Extending the HDC Conceptual Model

Submitted by
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Preamble
In the January 2011 issue of the M&S Magazine, the authors submitted a conceptual model for the main portion of the Happy Faces Daycare Center (HDC) project (as outlined in the October 2010 issue). That conceptual model was formulated using the ABCmod conceptual modeling framework. The project description included an extension and we provide below the modifications to the original submission that accommodate this extension.

The extension relates to the occurrence of an “emergency vehicles event” (EVE) that disrupts the turning activity into Oak St. The necessary modifications are briefly summarized below:

- Three additional attributes have been added to the Car entity structure; namely, TurningTimeOntoOak, StartMerge and Halted.
- Three new Constants that characterize the EVE have been added; namely, EVE_TIME, SETTLING_TIME and HALT_TIME.
- The EVE has two distinct effects on the turning activity into Oak St; namely, halting and slowing. Both these impacts are managed via environmental input variables which are called uTrafficBlocked(t) and uMod(t). The value of uTrafficBlocked(t) is appropriately adjusted in the Scheduled Activity construct called Emergency which in turn invokes the Triggered Activity construct called SlowTraffic where the value of uMod(t) is appropriately adjusted.
- The basic impact of the EVE is to interfere with (in fact, “interrupt”) the turning activity that is underway when the EVE occurs (8:00 am). Consequently we have replaced the original Activity construct (called MergeIntoOak) with by a more comprehensive Extended Activity construct (with the same name). The structure of the Extended Activity construct allows for the interruption of the activity’s duration by a prescribed precondition which is then followed by a specified Status Change Specification. Because the activity instance must be re-started at a later time, both the Precondition and the Starting Event of this Extended Activity construct are enhanced relative to the original MergeIntoOAK Activity construct. Note also that care has been taken to correctly accommodate the situation where the turning position is empty at 8:00 am but becomes occupied during the halt interval.

The updated ABCmod structures are given below. They are intended as substitutes for equivalent structures previously presented in the January issue of the M&S Magazine. However, there are two new structures; namely, the Scheduled Activity construct called Emergency and the Triggered Activity construct called SlowTraffic.
### Consumer Class: Car

Represents the Car entities that flow within the model's domain.

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Set to PARENT, RESIDENT or PASSTHRU according to the Car entity’s origin.</td>
</tr>
<tr>
<td>TimeEnterQueue</td>
<td>Records the time when a Car entity enters one of the Queue entities.</td>
</tr>
<tr>
<td>TurningTimeOntoOak</td>
<td>Provides a nominal initial value for the time duration which a Car entity will require to carry out the turn onto Oak St; when necessary, this value is adjusted to accommodate the impact of the EVE at 8:00 am</td>
</tr>
<tr>
<td>StartMerge</td>
<td>A time stamp capturing the value of time when a Car entity begins a merging activity into Oak St</td>
</tr>
<tr>
<td>Halted</td>
<td>Set to TRUE when a Car entity’s turning maneuver onto Oak St. is stopped because of the EVE at 8:00 am</td>
</tr>
</tbody>
</table>

### Constants

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUM_PAR_CAR</td>
<td>Number of Car entities that arrive at the HDC to drop of children</td>
<td>40</td>
</tr>
<tr>
<td>NUM_RES_DEPARTS</td>
<td>Number of Car entities belonging to residents that will depart</td>
<td>60</td>
</tr>
<tr>
<td>EVE_TIME</td>
<td>time of the EVE</td>
<td>8:00 am</td>
</tr>
<tr>
<td>SETTLING_TIME</td>
<td>The recovery time interval following the halt in the traffic flow onto Oak St</td>
<td>3 minutes</td>
</tr>
<tr>
<td>HALT_TIME</td>
<td>The time interval following the EVE during which no turns onto Oak St can take place</td>
<td>5 minutes</td>
</tr>
</tbody>
</table>

### Parameters

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUM_SPACES</td>
<td>Number of parking spaces for parents at the HDC</td>
<td>4 and 5</td>
</tr>
</tbody>
</table>

### Inputs

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Scheduled Action or Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>uTrafficBlocked(t)</td>
<td>Value is normally FALSE but changes to TRUE over the period of time when traffic flow into Oak St is halted due to the EVE.</td>
<td>Emergency</td>
</tr>
<tr>
<td>uMod(t)</td>
<td>Value is normally 1 but changes to 2 during the settling period following the halt in traffic flow onto Oak St.</td>
<td>SlowTraffic</td>
</tr>
</tbody>
</table>

