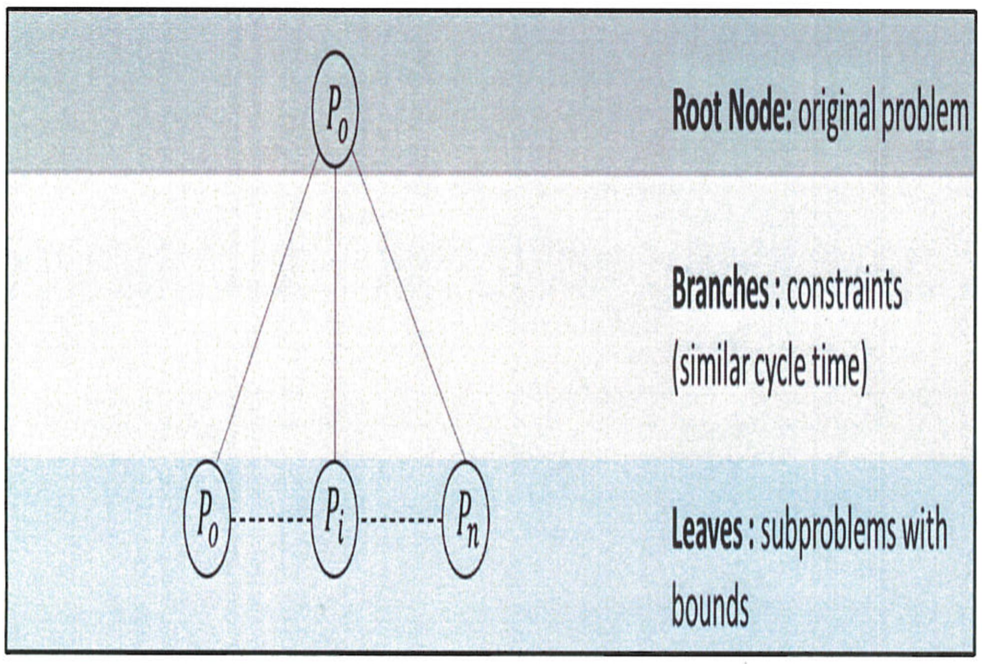
Development of a Decision Support System using the Cell Transmission Model for Optimal Selection of Signal Timing Plans

Master's Thesis of Mayookh Sikka

Mentoring:
Dipl. -Ing. Jakob Kaths
M.Sc. Eftychios Papapanagiotou

External Mentoring:
Dipl.-Ing. Carsten Kemper (GEVAS software)
Dipl.-Ing. Jonas Lüßmann (GEVAS software)

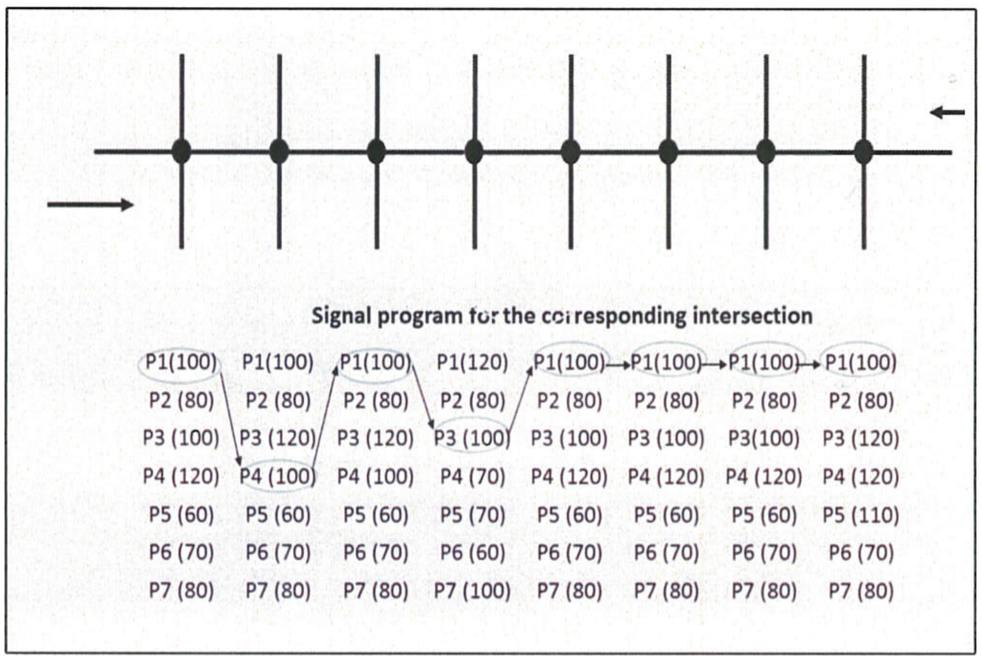
Traffic signal control directly affects the quality of traffic flow. Though fixed time signal control is most widely used traffic control system worldwide, it has its limitations in case of stochastic situations. This has led Adaptive Traffic Control System (ATCS) to be an ever-increasing topic of attraction for many researches. However, the main area of interest of researchers is mostly limited to one field of ACTS, i.e. adapting the signal plan as per the changing demand. A drawback of this approach is that it lacks the possibility to test the calculated frame signal programs with the local actuated control which leads to a black-box situation, i.e. the output is unknown and the new signal plans could cause unintended behavior. Therefore, this thesis efforts to improve this problem by focusing on the other aspect of ATCS, namely, selection of signals plans. This work is built on existing fixed signal plans, instead of designing new coordination schemes or fresh timing techniques, which could be tested with local traffic actuated control beforehand. This avoids the black-box scenario and also encourages to include different objectives as input parameters.

