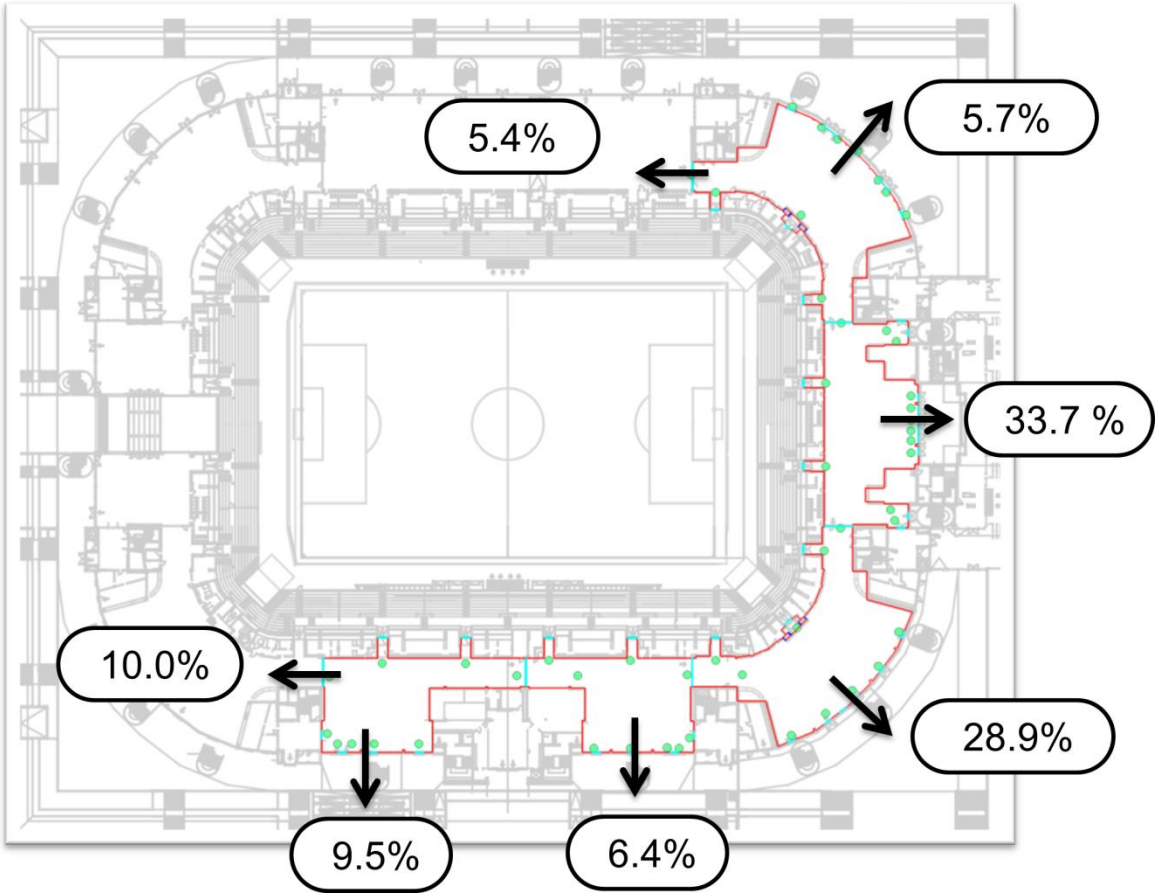
Route choice: beginning of the event



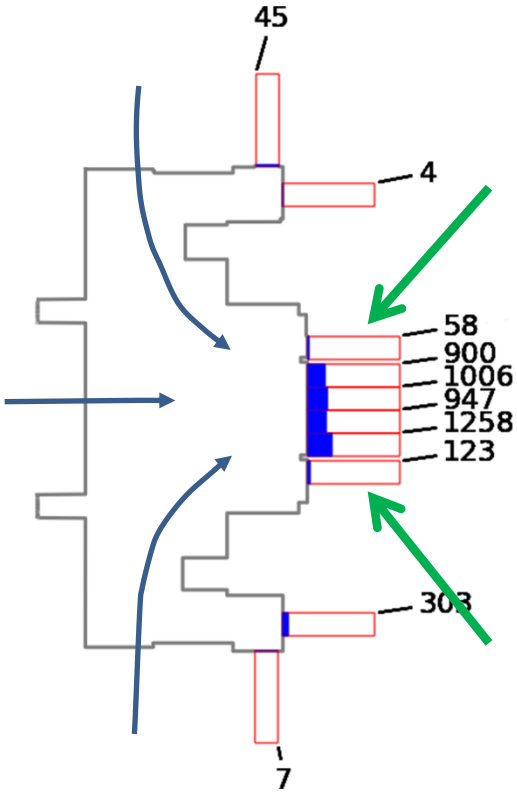
Route choice: end of the event



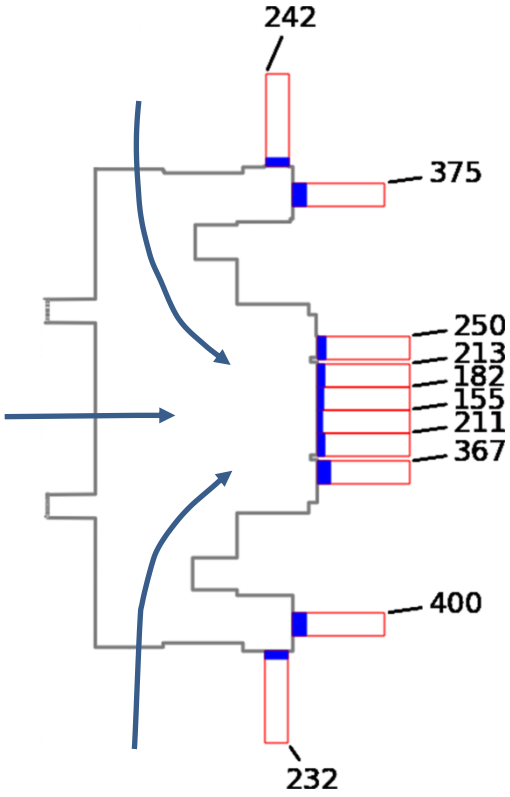
