# Explanations ".Q" model

## I. Network model

Hereafter a description of the files modelling the network as required by the ".Q" is presented. All files are in a text format.

1) File *"fi_demand_param_entry_link"*
   This file describes the vehicle demand related to each entry link.
   Each line of this file corresponds to an entry link and consequently the number of rows depends on the number of entry network links.
   Two columns correspond to each row. The first column presents the link id and the second column describes the parameter for the defining the time of each vehicle appearance at the corresponding entry link. If a stochastic demand will be considered, this value is the parameter of the Poisson process (mean number of vehicle appearance per time unit) associated with the entry link. If a deterministic demand is desired, the value of the second column should be the time (in secs) between two successive vehicle arrivals.
   e.g. Line $1\ 0.6$ indicates that for entry link $1$ the related Poisson parameter is $0.6$.
2) File *"fi_id_all_network_link_id_orig_dest_node_length_link_capacity_link_param_travel_duration"*
   This file describes each network link.
   The number of lines of this file depends upon the number of links. The number of columns of each row is fixed and the signification of each column is the following.
   The first column indicates the link id.
   The second and third columns correspond to the id of the origin and destination node of the link. For entry links the second column values $-1$ while for exit links the the third column values $-1$.
   The fourth column indicates the link length. This value is not directly employed by the ".Q". It is utilised for calculating the mean value of the link travel time. Any units can be utilised for expressing the link length. However, a possible conversion may required when the mean travel time of links is computed since the latter value should be expressed in seconds.
   The fifth column presents the link vehicle storage capacity (an integer number is required) and when finite link capacities are considered it takes strictly positive values for internal links. When infinite link capacities are considered it values $-1$. For entry or exit links this column values zero.
   The sixth column indicates the mean value of the link travel time (measured in seconds). It takes a strictly positive value for internal links and equals zero for entry and exit links.
   e.g. Line $10\ 9\ 10\ 1\ \ -1.00\ 60.00$ indicates:
   Link $10$ originates at node $9$, heads towards node $10$, has a length of one unit, value $-1.00$ of the fifth column indicates that infinite link capacities are considered for the network, while the mean travel time of link $10$ is $60$ seconds.
3) File *"fi_id_all_phases_max_queue_size_sat_flow_queue_type"* describes all movements of each network link.
   A movement is described by a pair $(l, m)$ where $l$ is an incoming link to a given node and $m$ is an outcoming link from the same node.
   The number of lines of this file depends upon the number of movements. The number of columns of each row is fixed.
   The first line of this file provides some explanations and will always be ignored. The explanation of the columns of any other row is the following:
   The first and second columns indicate and incoming and outcoming link of/from the given node, describing the phase id ($(l, m)$).
   The third column indicates the maximum allowed size of the queue related to this movement. Although for the current version this value is not utilised, it wll employed when shared lanes and pockets will be modelled. Consequently at present this value is always $-1$.
   The fourth column indicates the saturation flow of the related movement measured in vehicles per time unit. When a movement is not allowed (conventionally called *phase* for this model), the saturation flow values zero, otherwise it takes a strictly positive value.
   The fifth column indicates the type of movement. More precisely it values $1$ when a movement corresponds to right turn and zero otherwise.
   e.g. Line $1\ 2\ \ -1\ 0.150\ 0$ indicates that
   movement $(1, 2)$ has an infinite queue size (third column values $-1$), a saturation flow of $0.15$ vehicles per time unit and it is not a right turn (last column values zero).
4) *"fi_id_entry_exit_lk_related_path"*
   This file describes the path which should be employed when OD matrices are considered (case of a unique path). This file is not employed by the current version of the ".Q".
5) *"fi_id_internal_link_id_orig_dest_node"*
   This file refers to the internal network links. The number of lines equals to the number of internal links and the number of columns of each row is fixed.
   The first column of any row indicates the internal link

id.
The second and third columns indicate the origin and destination node of this link.
e.g. Line 2 1 2 indicates that internal link 2 is originated at node 1 and heads towards node 2.

6) *"fi_id_link_id_sublinks"*
This files refers to the sublinks of each link and it is not employed by the current network model.

