F.A.S.T. – How does it work?

In order to mimic the real-world traffic conditions, a computer model is built using Java® in order to simulate a 6 km freeway and simplify the complex patterns of traffic flow.
The F.A.S.T. model consists of 2 main parts: (1) agent-based model representing traffic flow patterns and collected various performance metrics of freeway operated by manual non-intelligent vehicles, and a second part (2) allowing the addition of CACC embedded vehicles in order to study the effect of this technology on traffic flow and assess its impact**.**

Three scenarios are being studied:

1- Traffic flow under low to high traffic conditions (low to high arrival rate of agents) with a ramp (agents merging from a ramp into the system), under different CACC penetration levels.
2- Traffic flow under low to high traffic conditions with a ramp under a low CACC penetration level (≈ 20% PR) but where the CACC cars have priority access to Special HOV lanes.
3- Traffic flow under low to high traffic conditions without a ramp under a low CACC penetration level (≈ 20% PR) but where the CACC cars have priority access to Special HOV lanes.

In other words, two sources of traffic are being modeled: mainstream traffic entering the freeway section from the upstream direction, and merging traffic entering by way of the on-ramp. The ramp allows additional vehicles to enter the freeway acting as a shockwave generator. Note that the ramp is not the only cause of shockwave generation in the traffic flow; any inhomogeneity resulting from vehicles acceleration/deceleration could produce minor oscillations resulting in shockwaves causing ultimately traffic congestions. The on-ramp flow rate is relatively small (compared to the mainstream arrival rate) but large enough to cause minor perturbations in the traffic flow and cause traffic jams.

Basic Rules

Agents behave individually according to their own interest (in this case reaching the maximum velocity allowed) but follow rules that are pre-set by the modeler. The basic rules of F.A.S.T. that all agents follow are the following:
- Agents enter the system (if there is enough space) with their maximum speed (depending on the agent type – car or truck), but adapt it according to the traffic flow.
- Agents use a car-following behavior to avoid collisions with other agents, by decelerating (the speed is reduced to match the preceding agent's speed) when another agent is ahead, and accelerating when the road is clear, and/or no other agents are directly ahead.
- Agents are selfish in nature. It is the goal of each and every agent in the model to reach its destination (i.e. exit the system) as fast as possible, ignoring its behavior's effect on the overall system.

- Agents could reach their maximum speed (also called free-flow speed) only after a certain time without any deceleration. This speed is limited to 120 Km/hr for cars and 110Km/hr for trucks.
- Agents could reach a minimum speed of 0 km/hr (i.e. complete stop) in order to avoid a collision or in the case of a bottleneck.
- The speed limit on the highway is 100 km/hr (or 60 mph)
- Agents can perform overtaking, weaving, and lane changing after a certain time has elapsed according to the lane-changing model MOBIL [1].
- Agents can switch between all the lanes (having 4 lanes) but are limited to them (i.e. vehicles cannot go off-road).
- In the case of a traffic jam, agents are forced to maintain a minimum bumper-t-bumper gap set at the beginning of the simulation.
- When agents come to a complete stop (whether mainstream traffic or on ramp), they are forced to start accelerating from 0 before reaching their desired speed.
- Agents of type car are less polite then agents of type trucks while overtaking according to MOBIL [1]. This means that when merging or changing lanes, cars are more inconsiderate of incoming traffic than trucks.
- All agents of type car have an equal size length of 4 meters and width of 2 meters. Agents of type truck have an equal size length of 6 meters and width of 2 meters.

Basic Configuration

At present, F.A.S.T. is primarily a descriptive analysis tool for the evaluation of traffic patterns on freeway operated by manual non-intelligent vehicles. The basic configuration of the model (by default) is:
- The low arrival rate is set to 4000 vehicles/hour
- The high arrival rate is set to 8000 vehicles/hour
- The ramp inflow is set to 500 vehicles/hour when on, and 0 vehicles/hour when off
- The truck percentage is set to 10% capable of reaching 100%
- The CACC vehicles percentage is set to 0% capable of reaching 100%
- The simulation speed is set to 6.9 times (normal speed). It can be reduced or increased by the modeler.
- The ramp politeness factor is set to 0. The range is from 0 to 3 (0 meaning that the vehicles are aggressive in merging and 3 meaning that they are not)

Model assumptions and limitations

- Failures in the operation of the sensing and communication equipment of CACC are not considered.
- Collisions, work zones, and weather conditions, although they highly affect the traffic flow, are not implemented.
- The CACC system is automatically turned off when a lane change is occurring or when there are no vehicles within the sensor's range of detection. The system is turned back on under the normal conditions maintained by F.A.S.T.
- If the agent preceding a CACC agent is not a CACC agent, the CACC agent acts like ACC. In other words, platooning and close vehicle following could not be achieved, but smoother deceleration could be achieved.
- F.A.S.T., at this stage, does not attempt to find the optimal configuration of the acceleration and deceleration parameters of the intelligent vehicles. However, traffic performance results using the current parameters outperform the traffic performance by manual vehicles.
- The proposed model (the traffic simulator F.A.S.T.) will be expanded, tested, and evaluated. Then, different variables will be manipulated and the results will be analyzed. The current model is still a work in progress.

Future Work

-The CACC acceleration/deceleration parameters will be optimized (the whole ECACC algorithm used will be optimized)
-The CACC agents will perform "platooning" reducing the headway gap to as low as 0.5 meter taking into considerations agents that want to split from a platoon or join it.
-Cars will have the ability to carry people on board (sub-agents). Their HOV accessibility depends on their carrying number of sub-agents.
- Accidents and other perturbation generators will be implemented
- Emergency vehicles will be implemented.

This is a brief write-up describing the basic rules of all agents and their interaction in F.A.S.T. This is also available online at: at: www.georgearnaout.com under **F.A.S.T.**

Reference

1. Helbing, M.T.a.D., *Minimizing Overall Brakings Induced by Lane-changes*, D.T.a. Rolf, Editor. 2002. p. 514-520.