Route choice: end of the event



Individual exit selection

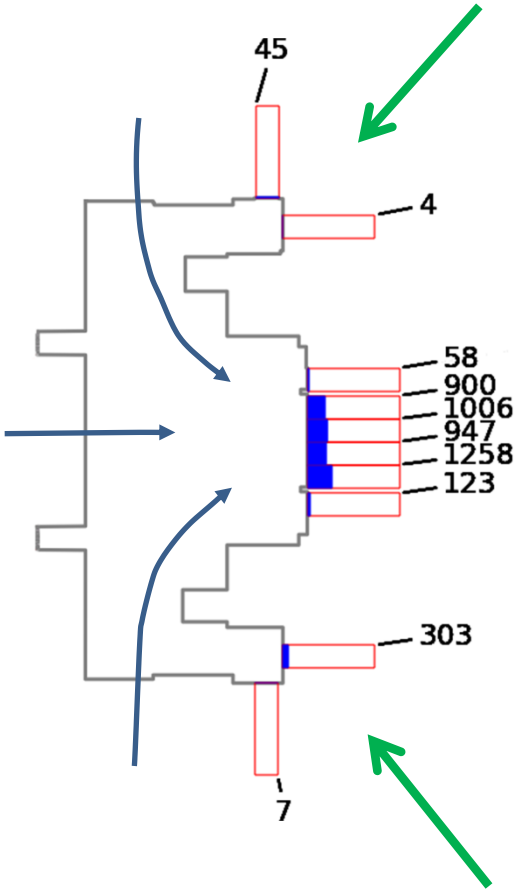


Observation

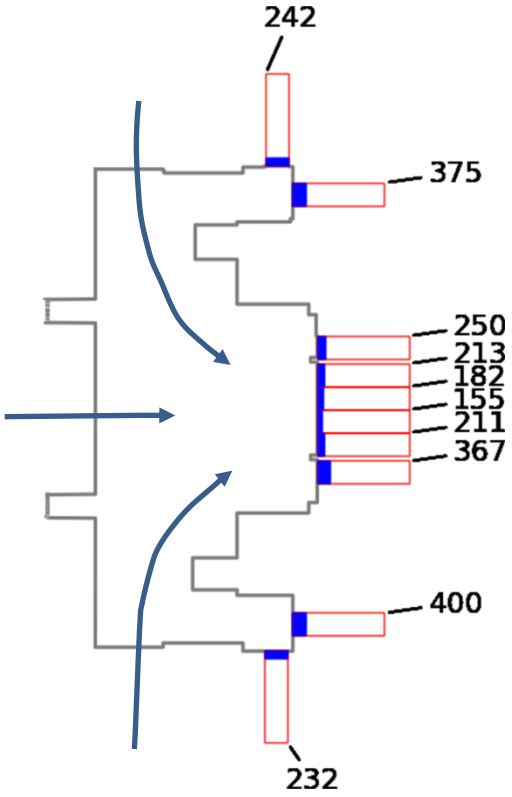


Simulation (evacuation)

Not perceived doors ?

