Traffic Modelling of Large Events - A Summary of Selected German Examples

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Large events impose additional loads on the transport system. Regular and surplus event based traffic is modelled in order to improve traffic operations during arrival and departure of the visitors. This paper presents three modelling approaches applied in Germany over recent years. in Hanover. First micro simulation is applied to evaluate access to parking facilities to the Allianz-Arena in Munich. Second a mesoscopic model has been used at the EXPO2000 in Hanover to forecast travel times and third a macroscopic traffic model supplemented by a new propagation algorithm is being used in Berlin for multiple purposes including traffic flow estimation during the FIFA championship. All examples contain simultaneous modelling of various traffic control measures. *Copyright © 2006 IFAC*

Traffic control, Transportation, Simulators, Information technology

1. INTRODUCTION

Like other countries Germany was proud in hosting a number of large events over the past years. Not all but some of these venues required extensive investment in the transportation infrastructure which required comprehensive planning either in the design or the operation of additional road infrastructure. This paper will present three typical examples each with a different focus. All planning activities were accompinied by using a dedicated transport model to decide on different options of implementation. The three examples are ordered by complexity of the model rather than chronological.

1.1 Allianz-Arena Munich

In the past large soccer meetings in Munich were held in the general atheletic Olympic stadium of 1972. The UEFA-team Bayern München and the upcoming FIFA championship in Germany required a dedicated soccer stadium, which was build from October 2002 until April 2005 in the north of Munich. Different options were available to build the access to the parking area. Microsimulation has been used to test, analyse and evaluate these options.

1.2 Hanover EXPO 2000 fair ground

From June 2000 the 20th World exposition was held in Hanover with the theme Humankind – Nature – Technology. Up to 400.000 visitors were expected per day. Like other large events this fair was taken as a chance to improve some of the obsolete road infrastructure. In total 282 Mio€ were spent to widen national motorways in the area of Hanover plus 61 Mio€ to expand urban intersections. ITS measures like dynamic speed control, bad weather warning and an automatic tidal flow system were implemented valuing 69 Mio€. As part of the ITS measures a new traffic control centre was designed with travel time forecasts to and from the fair ground to major locations outside of Hanover. A mesoscopic traffic flow model has been applied to model travel times on motorways and major highways.

1.3 Berlin – the traffic management centre VMZ and FIFA-games

The Olympic stadium in Berlin had a seating capacity of 66.000 visitors during the FIFA games (BMVBS, 2006). There was no direct access by private cars. A free park&ride facility for 7.500 cars with shuttle service was provided couple kilometres away with good access to the urban motorway A100 and A115. Additional free park&ride locations provided space for another 5.500 vehicles. In 2003 the traffic management centre VMZ Berlin was introduced providing Advanced Traveller Information Services including dynamic route guidance for the whole metropolitan area of Berlin and its surrounding. The system is continuously updated with new services and improved algorithms to generate realistic traffic dependent travel times for trips by car. The system is coupled with the journey planner for public transport including information on trip options for intermodal trips with utilization of park&ride facilities. Current developments link dynamic travel time estimation with the urban traffic control centre in a feedback loop. The major difficulty addressed in this project has been modelling traffic situations in a mixed (combined motorway and urban) road network in real-time with limited number of detectors.

2. SYSTEM ARCHITECTURE

All three examples have some similarity as some modules of the modelling systems are much alike. In all cases origin-destination data were needed. Traditional transport planning applications maintained by each of the regional planning organizations provided 24h resp. 3h OD-data separated by car and truck traffic. For traffic management the temporal resolution of OD-data has to be at least on an hourly scale classified by weekday and month. Since the basic input of the demand models did not allow to generate these specific data based on socio-economic input, a statistical analysis of historical sensor data was used. Cross sectional flow profiles were being used in conjunction with matrix estimation to generate hourly OD data. The method will be explained with the Berlin application since it is the most advanced and most recent application.

Event specific demand is added as additional OD´s since route options, local knowledge and as such route choice differs between the general purpose and event-based traffic. Much emphasis has to be put on modelling the given network topology. Today´s digital navigation maps are of great help but have to be supplemented by characteristics needed for traffic modelling like detailed lane configurations at junctions, speed restrictions, locations of traffic control devices and specifications to reflect that travel time depends on the degree of saturation. Traffic at large events is monitored, guided and regulated by a number of control devices like variable message signs for information, dynamic speed control, revised signal timing and dedicated lane allocation. These control devices impact the capacity of the road network. Therefore all applications were sensitive to temporal changes of capacities and route guidance by interfacing traffic control information and network topology during the simulation runs.