7) *"fi_id_node_id_entering_links_to_node"*
This file describes the incoming links for each network node. The number of lines equals to the number of intersections. The number of columns of each row depends upon the number of incoming links to each node.
The first column of any row indicates the node id. The next columns indicate the id of incoming links to the related node.
e.g. Line 1 1 17 signifies that at node 1, links 1 and 17 are incoming.

8) *"fi_id_node_id_entry_links_to_network"*
This file indicates the entry links to each intersection.
The number of lines depends on the number of intersections with entry links. The number of columns of each row may vary. It depends on the number of entry links associated with a node.
The first column indicates the node id with entry links. The next columns indicate the id of each entry link associated with the corresponding node.
e.g. Line 1 1 17 indicates that with node 1 two entry links are associated, links 1 and 17.

9) *"fi_id_node_id_exit_links_from_network"*
This file describes the exit links associated with an intersection.
The number of lines depends on the number of nodes with exit links. The number of columns of each row depends on the number of exit links associated with the related node.
The first column indicates the node id with exit links. The next columns indicate the id of each exit link associated with the corresponding node.
e.g. Line 15 46 16 indicates that for intersection 15 there exist two exit links 46 and 16.

10) *"fi_id_node_id_leaving_links_from_node"*
This file presents for each node the related outcoming links.
The number of lines depends on the number of intersections. The number of columns of each row depends on the number of the outcoming links from the node.
The first column indicates the node id. The next columns present the id of each outcoming link from the corresponding node.
e.g. Line 1 2 18 signifies that the outcoming links from node 1 are inks 2 and 18.

11) *"fi_id_node_type_node"*
This file specifies whether a node is signalised or not.
The number of lines equals to the number of intersections. The number of columns of each row is fixed.
The first column of each line indicates the node id.
The second column values 1 of the node is signalised and zero otherwise.
e.g. Line 11 1 indicates that intersection 11 is signalised.

12) *"fi_mod_cum"*
This file is employed when OD matrices are considered and indicates the cumulative probability of each exit link when originated at an entry link. This file should remain empty when vehicles move according to turning ratios.
The first line of this file is ignored by ".Q" , it explains what each column represents. Next lines correspond to each allowed entry and exit link. Consequently, the number of lines of this file depends on the allowed possibilities (entry, exit) links. The number of columns is fixed (it is previewed to have a varying number of columns whenever the values of the OD matrices vary. Not available for the current model).
The first and second column indicate the id of the entry and exit link respectively.
The third column indicates the cumulative probability to select the corresponding exit link when originated at the indicated entry link.
e.g. Two possible lines will be of the form:
1 78 0.6
1 77 1
and signifies that when originated at entry link 1 the probability of choosing exit link 78 is 0.6 while the probability of exiting at link 77 is of 0.4. Evidently, the only exiting possibilities from link 1 should be either exit link 78 or link 77.

13) *"fi_mrp_cum"*
This file indicates the cumulative probabilities of each *phase* (allowed movement) defining the vehicle routing. If OD matrices are considered, this file should remain empty.
The first line of this file explains each column of the file and it is ignored by the ".Q". The rest number of lines depends upon the number of the network phases.
The number of columns if each row is fixe.
The first and second columns indicate the *phase* id (input, output link forming the allowed movement).
The third column indicates the corresponding cumulative probability value of the related phase.
The order at which phases and their cumulative probability values are written in this file is not important.
e.g. Line 1 2 1.00 represents that the cumulative probability of *phase* $(1, 2)$ is one.

14) *"fi_mrp"*
This files describes the turn ratios of the *phases*. If OD matrices are considered, this file should remain empty.
The first line of this file explains each column of the file and it is ignored by the ".Q". The rest number of lines depends upon the number of the network phases.
The number of columns if each row is fixe.
The first and second columns indicate the *phase* id

(input, output link forming the allowed movement).
The third column indicates the probability value of the related phase.
The order at which phases and their related probability values are written in this file is not important. However, the following equality should be respected:
$\sum_m (l, m) = 1$, for all incoming links $l$ of a node.
e.g. Line 1 2 1.00 represents that the probability of *phase* $(1, 2)$ is one.