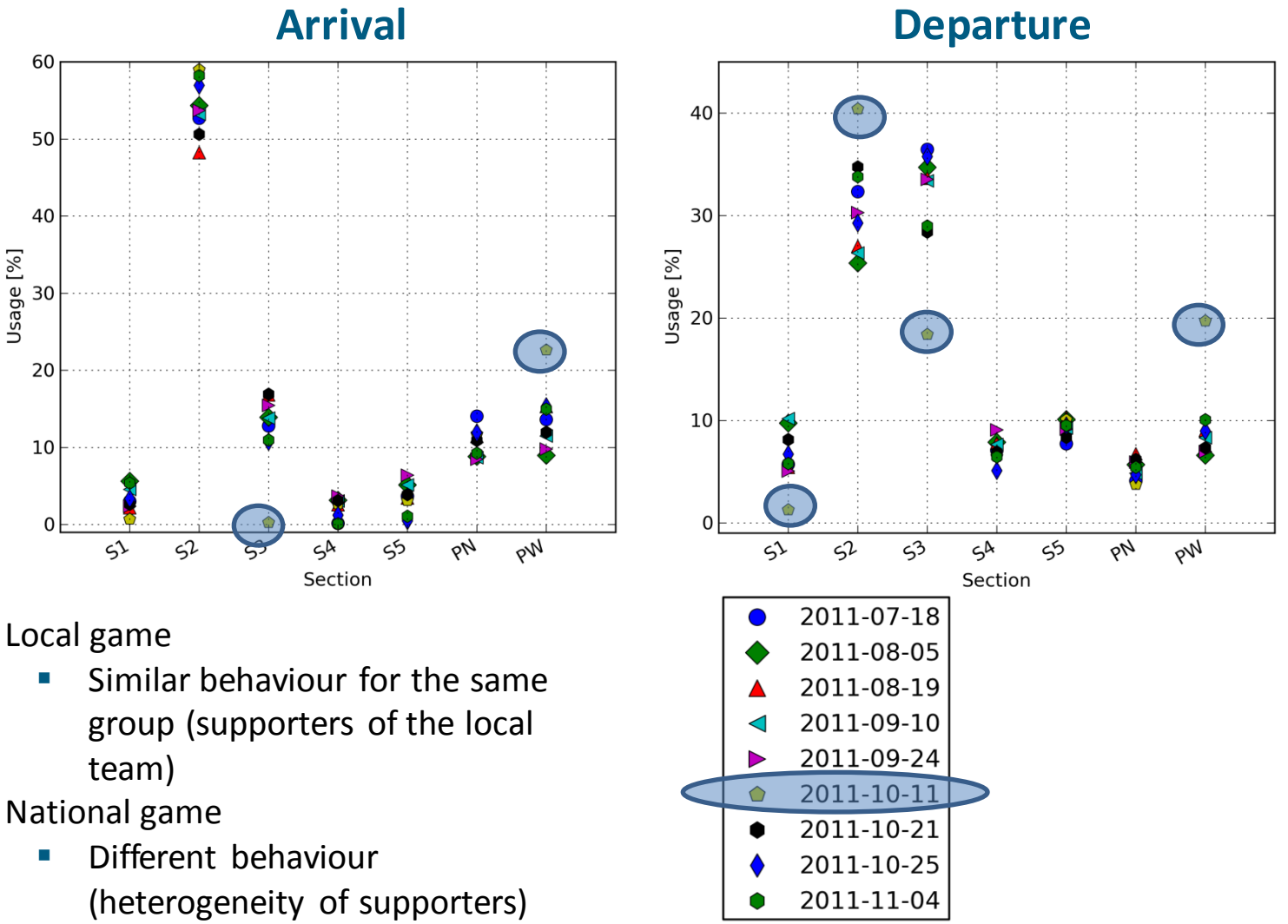


Observation



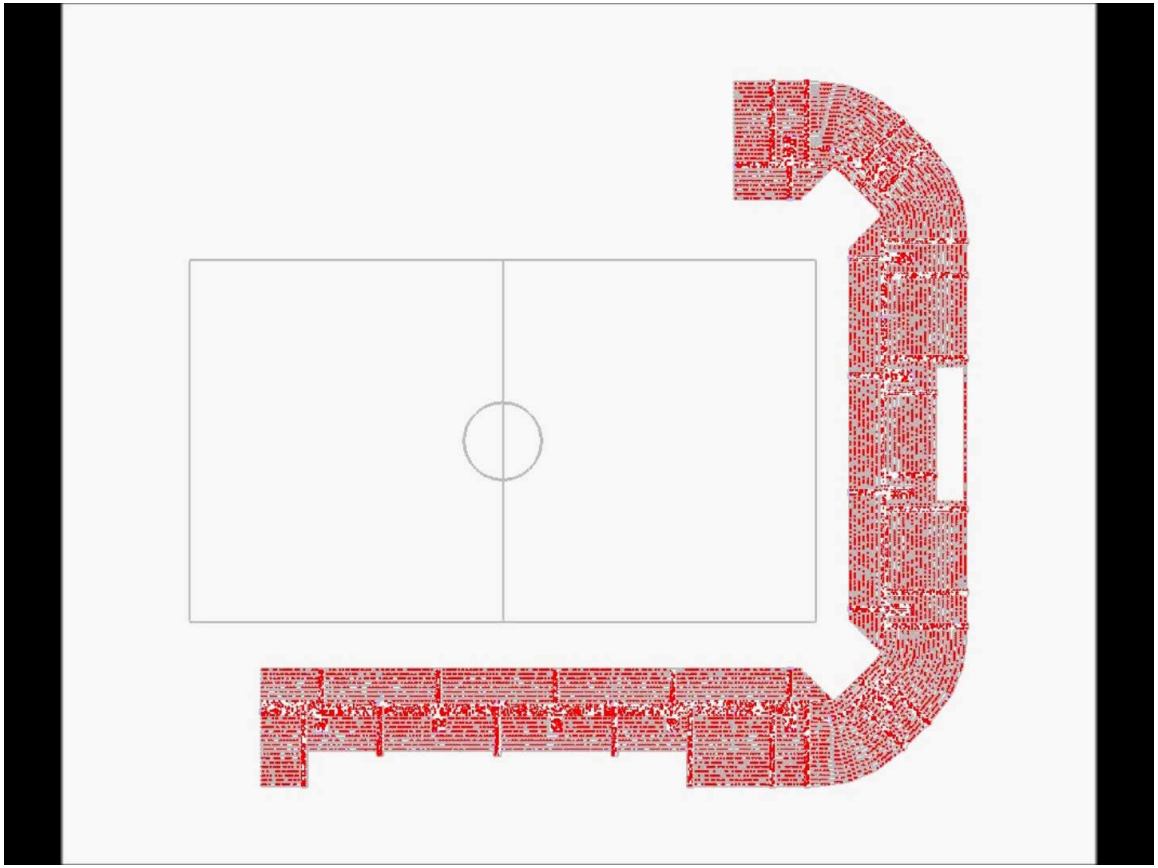
Simulation (evacuation)

Comparison across different games



- Local game
  - Similar behaviour for the same group (supporters of the local team)
- National game
  - Different behaviour (heterogeneity of supporters)

Simulation



Summary and outlook

- Evacuation assistant for large events with emphasis on validation
- Designed for evacuation and tested on routine clearing where the behavior, especially the route choice pattern is different
- The interpretation of the results is always specific to the context (evacuation type, game type, audience, …)
- Extension of the existing models, for instance with perception