Route choice is done in all applications by multiclass assignment algorithms; thus selecting an optimal route between an OD-pair depends on the user class. Local general purpose traffic may choose different routes because of local knowledge compared to unfamiliar visitors who will follow roadsigns and/or in-car navigation. In both real-time applications route choice is also influenced in a feedback loop by real-time traffic detector data and reported incidents.

All three applications differ by the traffic model being applied due to different objectives. Since computation time and effort for calibration is not as important as detailed representation of ITS control logics, realistic lane allocation and dynamics of queues a detailed micro simulation was used in Munich while the other two required less detailed but faster and more robust models for real-time applications.

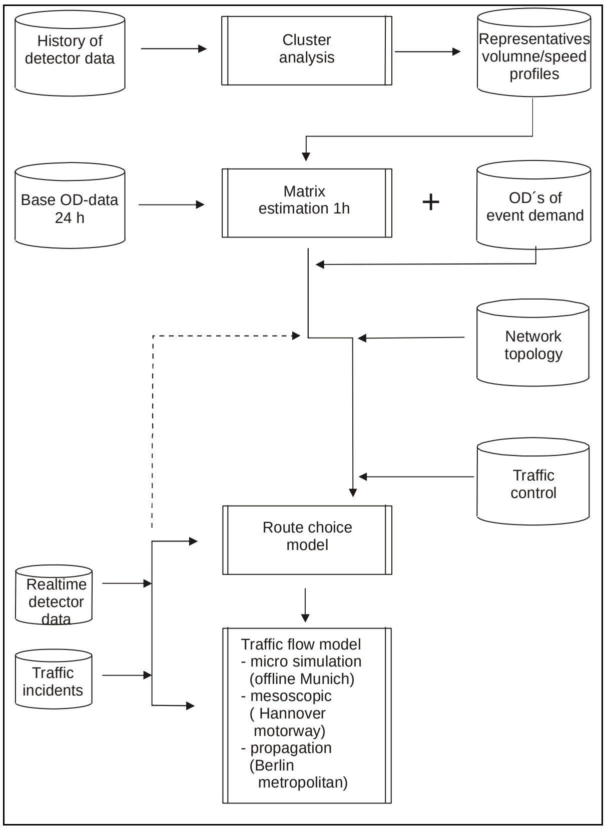

Fig. 1. System architecture of event-based modelling in Hanover, Munich and Berlin

3. MICROSCOPIC APPLICATION IN MUNICH

3.1 Description of the site

The new Allianz-Arena in the north of Munich has a seating capacity of close to 70.000 visitors which was reduced to about 60.000 seats during the FIFA tournaments. From previous experience at the Olympic stadium only about 29%-39% of the visitors arrive by public transport. Next to the stadium a parking capacity for about 11.000 cars plus 350 buses is available.

Fig. 2. Location of Allianz-Arena north of Munich

All parking facilities can only be accessed directly via the two adjacent motorways A9 and A99. In order to provide acceptable access in reasonable time frames before and after the games anew entry had to be built from motorway A99 and the existing entry Fröttmaning on the A9 had to be expanded associated with widening the motorway itself. Micro-simulation as an offline tool was being used to decide on options of construction and ITS operations like dynamic speed control, lane allocation and shoulder lane usage.

3.2 Microsimulation

A microscopic traffic simulator has been applied for this simulation. Extensive calibration and validation of car following parameters were conducted with field data from Munich following the methodology explained in Hoyer, Fellendorf (1997). Since route guidance with different compliance rates had to be modelled, dynamic assignment with different user classes was being employed. The most critical issue has been the demand side explained in the next section. Control logics had to be developed to model (a) dynamic speed control according to the German guidelines MARZ, (b) an innovative shoulder lane usage to widen A99 from 3 to 4 lane during peak periods along with truck passing prohibition and (c) actuated signal control at some adjacent junctions close to the entries without ramp metering.