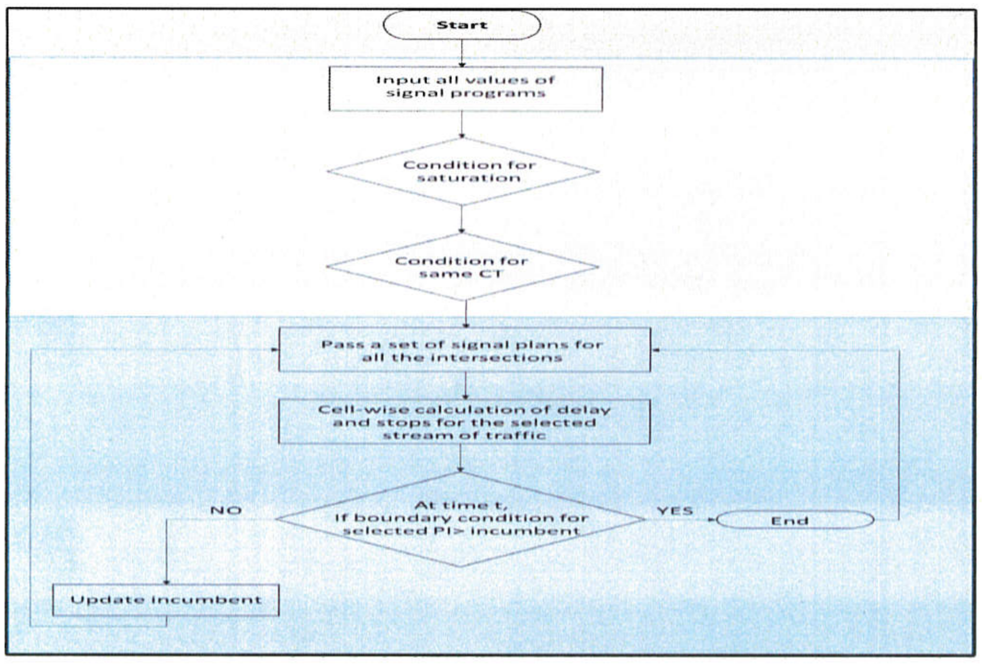


The complete enumeration is improved by adding 'bounds' and thereby reducing the computational time effectively. This second approach is well known as 'Branch-and-bound' method.

The concept is summarised below to explain the algorithm as a whole:

1. The fixed signal plan designed for the particular TOD is run for the defined simulation period and the bounding functions are stored in a variable (as per the objective function to be optimized). This acts as the present incumbent,
2. Saturation rate is used to filter out signal plans to further decrease the solution space and the Signal plans with same cycle time are searched for and passed to CTM,
3. The passed signal plan calculates the delay and stops for every cell i and adds. The moment they exceed the incumbent, the signal plan is fathomed and the third step is repeated. If the calculated value for the current plan is better than the incumbent, it replaces the best one and the process continues till the best one is achieved.





The evaluation is done to gauge the quality and efficiency of the algorithm. First, network is filled with vehicles to get realistic results. Secondly, new signal plans are designed from CROSSIG (considering stage sequence and demand scenarios) to form the solution space. To assess the quality, complete enumeration and original fixed signals plans are used as reference quantity. The result shows that proposed algorithm works better than the original fixed signal plans for majority of demands. There is an average reduction of about 20% total delay and about 30 % total fuel consumption as compared to the original frame of signal plans. Then, the efficiency is evaluated by checking the computational time for the algorithm. With the applications of constraint, the computational time is reduced by 50-99.4% as compared to complete enumeration. Finally, the running time of algorithm is measured for medium and high demand scenarios, which is observed to increase linearly over range of planning horizons