15) *"fi_presence_detector"*
Currently not employed.
16) *"fi_que_size_detector"*
Currently not employed.
17) *"fi_series_cum_val_varying_rp"*
This file models the case of varying turning ratios. If the turn ratios are fixed, this file should remain empty.
The first line of this file explains the signification of each column and it is ignored by the ".Q". The number of lines depend on the number of the network *phases*.
The number of columns of each row may also vary and depends upon the number of variations.
The first column of each row indicates the node id.
The second and third columns indicate the *phase* id (incoming, outcoming link of the corresponding node).
The fourth column indicates the duration of the currently employed turn ratio values.
The fifth column indicates the cumulative value of the turn ratio value to be employed at the first variation, for the related phase.
The sixth and seventh columns (if they exist) have the significancy of the fourth and fifth column respectively and so forth.
e.g. Lines
1 1 2 1500 0.80 1500 0.10
1 1 3 1500 1 1500 1
represent the following scenario.
Interpretation of the first line.
At node 1 (first column), the first variation of the turn ratio of *phase* $(1, 2)$ (second and third columns) will be realised after 1500 time units from the beginning of the simulation (fourth column) and the new cumulative turn ratio value for this *phase* will become 0.8 (fifth column). The duration of this value will be 1500 time units (sixth column) and then the new cumulative turn ratio value will become 0.1 (seventh column). In total three changes of the turn ratio values will be applied for *phase* $(1, 2)$.
Interpretation of the second line.
At node 1 (first column), the first variation of the turn ratio of *phase* $(1, 3)$ (second and third columns) will take place after 1500 time units from the beginning of the simulation (fourth column) and the new cumulative turn ratio value for this *phase* will become 1 (fifth column). The duration of this value will be 1500 time units (sixth column) and then the new cumulative turn ratio value will become 1 (seventh column). In total three changes of the turn ratio values will be applied for *phase* $(1, 3)$.
As previously, the possible destinations from link 1 are links 2 or 3.
18) *"fi_series_varying_rp"*
This file describes the case of varying routing probabilities (otherwise this file should remain empty).
The first line of this file explains the signification of each column and it is ignored by the ".Q". The number of lines depend on the number of the network *phases*.
The number of columns of each row may also vary and depends upon the number of variations.
The first column of each row indicates the node id.
The second and third columns indicate the *phase* id (incoming, outcoming link of the corresponding node).
The next columns indicate the turn ratio values for the following periods.
e.g. Lines
1 1 2 0.80 0.10
1 1 3 0.2 0.9
represent the following scenario.
Interpretation of the first line.
At node 1 (first column), the second value of the (varying) turn ratio of *phase* $(1, 2)$ (second and third columns) will be 0.8 (fourth column) then the new turn ratio value will become 0.1 (fifth column).[1] In total three changes of the turn ratio values will be applied for *phase* $(1, 2)$ (including the currently employed turn ratio value starting at the beginning of the simulation).
Interpretation of the second line.
At node 1 (first column), the second value of the (varying) turn ratio of *phase* $(1, 3)$ (second and third columns) will be 0.2 (fourth column) then the new turn ratio value will become 0.9 (fifth column). In total three changes of the turn ratio values will be applied for *phase* $(1, 3)$ (including the currently employed turn ratio value starting at the beginning of the simulation).
19) *"fi_stages_each_non_sign_inters"*
This file should remain empty for the current version. It refers to the case of non-signalised intersections, for which the vehicle departure priority is not yet completed.
20) *"fi_stages_each_sign_inters"*
This file defines the *stages* of each signalised intersection. A *stage* defines the simultaneously compatible *phases*.
The first line of this file explains the signification of each column and it is ignored by the ".Q". The number of lines depend on the number of the *stages* of each intersection.
The number of columns depends upon the number of *phases* actuated by each intersection *stage*.
The first column indicates the node id.
The second and third columns indicate the *phase* id

[1] the first value of the turn ratios is the one employed at the beginning of the simulation

actuated by the stage.
The fourth and fifth columns (when defined) indicate the id of another *phase* simultaneously actuated with the *phase* defined by the second and third columns.
Similarly for the next columns (if any).
e.g. Line $1\ 1\ 2$ signifies that at node $1$ (first column) a stage actuates only *phase* $(1, 2)$ (second and third columns).