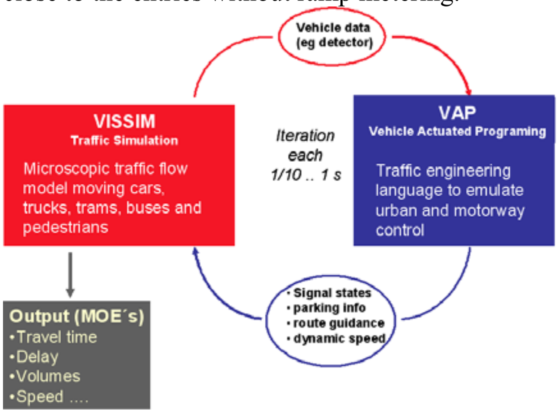

Fig. 3. Continous task communication between traffic flow simulator and traffic control

3.3 Travel demand

Like in many other studies the regional demand model only provided only 24 hour OD matrices for truck and car. For this study only the motorway network, the neighbouring entry areas and some major urban roads south of the stadium were important to be modelled. Therefore the macroscopic network model and the OD-matrices were partitioned to keep the motorway network with 36 entries and three motorway interchanges. Only travel demand for the reduced network has been considered. Since detector data of 67 cross sections was available in 5 min counts for a period of 3 months, the reduced OD-matrices should match this data. Matrix estimation has been employed as the best option to match base motorway travel demand without the impact of a sporting event. The matrix estimation is an enhancement of Van Zuylen, Willumsen (1980) being reported by Friedrich etal. (2000). Detector data contains some uncertainty which should also be reflected within the estimated OD-matrices. Although counts change from day to day, assignment of one estimated OD matrix will result in one specific link value. Therefore some slackness has been added to the standard maximization of entropy. Let t_k be the travel demand on one non-zero od-pair in the base matrix and $\hat{t}_k$ be the travel demand for the k-th od-pair in the estimated OD-matrix with vector $\mathbf{t}$ containing all non-zero od-pairs. Then the objective function q($\mathbf{t}$) has to be maximized with

$$q(\mathbf{t}) = -\sum_{k=1}^{p} t_k \cdot \ln \frac{t_k}{\hat{t}_k} - t_k + \mathbf{q}(\bar{\mathbf{s}}) + \mathbf{q}(\underline{\mathbf{s}})$$

subject to $\mathbf{A} \cdot \mathbf{t} + \bar{\mathbf{s}} = \bar{\mathbf{v}}$ and $\mathbf{A} \cdot \mathbf{t} + \underline{\mathbf{s}} = \underline{\mathbf{v}}$ with $\mathbf{A}$ being the share matrix and $\mathbf{v}$ denoting a vector of m traffic counts $\mathbf{v} = (v_1, v_2, \ldots, v_m)$. $\bar{\mathbf{v}}, \underline{\mathbf{v}}$ denote the maximum resp. minimum of the Fuzzy Set traffic count vector. $\bar{\mathbf{s}}, \underline{\mathbf{s}}$ are slack variables and

$$q(\bar{\mathbf{s}}) = -\sum_{l=1}^{m} \bar{s}_l \cdot \ln \frac{\bar{s}_l}{\hat{\bar{s}}_l} - \bar{s}_l ; \; q(\underline{\mathbf{s}}) = -\sum_{l=1}^{m} \underline{s}_l \cdot \ln \frac{\underline{s}_l}{\hat{\underline{s}}_l} - \underline{s}_l$$

Details on solving this problem with the Lagrange multiplier method are stated in Friedrich etal (2000).

This method of matrix estimation has been used not only in the Munich application but in Berlin as well with promising results in all cases in which the relative od-ratios of the base matrix resemble well with the estimated matrix. Certainly a full demand model with structural sound data would be preferable but not being available in many cases.

4. MESOSCOPIC MODEL IN HANOVER

4.1 Description of the site

With 500.000 m² of indoor space and additional open grounds the exhibition area of Hanover is the largest worldwide hosting renowned annual exhibitions like the CEBIT (IT technology) and Hannover Messe (Industrial Automation). This site was chosen for the EXPO2000. About 18 Mio people visited the exhibition which was opened between June and October 2000. At peak days about 400.000 visitors were counted. Although the 18 ha area was directly accessible by intercity trains as well as local tramlines, up to 45.000 parking places are available around the exhibition some of them accessible via shuttle buses.

The parking area was split in four coloured areas and guided along with prepaid ticketing depending on the direction cars were approaching to minimize parking search traffic. Car traffic approaching from the main motorways A2 and A7 was guided via the motorway A37 or the divided highways B3, B6 and B65. The parking facilities can be reached via the exhibition circle. 32 variable message signs as additive route guidance system and 80 km of variable message signs for dynamic speed control and bad weather warning were implemented on the surrounding motorways. A unique tidal flow system allowing contra flow traffic on 12km of the motorway A37 was installed to generate a one-way system during peaks of arrival and departure. A park-guidance system with number of left spaces supplemented with dynamic park&ride signs was installed. Following the EXPO´s objective of sustainability these ITS measures are continuously of great value during the weeks of the large exhibitions to allow access to the exhibition area without too much interruption of the local traffic within Hanover.

