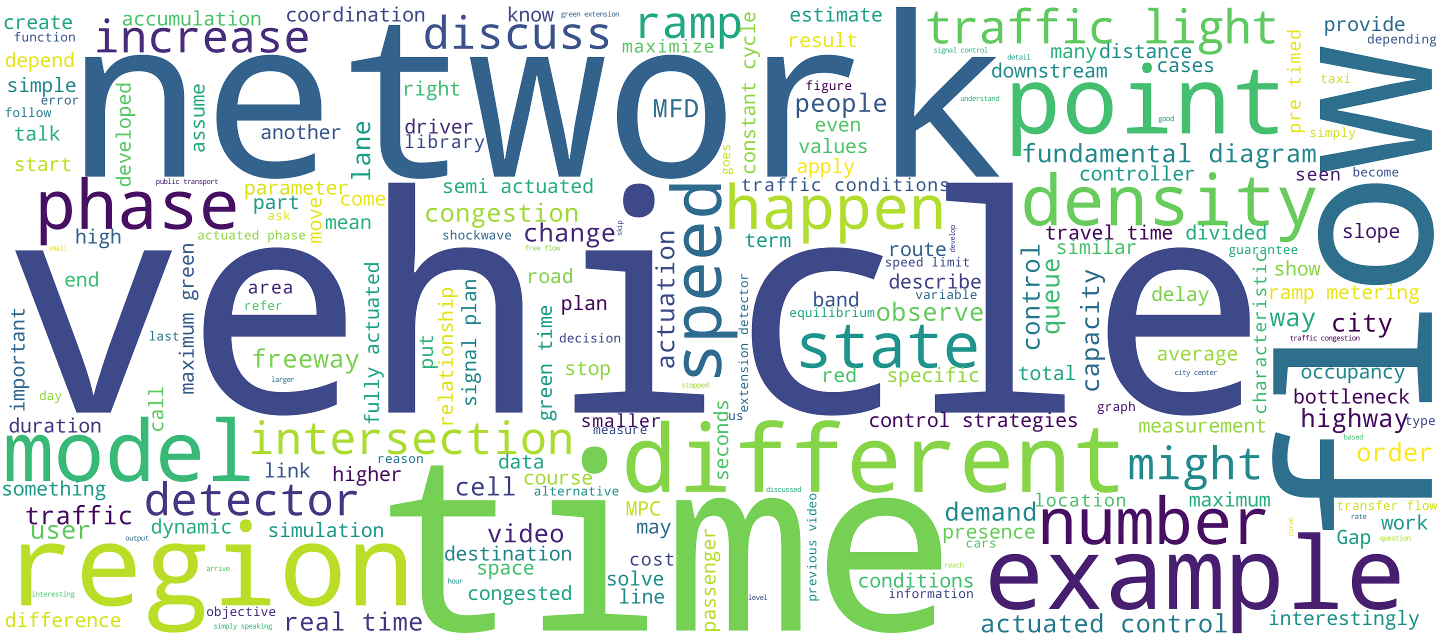


Search MOOC

Video

Control strategy characteristics

- Fixed-time/Traffic responsive:
  - historical demand (constant)
  - real-time measurements (one or two loops per link)
- Isolated/Coordinated/Distributed/Centralized:
  - one junction
  - a set of junctions
  - regions or network-wide
- Undersaturated/Oversaturated traffic:
  - static (queue forming only during red phase)
  - queue dynamics, queue spillback

Welcome! My name is Anastasios Kouvelas and in this video we are going to talk again about traffic signal control. In the previous video we saw that terminology and how we can design pre timed control plans. In this video we are going to discuss the more advanced control strategies. So we are going to talk about actuated traffic control fully actuated and semi actuated. How we do coordination between traffic intersections and also we are going to discuss about the adaptive signal control strategies. So let me remind you from the previous video that we have different classes of control strategies depending on the characteristics. So in this video we are going to deal with coordinated strategies. We will talk mostly about centralized strategies and the strategies referred to oversaturated traffic conditions and the. We will discuss also about traffic responsive strategies. There are also other categories that have been discussed in the previous video.

Notes

Summary

0m 05s

Traffic actuated signal control

- Vehicle actuations change the phases durations (and cycle length).
- Min, max greens (pedestrians).
- Phase skip; gap acceptance; recall.
  - Semi-actuated (coordination)
  - Fully-actuated (change cycles)

So let's talk a bit about traffic actuated signal control. So this refers to the cases that we have vehicle accelerations that contains the durations of some phases dynamically. And in this cases I can apply a minimum and maximum greens that I have to respect. But depending on the actual that happen on my detectors I can have a phase skip, I skip a phase if I don't see any presence of a vehicle I can have what they call a gap that increases or cut my phase and the some detector that is calling for green. So there are two basic categories “semi actuated control” where I can keep the coordination between intersections and the “fully actuated control” that the changes the cycles that cannot guarantee coordination. I will discuss these two cases in the next slide so on the picture here on the right I want to show you the types of detectors that we can use for actuated control. So there is an intersection with vehicles and I have some detectors here. So these are typically called extension detectors because they can ask for green extension. So how they work is that I give some minimum green to this approach. And after the minimum green I check this detector is that actuated or not.