### Input Entity Streams

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>uParArrives(t)</td>
<td>This input variable represents the arriving stream of Car entities with Type=PARENT</td>
<td>ParentArrivals</td>
</tr>
<tr>
<td>uResDeparts(t)</td>
<td>This input variable represents the stream of Car entities belonging to residents and departing from the area. (Total number of departures not to exceed NUM_RES_CAR)</td>
<td>ResidentDeparts</td>
</tr>
<tr>
<td>uEtoO_Arrivals(t)</td>
<td>This input variable represents the stream of Car entities that pass-thru from Elm St to Oak St</td>
<td>ElmToOakArrivals</td>
</tr>
<tr>
<td>uOtoE_Arrivals(t)</td>
<td>This input variable represents the stream of Car entities that pass-thru from Oak St to Elm St</td>
<td>OakToElmArrivals</td>
</tr>
</tbody>
</table>
Initialize

\[
\begin{align*}
R.TurnPosOak.Car & \leftarrow \text{NULL} \\
R.TurnPosElm.Car & \leftarrow \text{NULL} \\
uMod & \leftarrow 1 \\
uTrafficBlocked & \leftarrow \text{FALSE}
\end{align*}
\]

**Scheduled Activity Construct:** Emergency

Signals the occurrence of an EVE by setting the value of the environmental input variable \(uTrafficBlocked\) to TRUE. The settling time following the traffic halt is managed by invoking a Triggered Activity called SlowTraffic in the Terminating Status Change Specification.

- **TimeSet** \(t = tk \in \{\text{EVE\_TIME}\}\)
- **Event** \(uTrafficBlocked \leftarrow \text{TRUE}\)
- **Duration** HALT\_TIME
- **Event** \(uTrafficBlocked \leftarrow \text{FALSE}\)
- **TA.SlowTraffic**

**Extended Activity Construct:** MergeIntoOak

A Car entity is moved from the head of Q.ExitOak into the turning position and the turning maneuver into Oak St is carried out. The turning maneuver can be interrupted by the EVE.

- **Precondition**
  \[(Q.ExitOak.N > 0 \text{ AND } R.TurnPosOak.Car = \text{NULL}) \text{ OR} (uTrafficBlocked=\text{FALSE} \text{ AND } R.TurnPosOak.Car \neq \text{NULL} \text{ AND} R.TurnPosOak.Car.Halted = \text{TRUE})\]
- **Event**
  - If \((Q.ExitOak.N > 0 \text{ AND } R.TurnPosOak.Car = \text{NULL})\)
    - \(R.TurnPosOak.Car \leftarrow \text{SM.RemoveQue}(Q.ExitOak)\)
    - \(iC.Car \leftarrow R.TurnPosOak.Car\)
    - \(iC.Car.TurningTimeOntoOak \leftarrow \text{DM.TimeTurnOntoOak}()\)
  - Endif
  - \(iC.Car.StartMerge \leftarrow t\)
  - \(R.TurnPosOakCar.Halted \leftarrow \text{FALSE}\)
- **Duration** \(iC.Car.TurningTimeOntoOak \ast uMod\)
- **Interruption**
  - \(uTrafficBlocked = \text{TRUE}\)
- **Precondition**
  - \(iC.Car.TurningTimeOntoOak - \leftarrow (t - iC.Car.StartMerge)\)
  - \(R.TurnPosOak.Car.Halted \leftarrow \text{TRUE}\)
  - Terminate
- **Event**
  - \(R.TurnPosOak.Car\leftarrow \text{NULL}\)
  - IF(iC.Car.Type = PARENT)
    - \(\text{SM.Put}(\text{PHI}[\text{ExitOakWaitTimesP}[\text{Car}]], t - \text{iC.Car.TimeEnterQueue})\)
  - ELSE IF(iC.Car.Type = RESIDENT)
    - \(\text{SM.Put}(\text{PHI}[\text{ExitOakWaitTimesR}[\text{Car}]], t - \text{iC.Car.TimeEnterQueue})\)
  - ENDIF
  - \(\text{SM.Leave}(iC.Car)\)

**Triggered Activity Construct:** SlowTraffic

Adjusts the value of the environmental input variable \(uMod\) in accord with the settling time specification.

- **Event** \(uMod \leftarrow 2\)
- **Duration** SETTLING\_TIME
- **Event** \(uMod \leftarrow 1\)