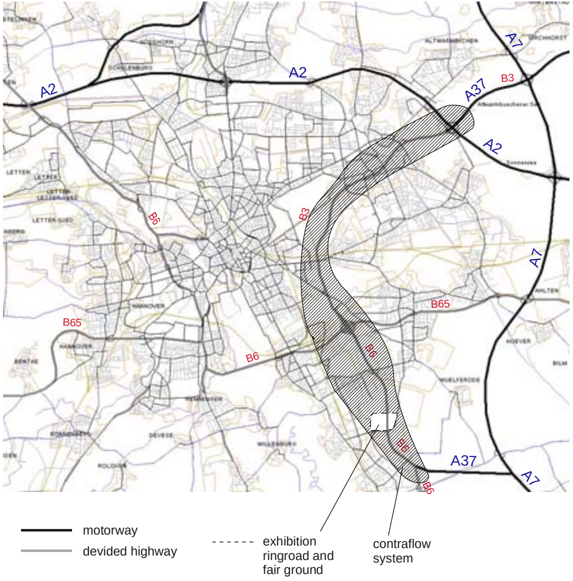

Fig. 4. Hanover network with exhibition area southeast; road network in black being modelled

4.2 *Objectives and requirements of the model*

In order to design, test and analyse the control measures of the ITS measures route guidance, dynamic speed control, contra flow system and parking guidance a traffic model was implemented in the control centre of the operating agency MOVE (Fellendorf etal, 2001). The model has also been used to predict travel times between specific locations on the motorway travelling to and from the exhibition. Travel times were indicated as base travel without traffic and the surplus due to traffic. The destinations chosen were all around 20 to 60 minutes away from the exhibition area and the surplus was given in extra minutes. The model predicting travel times was more precise providing link travel times.

A number of requirements had to be met in order to model the network as detailed as possible but not more than needed

- Reduce the regional planning network from about 550 zones to 200 zones and from 12.000 links to 4.000 links to stay within computational limitations by eliminating a majority of urban arterials
- Reduce all OD-demand which is not travelling on any of the remaining links and adjust all zonal connectors
- Estimate event based travel demand separate of the remaining general transport demand and do not add OD-data since route choice will be different (Schütte, 2000)
- Introduce global zones for the external event based traffic on a scale of very few cordon zones
- Keep scenarios of all network changes (temporal or permanent) in one network topology to minimize chances of redundancy. Attributes of non-active network elements are set to 0.
- Introduce and adjust values of temporal link attributes which may change during simulation like the contra flow system

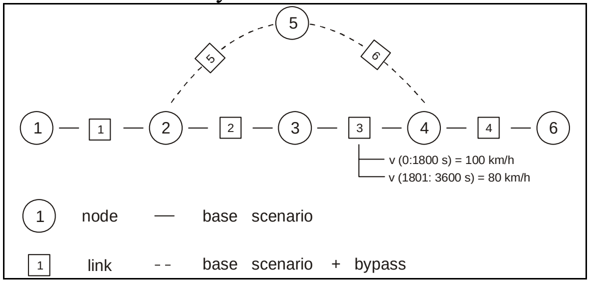

Fig. 5. Two scenarios in one network by (de)activating link attributes plus temporal changes of link attributes (eg. Free flow speed)

4.3 *Path-Flow-Estimator (PFE)*

In several different approaches of traffic state estimation using limited link detector information traffic assignments are adjusted to match local counts. In the Hanover application the static Path Flow Estimator PFE (Bell, Grosso, 1998) has been applied with results that have to be discussed. The PFE adjusts travel demand by (a) increasing/decreasing certain od-pairs, (b) adjustment of link volumes by changing impedances of the volume/delay curve and (c) adjustment of route choice with fixed demand and supply. The assignment is based on static deterministic user equilibrium. Static assignment implies that all trips start and end instantaneously since a time scale is lacking. Therefore the time horizon of assignment should at least be as long as the longest trip between any od-pair. As a simplification in Hanover 1 hour time slices were taken although maximum travel times within the modelled network went up to 2 hours. The PFE has been used to adjust the OD matrices and to provide an initial set of route choices but travel time for forecasting purposes were based on a mesocopic traffic flow model.