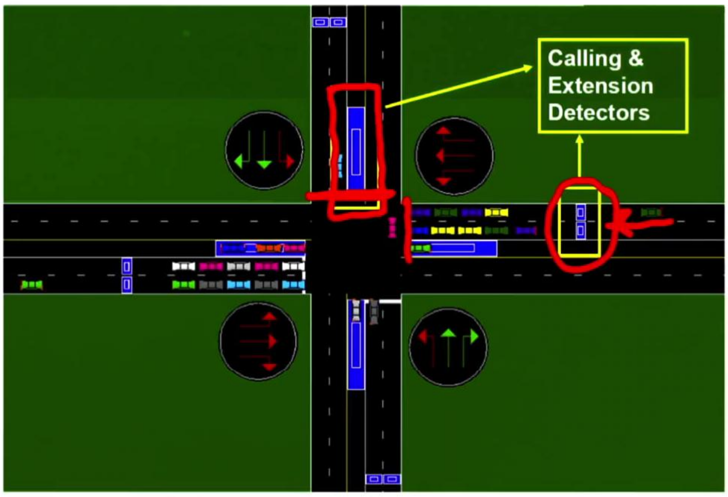
Notes

Summary

1m 21s

Traffic actuated signal control

- Vehicle actuations change the phases durations (and cycle length).
- Min, max greens (pedestrians).
- Phase skip; gap acceptance; recall.
  - Semi-actuated (coordination)
  - Fully-actuated (change cycles)



So if I have a vehicle coming, it will accelerate the detector so it will ask for a green extension. And also if I have detectors like this so these are called calling detectors and they are usually installed close to the stop line of the intersection. And this detection total for example if it's not actuated at all during a cycle I can skip this phase. So if I don't detect any presence of vehicle this phase can be skipped completely from my cycle. So these are two different types of detectors the extension detectors and the calling detectors that I can have in my network in order to apply semi actuated or fully actuated control that we will discuss next.

Notes

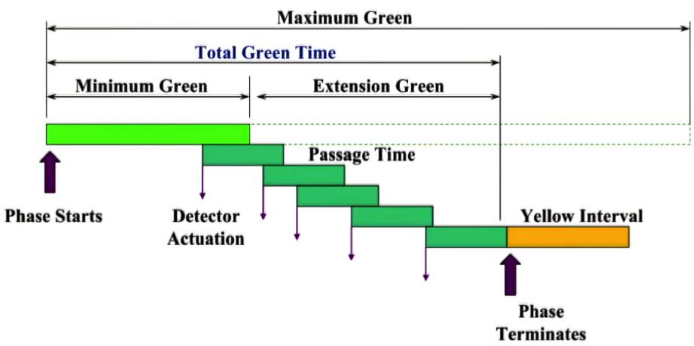
Summary

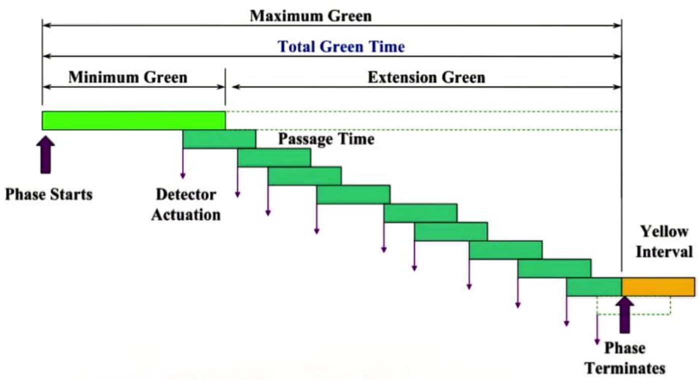
2m 54s

Operation of an actuated phase

Case 1: Max green not reached (Gap out).

Case 2: Max green reached (Max out).





So let me demonstrate you through an example how an actuated phase works. So I have this phase and I define something that they call Gap. Let's say that they put it equal to three seconds and this phase has a minimum green duration which is this. And then I have extension detectors 40, 50 meters upstream over this top line. And if this detector is actuated by every vehicle actuates for a green extension. So I extend my green for some constant period of time and I have defined this Gap which is three seconds. This means that if I don't see any actuation for three seconds then I will stop my green time so I can stop it here. But if there is an actuation I can increase again my green time I can increase again I can increase again I can increase my green time more until. There is no other actuation so I have what I call Gap out and the phase is terminated here. And this followed by a yellow interval and then by the red interval. Note here that the maximum green is this duration. So I feel finished to my phase without reaching the maximum green because of the Gap out because there were three seconds but I didn't observe any vehicle on my extension detector.