21) *"fi_init_state_que"*
This file describes the queue for which a particular initial state should be defined. If the initial state of all the network queues is empty then this file should also remain empty.
Otherwise, the number of lines depends on the number of phases having a particular initial state. The number of columns of any row depends upon the number of vehicles to be added (when this is the case) and when the final destination of each vehicle is initially defined. When vehicles are moving according to turn ratios, the number of columns is five.
More precisely, the first column denotes the node id.
The second and third column indicate the phase id.
The fourth column represents the total number of vehicles in the related queue.
The fifth column corresponds to the id of the vehicle final destination and makes sense when the current queue state is inferior to the desired state (number of vehicles indicated in the fourth column). If the current queue state is superior to the desired one, the already defined state of the existing vehicles will be employed. If vehicles move according to turn ratios this column should value $-1$. If the final destination is predefined then the fifth column will represent the final destination of the first added vehicle (case when current queue state is inferior to the desired one). Consequently the number of columns indicating the vehicle final destination equals to the desired queue state minus the current queue state. There is no need to redefine the vehicle final destination for the existing vehicles.
e.g. Line $1\ 17\ 18\ 4\ -1$ describes that at node $1$, queue $(17, 18)$ should have four vehicles in total of which the final destination will dynamically defined (last column values $-1$).
Another possibility would be $1\ 1\ 2\ 2\ 16$ which describes the following scenario: At node $1$, queue $(1, 2)$ should have $2$ vehicles by the beginning of the simulation. The final destination of the second vehicle will be link $16$. This implies that currently at queue $(1, 2)$ there exist one vehicle of which the final destination is already determined.

22) *"fi_phase_interference"*
File indicating the phase interaction when this is the case. When there exists no phase interference this file should remain empty. The first line of this file is comments and it is ignored when reading this file. The signification of any other line is the following:
The first column indicates the node id.
The second and the third column indicate the id of the affected phase.
The fourth and fifth column indicate the id of the affecting phase.
The sixth column indicate the corresponding parameter for defining the saturation flow of the affected phase.

## II. Database

This is the signification if each column of any line recored by the ".Q".

1) the event time
2) the event type
3) the id of the intersection node
4) the type of the intersection node, (signalised or not)
5) the list with the $[t\_start, t\_duration]$ for each intersection control matrix for the next cycle
6) margin time to computs the intersection control matrix for the next cycle. If the current cycle finishes at t_fin, then the new network control matrix, should be calculated at t_fin- margin_dt.
7) the time at which the current intersection control starts
8) the duration of the current intersection control
9) the current intersection control matrix
10) the current network intersection matrix for the associated link
11) the duration of the current cycle
12) the vehicle id
13) the time at which the vehicle appeared in the the network
14) the id of the entry link at which the associated vehicle appeared
15) the id of the link where the vehicle is currently located
16) the time at which the vehicle arrived at the current link
17) the time at which the vehile started its departure from the current link
18) the time at which the vehile left the current link
19) the current queue location of th evehicle (in the form of (l,m))
20) the type of the queue (right turn or other)
21) the time at which the vehicle arrived at the current queue
22) the time at which a vehicle started its departure from the current queue
23) the time at which the vehicle left the current queue
24) the id of the destination link of the vehicle when leaving the current link
25) the time at which the vehicle left the network
26) the id of the link associated with the current event
27) the answer 1 or 0 indicating if the vehicle can leave the queue by its arrrival or not
28) the time at which the vehicle will arrive at the next link or queue (this is for verifying the calculations)
29) the currently achieved service rate of the queue where the vehicle is, including the vehicle (case when the vehicle can leave the queue)
30) the current value of the service rate of the queue where the vehicle is located