4.4 *The DYNEMO traffic flow model*

DYNEMO is a simulation tool designed in the 80´s for route guidance systems on motorways (Schwerdtfeger, 1984). It is able to deal with networks with about 250,000 vehicles moving simultaneously on current PC technology. Regarding movement of vehicles, DYNEMO is a mesoscopic model in the sense that the unit of traffic flow is the individual vehicle rather than the temporal and spatial aggregates used in static assignment models. Their movement, however, is governed by the average traffic density on the link they traverse rather than the behaviour of other driver-vehicle units in the immediate neighbourhood as in microscopic models.

Each link is subdivided into sections of typically 100-200 meters length for which constant traffic density is assumed. The traffic condition on a section S_i is characterised by traffic density ρ_i. As input to the model, depending on the type j of the section (motorway, highway, ramp ...) the relation between density and mean speed is given by a function U_j: where v_j denotes the speed distribution at free flow.

At each time step ρ_i is updated by counting vehicles on the section. Then the mean speed for each segment i and its link type j is computed according to $u_i = U_j(\rho_i)$. A vehicle which is at time t at position $x^{(t)}$ in segment S_i and drives with speed $v^{(t)}$ is moved in accordance with the speeds u_i and u_{i+1} (the speed in the next section downstream) and with its own state:

$$v^{(t+\Delta t)} = f\left(\left(1-\frac{x^{(t)}}{\text{length}(S_i)}\right)u_i + \frac{x^{(t)}}{\text{length}(S_i)}u_{i+1}\right) \quad (1)$$

The function f chooses a speed based on the computed mean speed and on the distribution V_j. The new position of the vehicle becomes:

$$x^{(t+\Delta t)} = x^{(t)} + \frac{1}{2}\left(v^{(t)} + v^{(t+\Delta t)}\right)\Delta t \quad (2)$$

If $x^{(t+\Delta t)} > \text{length}(S_i)$, the vehicle is placed in segment S_{i+1}, the successor downstream, and the vehicle counts of S_i and S_{i+1} are adjusted. Then the traffic densities are updated and the next time step is computed.

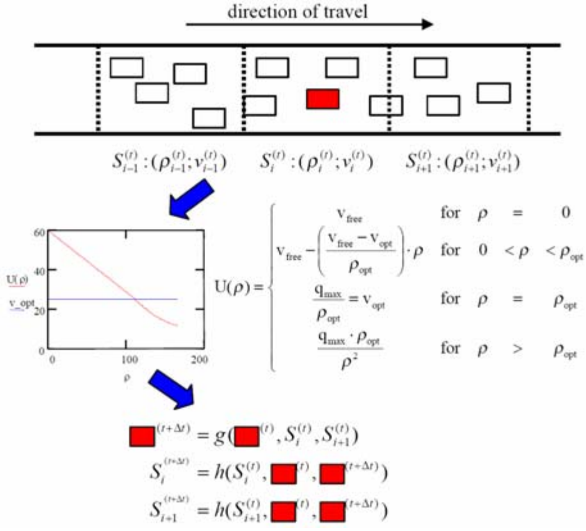

Fig. 6. Schematic representation of the DYNEMO´s mesoscopic traffic flow model

The shaded vehicle in figure 6 shows an arbitrary vehicle travelling down the link from left to right. Here ρ_{opt} and v_{opt} denote the density and mean speed at maximum capacity of the section, respectively. v_{free} is the free flow speed.

4.5 *Results*

Combining PFE and the mesoscopic model DYNEMO has shown to be successful; the PFE adjusted the OD-matrices and provided a suitable set of routes for DYNEMO to choose on. However the mesoscopic approach was not reliable to estimate delays and queues at signalized and yield junctions. The speed-density functions could not be adopted to urban traffic behaviour. This shortcoming had no effect on the Hanover application since its intention was travel forecast on the major road network. Nearly all of the junctions within this network were reconstructed to be grade separated prior to the EXPO opening. The demand matrices generated and the coded network were reusable by the regional planning authority without using the mesoscopic model itself.