Notes

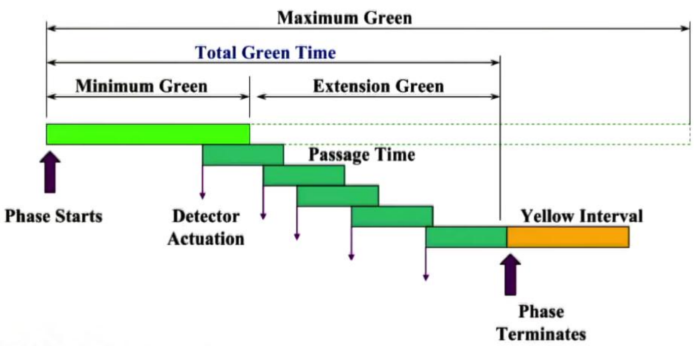
Summary

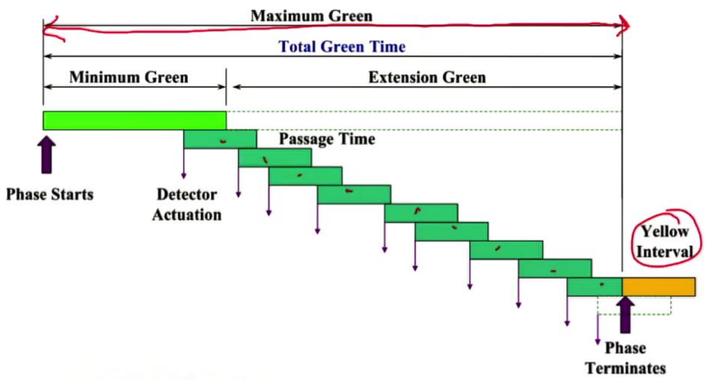
3m 50s

Operation of an actuated phase

Case 1: Max green not reached (Gap out).

Case 2: Max green reached (Max out).





Another case that can happen in this signal plan is what I call Max out. So here I have this gap again and if this is actuated several times by a vehicle. This will reduce my maximum green duration. So now even if there are actuations I have to stop the phase I reach the maximum green so I terminate the phase and I go to the yellow interval into the red interval. So this is a way that actuated phase works and these are two cases that can happen. The Gap out and the Max out, so depending on my measurement on the detector I can extend a green time or stop a green time if there is no actuation.

Notes

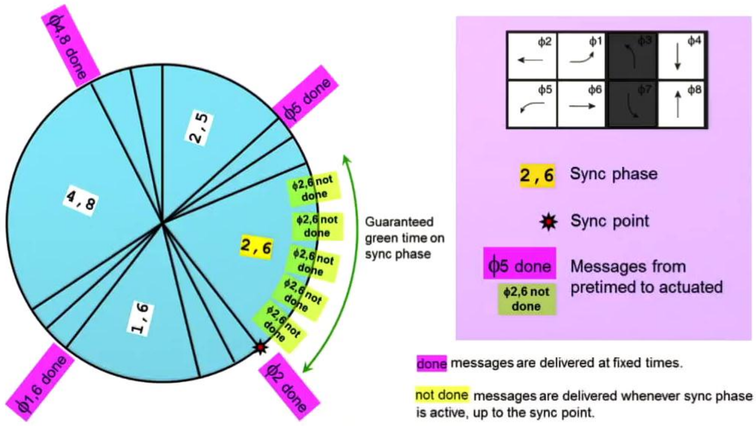
Summary

5m 29s

Semi-actuated and fully-actuated control

- Semi-actuated:
  - Keeps constant cycle length for coordination.
  - Only secondary approaches are actuated.
  - Skip phases according to presence detectors (usually left turns).
  - Remaining green goes to primary approach.
- Fully-actuated:
  - All phases are actuated.
  - Varying cycle lengths (no coordination).

Coordinated actuated



Combines pre-timed and actuated control.

So, let's now discuss the difference between semi actuated and fully actuated control. When I do semi actuated control this means that I have a constant cycle. And actually this allows me to have coordination in my intersection so if I have a constant cycles I can reduce the duration of some phases and usually I do these only in secondary approaches. So if I have a main arterial and some small side street I apply this actuation in the side streets and I can also skip some phases if there is no presence in my presence detectors. So this happens usually for left turns if I don't see any presence I can completely skip the phase and then I activate my secondary approaches. And because I have a constant cycle all the remaining green time goes to the primary approach to the main arterial until I complete my constant cycle. In contrast when I do fully actuated control I don't have a constant cycle for the intersection so all the phases of the plan can be activated both the primary approaches and the secondary approaches. But this will lead to varying cycle lengths I cannot pre-defined the duration of the cycle length. This depends on the actuations that are going to happen and as a result I cannot guarantee the coordination for this intersection.

