INLAND SHIPPING TRAFFIC PLANNING BASED ON REAL TIME MODELLING. [1]

Luk Knapen * **Bart De Munck** * **Frank Gevaerts** *

* *fks BVBA Stationstraat 108, 3570 ALKEN (Belgium)*

Abstract: Inland shipping traffic on a canal segmented by locks and crossed by drawbridges is controlled using real time traffic modelling. Ship position calculation is based on passage point notification. Operated locks and bridges have been modelled by using hierarchical parallel finite state machines. Actual traffic state is continuously monitored as a basis for traffic state forecast which is calculated as a resource allocation problem.

Keywords: Traffic Control, Traffic Modelling, Discrete Event Systems, Estimation

1. INTRODUCTION

Traffic on the Brussels-Scheldt canal consists of seagoing and inland vessels. The canal has two locks and is crossed by eight drawbridges/liftbridges. Most of the bridges serve regular road transport and can be opened on demand by the ships traffic; two of them are operated by the NMBS (belgian railway company) based on time tables.
The downstream end of the canal consists of the Wintam lock and gives access to the tidal river Scheldt. Therefor, seagoing ships can leave the canal only within specific timeslots. The responsible authority W&Z (Waterwegen en Zeekanaal) operates the VSZ software to manage traffic on their network (including the BS-canal). The VSZ traffic (forecast) model is presented in this article.

2. GOALS AND CONSTRAINTS

Short term forecast main goals are :

(1) to minimize traffic jam, to minimize the travel time and to optimize energy consumption by guiding the traffic
(2) to supply the operators with sufficient information at the right time in order to issue pilot service orders.

Constraints

(1) The communication between ship and shore (in the first project phase) is limited to voice messages over mariphone devices. Travel advice and feedback are communicated orally.
(2) The actual traffic state model thus has to be kept up to date using *passage notifications* only.

3. USE MODES

Route selection

- The requester specifies a set of points or dock identifiers defining the required route. A delay is associated with specified points and dock to keep track of suspension.
- The optimal route is calculated. The cost functions are assumed to be constants associated with fairway components (which does not induce any unrealistic additional constraints) : *cheapest* routes then are calculated by means of wave front algorithms.

Actual Traffic Model based forecast

[1] Project B1113 NV Zeekanaal, Belgium

- As soon as a skipper requests access to the fairway, a *traffic schedule* (*VaarSchema*) is defined using the specific ship or convoy characteristics, the specified route, the ETD and traffic model. The traffic schedule mentions travel distances, times and ETA values for passage points (mainly located near bridges and locks).
- The monitored area (network of canals) is subdivided in a set of *zones* corresponding to mariphone coverage areas. Each of the zones is managed by a single operator in the control room. An operator keeps in touch with the skippers in her/his allocated zone and is responsible for conveying information about travel schedule changes to the ship.
- Operators register *alerts* with specific moments in time relative to the ETA for specific locations in a travel schedule. VSZ issues notification messages to the appropriate operator when the relevant event occurs.
- Whenever a new travel schedule is entered in the system, the entire model gets recalculated to produce a new forecast. This can induce changes in forecasts for previously calculated travel schedules due to bottle neck situations at locks, bridges and fairway segments where ships cannot overtake each other nor pass traffic from the opposite direction. If the *difference* between the current and previously communicated travel schedule exceeds a predefined limit, the operator is asked to communicate the new situation to the monitored ships.

Statistics based forecast

- Long term forecasts are based on statistics because insufficient data about the actual traffic are available which makes forecast results unrealistic.
- The user selects the route and specifies values for some *statistical dimensions* (parameters for stochastics) : ship category/class, type of day time of day (ETD), load, ...
- ETA for relevant locations on the route are calculated using stochastics based on statistical data gathered while monitoring the actual traffic state.

4. MODELS

4.1 Fairway Network Model

The fairway is modelled as a general graph.

- Every edge in the graph has constant nautical characteristics (cross section) : edge lengths rougly are in the range 50 ... 1000 [m].
- The possibility for ships to fare and to pass and overtake each other, is calculated using the CEMT Ship Size classification based rules taking into account the vessel's draught.

Locks and drawbridges (liftbridges) have been modelled as *Hierarchical Parallel Finite State Machines (HP-Fsm).*

- Each one of the HP-Fsm has an *associated object* describing specific physical parameters (height, width, transition cost, ...).
- Each associated object has a specific set of *(boolean) availability indicators* that directly map to the user's application domain (ex. *Lock door unavailable due to service*). The set of availability indicators defines a set of *operating modes*. Operating modes determine the actual HP-Fsm behaviour by making some states or transitions infeasible.
- Definitions for HP-Fsm, associated object parameters and operating modes have been specified in XML documents which makes VSZ highly configurable.

Resources have been subdivided in S-Resources and T-Resources :

- *S-Resources* or State Resources : in order for ships to pass, the resource needs to be in a specific state during the entire passage period. Vessels are not allowed to pass under moving constructions.
- *T-Resources* or Transition Resources : in order for ships to pass, they need to participate in a sequence of state transitions (i.e. a lock is transiting from the lower to the upper state).

4.2 Traffic Models and Travel Schedules

VSZ keeps track of several versions of the traffic model :

- *Actual Traffic Model* : contains a travel schedule for each vessel/convoy in the system. This schedule is updated for each passage notification and thus holds the most recent information about the travel schedules.
- *Planned Traffic Model* : whenever a RIS-operator starts a planning session, the Actual Traffic Model is cloned. The RIS operator can force vessels to move in groups, allocate vessels to lock and bridge operations and fix operations to a specific moment in time. The RIS-operator thus has her/his private model to influence and simulate the traffic for the near future (typically 4 ... 8 hours).
  During the interactive planning operations, this model is not updated by external event notifications (because that would interfere with the planner's work). The RIS-operator however can, at any moment in time, expose the model to the queued external events so