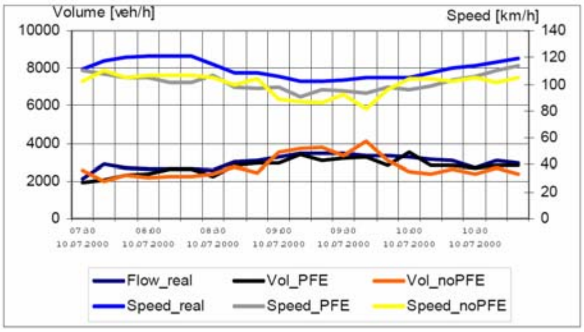

Fig. 7. Measured traffic volume and speed on 2-lane motorway; noPFE without rerouting option

5. PROPAGATION MODEL IN BERLIN

5.1 *Description of the site*

In 1999 a private consortium of DaimlerChrysler Services and Siemens AG were commissioned by the Senate of Berlin to set up and maintain a traffic management centre. Since the private operator is not entitled to run any traffic control devices, a better term would be Advanced Traffic Information Centre. In 2003 the centre started to provide free traffic information services like current roadwork's, parking status, life webcam pictures, maps displaying congestion and dynamic journey planners for private and public transport. A dynamic intermodal journey planner computes also optimal door-to-door information including split trips via park&ride facilities. Since Berlin is hosting a number of political, cultural and athletic events not only travel demand is changing due to external visitors but also the given road infrastructure due to security measures.

The dynamics in the system require a traffic model calculating present and forecasted travel times. The navigation network needed for door-to-door routing contains about 200.000 links while the network modelled for dynamic link travel times contains 5% of the overall links with about 1.000 zones.

5.2 *Representative OD´s with Cluster analysis*

The transport planning model contains three PCU OD-matrices for three time periods of a typical workday. Since the route choice model using assignment requires OD-data, which is specific for the hour to be modelled, adjustments have to be made to match time-of-day and type-of-day, a combination of weekday, month and holiday. A solid database of 250 above-ground-detectors plus additional 200 inductive loops on surrounding motorways with volume and speed per 1min intervals were available. The counts were aggregated to hourly values. However, faulty detectors have been a practical problem which was solved either dismissing faulty datasets or using substitute values in obvious cases.

The first task is to identify groups of days which contain detector profiles of good similarity. The similarity of two days d_i and d_j is computed by comparing two vectors $\mathbf{q}$ of volumes as correlation between all hourly volumes h of all detectors. Only significant time periods within a day should be chosen; e.g. 6am until 8pm. Let us compute the hourly similarity as:

$$sim(d_i,d_j,h)=corr(\mathbf{q}(d_i,h),\mathbf{q}(d_j,h))$$

Then the daily similarity is computed as its mean value:

$$sim(d_i,d_j)=\frac{1}{n}\sum_{h=1}^{n} sim(d_i,d_j,h)$$

Furthermore the largest hourly deviation between the values is computed as

$$sim\_\min(d_i,d_j)=\min\{sim(d_i,d_j,h_k)|k=1..n\}$$

Two days are only similar if their compatibility *comp* is true. The compatibility is expressed by the two criteria, that a minimum average similarity sim_0 is met and at the same time not any single hourly value exceeds a threshold of sim_min_0.

$$comp(d_i,d_j)=(sim(d_i,d_j)>sim_0)\wedge(sim\_\min(d_i,d_j)>sim\_\min_0)$$

Finding the maximum group of compatible days is like finding the maximum clique in a graph which is known to be NP-hard. Therefore a heuristic is applied with time complexity $O(n^2)$. First all compatible days for each day d_i are searched and defined to be part of set A_i . Since some days might be in multiple sets A_i suitable days have to be eliminated from A_i . This is done by looking in an ordered manner onto each d_j of A_i eliminating all days k from A_i with d_k being incompatible with d_i.

If some detector values depend on the values identified by other detectors then these detectors are elimated and not being used within the set A_n of investigated detectors. The identification of dependent detectors is exercised by comparing the shares of identical path volumes of any two detectors.

Once categories of typical daily profiles are identified, representatives of OD matrices have to be generated without considering the event based traffic. This is basically done by the classical approach of maximizing entropy supplemented by Fuzzy sets as already explained in the case of Munich.

5.3 Traffic state estimation with propagation

Like in the other two examples the current traffic conditions had to be modelled including dynamic changes in the network infrastructure (construction sites, changes in maximum speed, lane allocation) and variable demand. Micro-simulation was not considered in Berlin because of computational burgen and the DYNEMO-approach is not suited for urban environments like Berlin. Successive static assignment with time slices of a full dynamic assignment was not looked at because spill back effects and downstream metering should be considered to gain realistic link travel times.