Notes

Summary

6m 18s

Semi-actuated and fully-actuated control

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  - Keeps constant cycle length for coordination.
  - Only secondary approaches are actuated.
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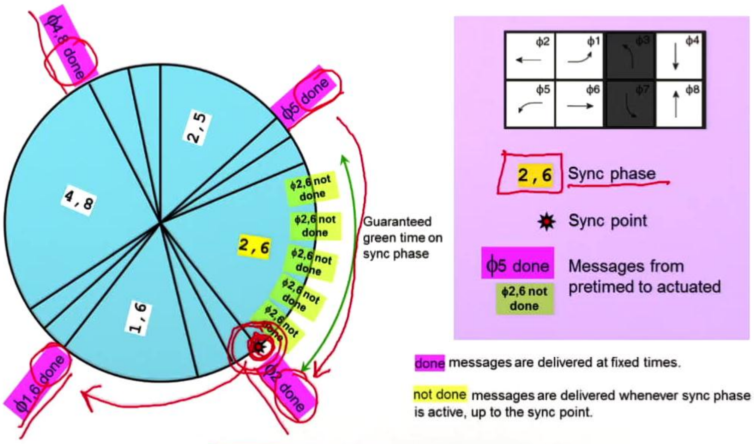
  - Remaining green goes to primary approach.
- Fully-actuated:
  - All phases are actuated.
  - Varying cycle lengths (no coordination).

Coordinated actuated



Combines pre-timed and actuated control.

So I would like now to discuss an example of coordinated actuated phase. So this is a semi actuated phase and it actually combines pre timed control and actuated control but it guarantees the coordination of the intersection. So here I have a starting point for my cycling and I go clockwise. So there are some phases activated 3 2 3 1 feet 6 and they are done they are stopped because of some actuation. For example they are stopped early and then another phase is stopped and then I read Phase 5 which is stopped. But now I have Phase 2 and 6 together which I call sync phase from synchronization and this phase cannot be stopped early. So I have to give all the remaining time to this phase in order to guarantee the coordination because I have this sync point here. That coordinates mined the section with the intersection upstream or downstream. Show no matter what this actuation here do the last phase is going to last until I reached this point and this is why this is called semi actuated order also coordinated actuated.

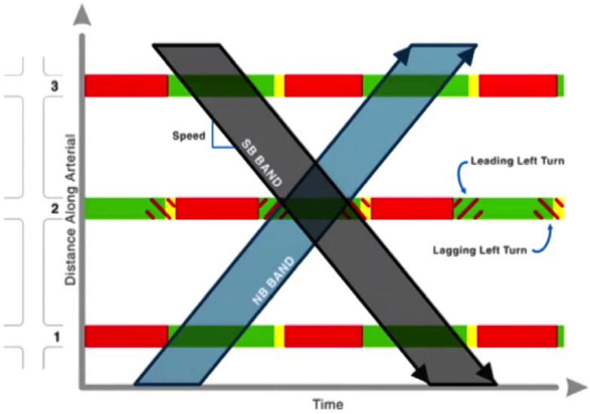
Notes

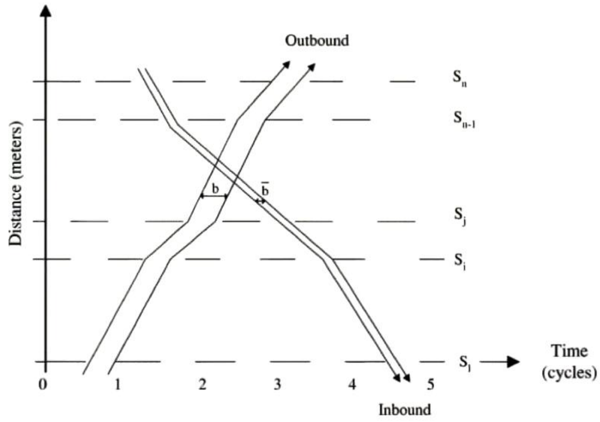
Summary

8m 08s

Pre-timed offsets (progression bands)

Maxband – First version: MIT





Two-way arterial with *n* signals.

Mixed integer linear problem (MILP).

Branch and bound algorithm.

And let's now talk about the offset control. Offset control can give me the difference between these starting points here between successive intersections show us to achieve the green wave. So here on this axis I have space and they have three intersections. And here I have time. So in principle I can move these signal plans left and right so as to synchronize my intersection and to create this here that I call band. So this is the north bound band and this is the south bound band. So I have two different approaches one that goes to the north and one that goes to the south and I want to optimize the size of this band this I mentioned actually of these two bands. So I want to increase the band with the bigger this band the more vehicles can cross multiple intersections with a green light without stopping. One of the first approaches that has been developed in the literature that tackles this problem is an algorithm that is called Maxband that maximizes this bands given some speed limits and some distances and I assume here that there are no queues between the intersections. So this first version was developed by M.I.T. and the researchers were able to come up with an MILP formulation that solves this problem.