31) a list with the ids of the vehicles in the associated queue with this event
32) the list of the network control matrices decided during the event Ev_end_decision_network_control, for the next cycle
33) the ncm chosen by mp control
34) the number of departing vehicle within an end veh hold at que event or with the ev end veh dep
35) matrix OD
36) the nb of vehicles in the arrival link
37) the nb of veh in the depart. link
38) the id of the veh final destination (when the model decides it by the veh appearance) (exit link)
39) variable returning the type of control , 0 if the ctrl is RC, 1 sinon
40) variable indicating the current values od the turn ratios of the intersection
41) variable indicating the new estimated values of the turn ratios
42) variable indicating the cum values of the new estim turn ratios
43) variable indicating the current estimated values of the turn ratios (before replaced by the new estimated ones)
44) variable indicating the time at which finishes the current intersection control
45) the id of the actuated staged by a new control
46) variable indicating the current cummulative values (not empoyed at all and saoul dbe deleted this variable as well some others).
47)

## III. Names of Files

Hereafter the name of the employed files are indicated. However, there is the possibility to employ different names by modifying the corresponding variable in files "File_names_network_model", "File_Sim_Name_Module_Files" included in the folder with the simulator code.[2]

### A. Names of network files

These files are also explained in section **??**. They are text files (".txt")

1) File *"fi_demand_param_entry_link"*
2) File *"fi_id_all_network_link_id_orig_dest_node_length_link_capacity_link_param_travel_duration"*
3) File *"fi_id_all_phases_max_queue_size_sat_flow_queue_type"*
4) *"fi_id_entry_exit_lk_related_path"*
5) *"fi_id_internal_link_id_orig_dest_node"*
6) *"fi_id_link_id_sublinks"*
7) *"fi_id_node_id_entering_links_to_node"*
8) *"fi_id_node_id_entry_links_to_network"*
9) *"fi_id_node_id_exit_links_from_network"*
10) *"fi_id_node_id_leaving_links_from_node"*
11) *"fi_id_node_type_node"*
12) *"fi_mod_cum"*
13) *"fi_mrp_cum"*
14) *"fi_mrp"*
15) *"fi_presence_detector"*
16) *"fi_que_size_detector"*
17) *"fi_series_cum_val_varying_rp"*
18) *"fi_series_varying_rp"*
19) *"fi_stages_each_non_sign_inters"*
20) *"fi_stages_each_sign_inters"*
21) *"fi_init_state_que"*
22) *"fi_phase_interference"*

### B. Names of the files with the parameters of the corresponding algorithms

One or more of the following files should be included in folder "Control_Param_Files" according to the employed control. The corresponding file with the control parameters should be located directly in folder "Control_Param_Files" and not in any other folder included in "Control_Param_Files'.

1) *"File_FT_Control_Alg_Param.txt"*, the name of the file of the parameter of the FT control
2) *"File_FT_Offset_Control_Alg_Param.txt"*, the name of the file with the FT with offsets control
3) *"File_MP_Control_Alg_Param.txt"*, the name of the file with the parameters of the MP control
4) *"File_MP_Qvalues_phases.txt"*, the name of the file with the values of the parameters indicating the Q value of the corresponding phase. This file should remain empty if no phase has a Q value and a MP control is employed
5) *"File_MP_without_rc_Control_Alg_Param.txt"*, the name of the file with the parameters od MP without red clearance control
6) *"File_MP_without_rc_Qvalues_phases.txt"*, the name of the file with the Q values of the phases, when a MP without a red clearance control is employed. This file should remain empty if no phase has a Q value. This file should remain empty if no phase has a Q value and a MP without red clearance control is employed.
7) *"File_MP_pract_without_rc_Control_Alg_Param.txt"*, the name of the file with the parameters of MP Practical control, without red clearance
8) *"File_MP_pract_without_rc_Qvalues_phases.txt"*, the name of the file with the Q values of the phases, when a MP practical without red clearance control is employed. This file should remain empty if no phase has a Q value and a MP Practical without red clearance control is employed
9) *"File_MP_Practical_Control_Alg_Param.txt"*, the name of the file with the parameters of MP practical control
10) *"File_MP_pract_Qvalues_phases.txt"*, the name of the file with the Q values of the phases when a MP practical control is employed. This file should remain empty if no phase has a Q value and a MP is employed.