First a static propagation algorithm and second one with queue dispersion has been developed by Vortisch [2006] to meet these requirements. The principles are explained in the following. Path flows of measured volumes branch out before and after a measured link. If the flow bundles are known then the flow ratios of turning movements at each adjacent node can be calculated. Therefore the propagation method needs either a prior assignment with saving of all path flows or a route choice algorithm like the PFE.

Forward propagation is the first step of the static propagation. The measured volume multiplied by the share for that link defined by the flow bundle will be added for each link downstream of measured detector *d*. This is done for all measured detectors *d* out of *D*. For each link I the volume of all flow bundles will be summarized. Thereafter the propagation will be done backward. Since the resulting flows calculated by forward and backward propagation will usually differ, the final link volume is a weighted average using a reliability factor $r_{\square}$ as weigthing factor. The reliability factor of a link is considering the distance $a_{\square}$ from the upstream resp. downstream detector and the number of links L located between link i and the upstream resp. downstream detector. α and β are calibration factor resp. a weighting factor for the distance.

$$r_i=\exp(\alpha(\beta\sum_{i\in L} length(i)+\sum_{i\in L} a_i))$$

$r_{\square}^{\square}$ is calculated upstream for the forward propagation and $r_{\square}^{\square}$ is used downstream for the backward propagation. Thereafter the volume $q_{\square}$ at each link is calculated by using forward and backward reliability factor as weighting factor by

$$q_i=\frac{1}{r_i^F+r_i^B}(r_i^F q_i^F+r_i^B q_i^B)$$

The following figure illustrates forward and backward propagation.

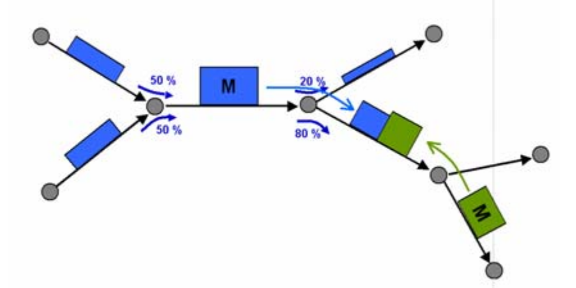

Fig. 8. Schematic representation of the static forward and backward propagation

The method so far does not memorize volumes of previous time slices nor does it model blocking back. Downstream volumes may be effected by large impedances on specific links but this does not effect any upstream links. The extended propagation algorithm considers building up and reduction of queues from one time slice to the next. When adding up link flows at one link from flow bundles passing a variety of detectors, the resulting volume is compared with the given maximum link capacity of each link. If the capacity is exceeded, then only the flow matching capacity will be marked as *q_prop_d_out* and the rest will remain queued with *q_prop_queue* = *q_prop_d_in* – *q_prop_d_out*. Since the algorithm is sensitve to the numbering sequence, an iterative method with 3-10 iterations is being applied. The *q_prop_queue* is kept as base load during the next time slice. The queued vehicles are first stacked vertically but by multiplying it with average vehicle length and comparing the value with the link length, the queues will be passed across multiple links upstream while considering the turning shares from the assignment. The original destination is kept within the queued vehicle to keep destination and for the event modelling also trip purpose.

The traffic information centre is not so much concerned about link volumes but the resulting link travel times and a quality measure such as the Level-Of-Service (LOS). The LOS is defined in Berlin as a function of degree-of-saturation (v/c) and queue rate. The queue rate compares the volume which passed the link over the queued volume. So far only three LOS-levels are being used in Berlin:

LOS = 0, if (v/c < 80%) AND (queue rate < 30%)
LOS = 2, if (v/c > 130%) AND (queue rate > 50%)
LOS = 1, otherwise

The travel time is computed using a BPR-function type with calibrated impedance factors added by the queued vehicles; thus Traveltime = BPR(volume, Capacity) + t_{queue}.(vehicles in queue)

The forecasting options in Berlin will not be explained in this paper of limited length and readers are referred to Vortisch (2006).

5.4 *Results*

The implementation was accompanied by an extensive validation test carried out by external consultants. Mobile detectors were located at various links outside of detected links counting volume and speed in aggregates of 5 min. These were aggregated up to 15 min intervals and the LOS was calculated. The measured LOS was compared with estimated and forecasted LOS. 13 testing sites far away from any detection were measured from 6:15am to 6pm (47 15 min intervals). In 33 (6.4%) of the total 611 intervals a wrong LOS was estimated which is quite acceptable considering that less than 5% of the 10.000 link network are equipped with detectors. Comparing measured and estimated volumes the general results can be confirmed but need some interpretation. The above figure illustrates volume over time. The first four sites show excellent compliance. The amplitude between adjacent time intervals of the measurements is certainly higher than .by estimation without effecting the general result. However in the fifth case the difference between morning and evening is not drastically enough and od demand has to be checked here. The last site indicates the right shape of estimated volume over time but in general at a far to high level. The link had been modelled with a capacity value which was too high. In reality the upstream capacity of the junction is much lower not providing enough throughputs for this link. Therefore the planning network has been recalibrated.