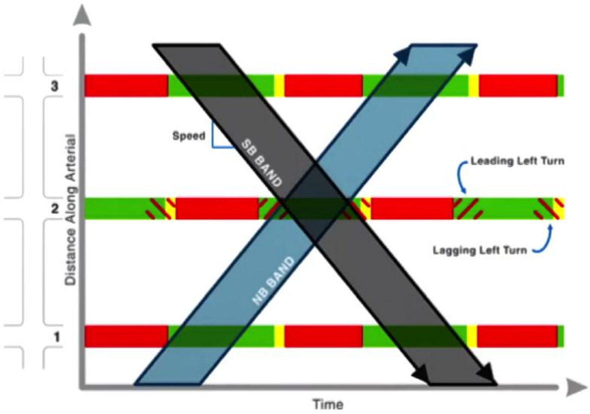
Notes

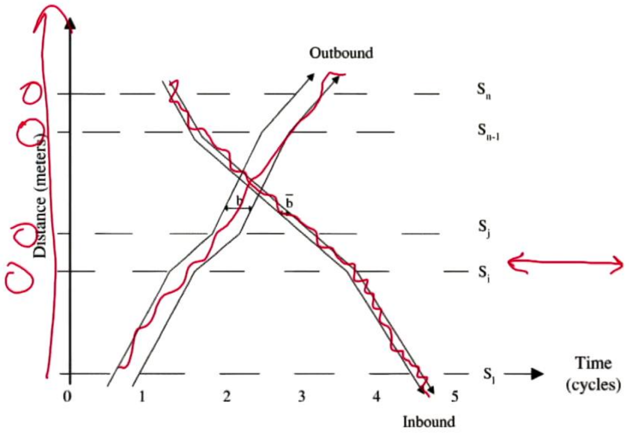
Summary

9m 44s

Pre-timed offsets (progression bands)

Maxband – First version: MIT





Two-way arterial with n signals.

Mixed integer linear problem (MILP).

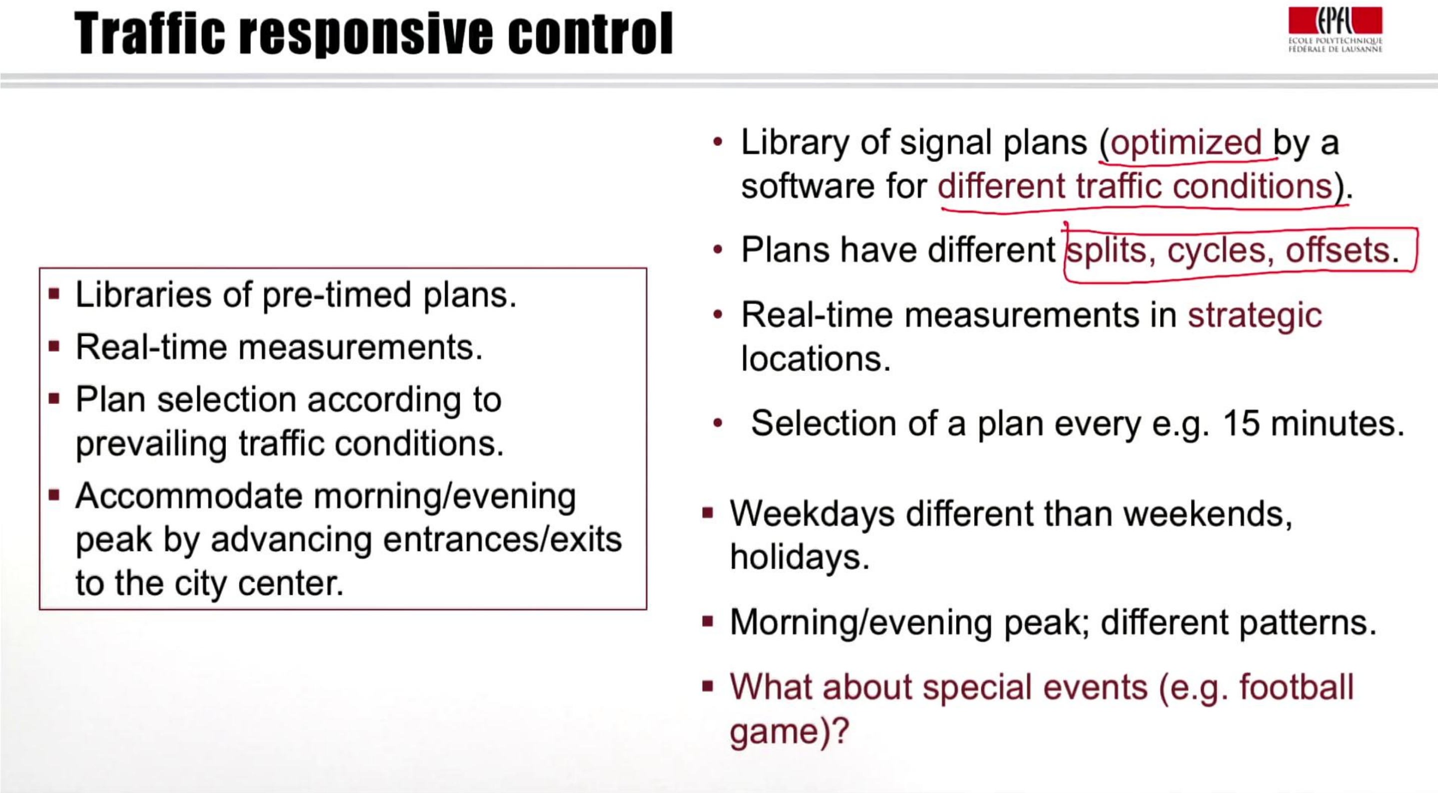
Branch and bound algorithm.

