Case Study: Traffic Light System

What is being organized?

Traffic light is something we could see every day. Actually, one single traffic light in the crossroad is already a unique organizing system because every single traffic light has its own particular resources.

Basically, every traffic light systems needs to organize basic timing functions. For example, MIN time determines the minimum duration of the green interval for each movement. Left turns, right turns, minor streets, major streets, usually have different MIN times. MAX time limits the maximum time of the green interval. Like MIN time, it is also different due to different conditions. Moreover, within the technology of sensors, MAX time sometimes are dynamic adjusted to the real-time traffic loads.

Besides the timing functions, traffic light systems also needs to organize other resources. Sometimes even the description of the same resource would be different. Although we usually assume that the colors of all traffic lights are green, yellow and red, they might also be different. For example, in Japan, due to culture and history factor, green lights are sometimes actually blue. Due to lexical perspective, in Japan, “green” light is also not called 緑 (みどり), the Japanese word for green, but 青 (あお, blue).

At last, while more advanced methods have been employed, like button input, video cameras and sensors, traffic lights are sometimes centrally controlled by monitors or by computers to allow them to be coordinated in real time to deal with changing traffic patterns. Thus, it requires the traffic light system to organize many different real-time input data.
**Why is it being organized?**

The traffic light system was invented to ensure the order of traffic and the safety of drivers, passengers and pedestrians. Thus, during the design of the system, timing function is highly required to set properly to handle different conditions and actual traffic situation. Without any doubt, it should organize the resources to ensure there would be enough time interval to let vehicles and pedestrians go through safely without collision.

Furthermore, facing more and more heavy traffic, people requires the traffic light system to organize its resource efficiently and effectively to present more benefits and capacities, such as, increasing the traffic handling capacity of roads, reducing collisions and waiting time for both vehicles and pedestrians, reducing driver frustration and road rage, to relieve the serious situations. “Green wave” is a very good example. It is a series of traffic lights (usually three or more) that are coordinated to allow continuous traffic flow over several intersections in one main direction. This allows higher traffic loads, and reduces noise and energy use. More than that, it is also used to limit speed in some countries, such as German. The car can go through the intersection without any stop however when their speed is lower than the limitation. Moreover, the traffic light system could even interact with the function of the lane. “Dynamic lane use” enables the traffic light system to adjust the lane function to go-through, left-turn or even be closed for this direction but open for another one. The traffic light intends to effectively utilize the limited space to maximize the traffic loads. Thus, the traffic light system are required to organize more complex data.
How much is it being organized?

Right now, there are mainly three types of control methods of traffic light, which thus decide different principles would be used to organize the system and categorize the resources. The basic control method is fixed time control. It uses fixed, signalized intersection time plans. All related resources are pre-defined and would not be changed frequently in the system. Meanwhile, in fixed time control, each traffic light would be a single, independent, isolated system which does not require either inter-systems interaction or outer-systems interaction. The second method is dynamic control. It uses input from sensors or human to adjust signal timing. For example, some traffic lights at pedestrian crossings have a button for pedestrian to press in order to receive green lights for walking through. Dynamic control allows a real-time interaction from outside the system to change its internal value or resource. At last, attempts are now often made to place traffic signals on a coordinated system which enables the central computers or monitors to coordinate several traffic lights to handle different real-time changing traffic patterns according to the input from sensors or video cameras. For example, adaptive signal control could resolve the issue that the driver has to wait for the green light while the intersection is actually empty. Within the data from the sensors, the control computer could adjust the timing signal to improve traffic flow. In coordinated control, it enables inter-systems interaction to allow the data from sensor could be processed together to provide an optimization plan and then alter each related traffic light’s resource.
Graph 5: Organizing Hierarchy

When is it being organized?
Most of the resources are organized when the traffic light is established, for example, the basic timing functions and the signals. However, for some resources, it is an on-going process. To handle the button input of pedestrians, the input signal would be organized immediately to process and to prepare for activating the change of the signals. It would alter the value of the timing functions. However, when the pedestrians have gone across the street, the signal of button would be reset and the value of timing functions would be changed back to the default one. For these inputs from sensors, they might require advanced process and computation. Thus, the system would maintain these data and compute these data to generate a reasonable plan that finally changes the signals.

How or by whom is it being organized?
Right now, due to the development of infrastructure and communication, most of traffic light in the city would be controlled by a center computer system. For example, in New York, above 60% are controlled by the central computer network. Other out-network traffic lights would become independent system to be self-organized but be maintained by the local government.
department.

Graph 6: Example of central control system

Other consideration?

With the development of technology, traffic light is becoming more and more smart and playing an important role in people’s daily life. However, the traffic light might not be necessary in the future anymore and finally disappear. Other incoming technology, like auto-driving car, might eliminate the traffic light system. The car does not demand these visible lights to guide its driving because if all the cars are auto-driving, they could drive interactively and coordinately to ensure safety and speed without the assistance of the traffic light.