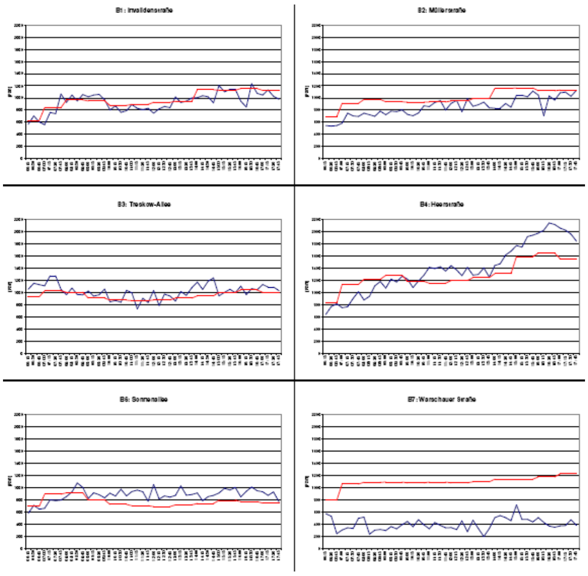

Fig. 9. Estimated volume over time at six non-detected links (blue: control measurement, red: estimates)

CONCLUSION

Models to estimate and forecast traffic at large events are available. Road networks have to be modelled in a level-of-detail which is sensitive to any changes in the road infrastructure and traffic control. Event based travel demand has to be kept separately from the general travel demand but impacts of event based demand on general demand should be considered if parts of the same group of people are affected. In many cases one single event will not justify to built up an extensive transport model. However if these events are repetitive like soccer games in Munich such planning is worthwhile. Large events are not only a reason to invest in the road infrastructure but also to built up a model which can be used as a general purpose transport model to improve the standard planning activities. Detailed models with disaggregated OD-matrices are not only suitable for strategic transport planning but also a valuable asset to test operational alternatives. This has been proven to be one of the biggest benefits of the application in Berlin.

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REFERENCES

Bell, M.G.H., Grosso, S. (1998): *The Path Flow Estimator as network observer*. Traffic Engineering & Control, London, pp. 540-549.

Bundesministerium für Verkehr, Bau und Stadtentwicklung BMVBS (2006): WMobility 2006 – Wege zur WM, Bonn (available under http://www.bmvbs.de/artikel,-949675/ WMobility-2006-Fachforum-am-15.htm

Fellendorf, M., Nökel, K., Handke, N. (2001). VISUM-online – traffic management for the EXPO 2000 based on a traffic model. In: *Proceedings of the 8th ITS World Congress,* Turin, Italy.

Friedrich, M., Mott, P.., Nökel, K. (2000): Keeping Passenger Surveys up-to-date – A Fuzzy Approach. In: CD-Proceedings of the 79th Transportation Research Board Annual Meeting, Washington.

Hoyer, R., Fellendorf, M. (1997). Parameterization of microscopic traffic flow models through image processing. In: *Proceedings of the 8th IFAC Symposium on Transport*, Crete.

Schütte, F. (2000). Dynamische Simulation des werktäglichen motorisierten Individualverkehrs – am Beispiel der EXPO 2000, Veröfffentlichungen des Instituts für Verkehrswirtschaft, Straßenwesen und Städtebau, Universität Hannover, Heft 28.

Schwerdtfeger, Th. (1984). DYNEMO: A Model for the Simulation of Traffic Flow in Motorway Networks. In: *Proceedings of the 9th International Symposium on Transportation and Traffic Theory*. Lyon, France

Van Zuylen, H., Willumsen, L.G. (1980): *The most likely rip matrix estimated from traffic counts*. Transportation esearch 14B, pp 281-293

Vortisch, P. (2006). Modellunterstützte Messwertpropagierung zur Verkehrslage-schätzung in Stadtstraßennetzen (Model based propagation of measurements for traffic state estimation), Ph.D. thesis at University of Karlsruhe, Faculty of Civil Engineering.