So again here I have space and I have different intersections with signal plans and I can move these signal plans so us to create this two bands and the objective is to maximize the summation of the two bandwidth. So in general I can have n signals and that is a formulation of an MILP and this can be solved relatively quickly with the Branch and Bound algorithm.

Notes

Summary

11m 34s

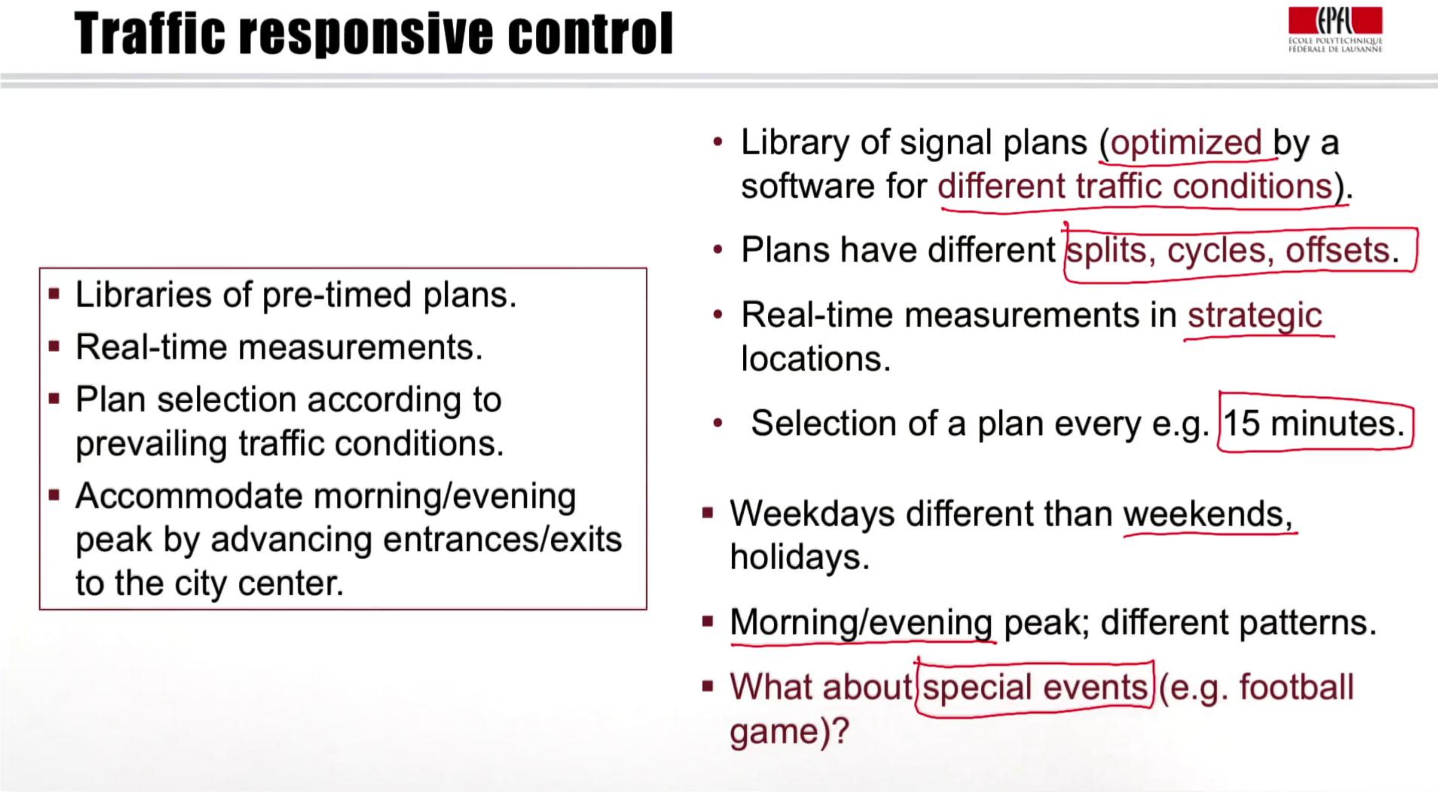


So let's now discuss some traffic responsive control strategies about the traffic lights. There are many cities around the world that they have some libraries of pre timed plans that come from an off line software optimization based on historical data and then you can get real time measurements from your network from some strategic locations. And according to this measurement you can select in real time one of the plans that you have saved in your library. So these plans can have different characteristics. And for example during the morning peak or the evening peak you can have a different plan that favors the entrances or the exits of your network. Because during the morning peak most of the people go to the city center and during the evening peak people leave the city center. But any kind of patterns that you can see