[2]in most cases changing the value of the variable directly in these files should work, in few case the explicit file name is employed

11) *"File_FA_no_red_clear_Control_Alg_Param.txt"*, the name of the file with the parameters of a FA without red clearance control. This control is not completed for the current version of the ".Q". It needs to be defined which sensor messages will be ignored
12) *"File_FA_with_red_clear_Control_Alg_Param.txt"*, the name of the file with the parameters of a FA with red clearance control. This control is not completed for the current version of the ".Q". It needs to be defined which sensor messages will be ignored
13) *"File_FA_MAX_GREEN_Control_Alg_Param.txt"*, the name of the file with the parameters of a FA with max green duration. This control is not completed for the current version of the ".Q". It needs to be defined which sensor messages will be ignored
14) *"fi_node_id_ctrl_type_category.txt"*, the name of the file indicating the type of control employed at each node and whether turn ratios will be or not estimated
15) *"fi_id_node_estim_turn_ratio_param_dur_turn_ratios.txt"*, the name of the file employed when turn ratios are estimated (the first column indicates the node id, the second column indicates the parameter ($\lambda$) for the convex combination when turn ratios are estimated - the employed formula is
$\lambda \times$ (new estimated value) $+(1-\lambda)\times$ (current estimated value).
This file is required only when turn ratios are estimated. This file is required only when turn ratios are estimated, (in other words it is useless to exist even empty if turn ratios are not estimated)
16) *"fi_estim_mrp.txt"*, the name of the file with the initial values of the turn ratios when the later ones are estimated. This file is required only when turn ratios are estimated, (in other words it is useless to exist even empty if turn ratios are not estimated)

## IV. Brief instructions for an implementation

1) Fill and save the Dsu_1 file (in folder cc). If more than one sims are desired, fill and save the corresponding number of Dsu_x files, x= $1, 2, 3$, etc.
2) Indicate the name of the Dsu_x files defined in file f_d.py (in folder cc) and save the file.
3) Fill and save file "fi_node_id_ctrl_type_category.txt" located in folder "Control_Param_Files" (in folder cc). If the last column of this fie values $1$ (it implies that turn ratios will be estimated during the implementation) the fill and save files "fi_id_node_estim_turn_ratio_param_dur_turn_ratios.txt" and "fi_estim_mrp.txt" and add them in folder "Control_Param_Files".
4) Fill and save the corresponding to the control algorithm, parameter file and add it also in folder "Control_Param_Files" (in folder cc).
5) In a terminal move to the cc file (by employing the cd command, e.g. cd /Users/jennie/Desktop/sim_x/sim_y/cc
6) Write python3.x Simulation.py or time python3.x Simulation.py, with x=is the corresponding version of python3 you have. e.g. if you have python3.3 you do python3.3 Simulation.py, if you have python3.4 you write python3.4 Simulation.py. The simulation code runs only under a version of python3.

## V. Brief instructions for a stat analysis

For doing a statistical analysis included in this code :

1) copy the produced folder Series_ by the simulation in file "Cl_Stat_Analysis_new.py", in variable "val_name_fol_FRes=" (located at the end of this file, line 2465) and save the file.
2) In a terminal, again placed in the cc folder (with the cd command, as when running a simulation) write
time python3.x Cl_Stat_Analysis_new.py or just python3.x Cl_Stat_Analysis_new.py

## VI. Remarks

1) Within the latest version of ".Q" model, when a previously completed simulation is wished to be continued, the two implementations must have the same control type.
One reason for this is due to the fact that various future tasks (amongst them control decisions) are planned during the previous simulation. Thus, the new simulation should be aware of what is decided in the past and has available all the extra required information. The appropriate way of doing so, is to model a variation of the control during the implementation.
This holds true for any other variations. They should happen during the simulation. The present version of ".Q" is planned for dealing with variations during a run instead of interrupting the implementation and plan a new configuration. However in the case of the control, the same type of control with different parameters can be employed.