in your network based on real time measurements you can associate them to one of the pre timed plans that you have in your library. So again I have different plans that have been optimized for different traffic conditions that I have collected from my network and this plans they have different split cycles and offsets for my network.

Notes

Summary

12m 09s

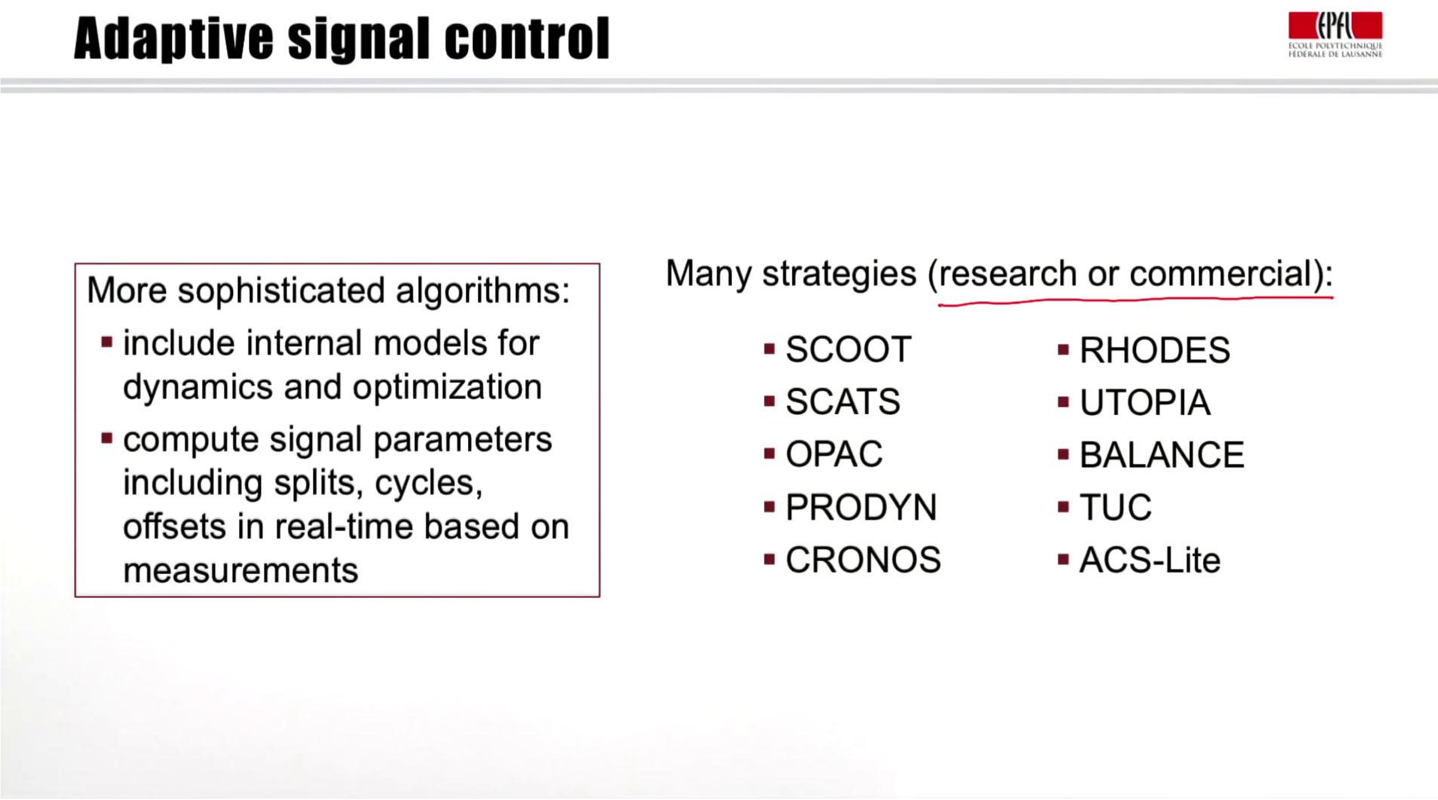


And if I measure some strategic locations of my network let's say for example every 15 minutes I can see which plan from my library can better serve this demand. And actually if you go to some cities you can see that for example in Saturday morning you can observe the similar settings in the traffic lights end in Friday evening you can observe again similar patterns. In the weekends for example on Sundays or in holidays the traffic cycles may be much shorter for example. So you can see some patterns you can see clearly some morning and evening patterns. So a basic question here is what happens when a city has some special event like a big concert or a football game. So in this case I may not have in my library a plan that is optimized for these specific conditions. So in this case I should rather have something real time some adaptive strategy.

Notes

Summary

13m 40s

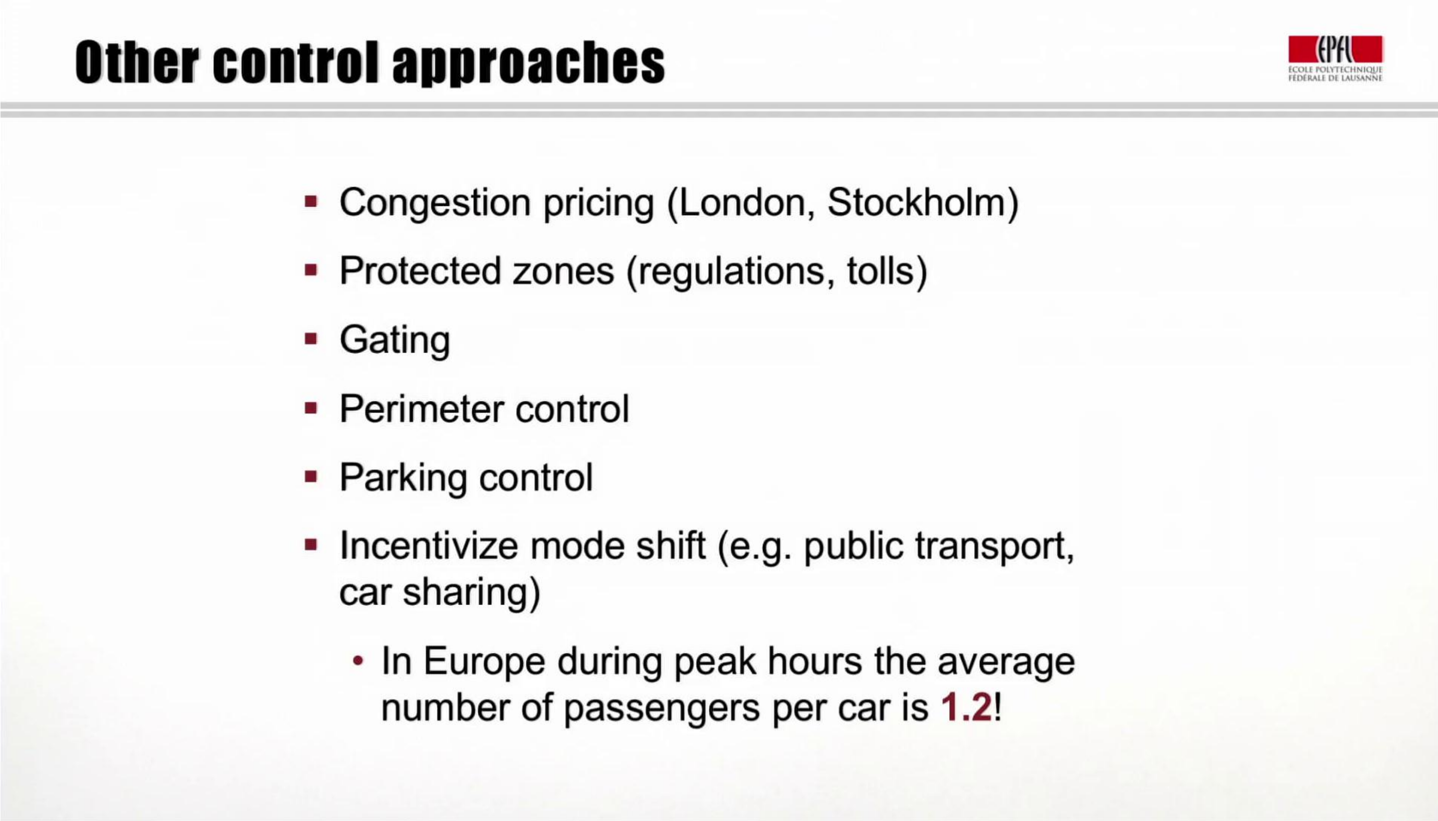


And the last class of control strategies is what we call adaptive strategies. So the key point of these strategies is that they are real time. So these include sophisticated algorithms that they have some internal models for the dynamics of traffic and for optimization and the what they do is they collect measurements from the network in real time and they compute these parameters for the signal like split cycles and offsets to optimally react in the prevailing traffic conditions. On the right I provide the list with the most popular adaptive control strategies which are both research and commercial.

Notes

Summary

14m 55s

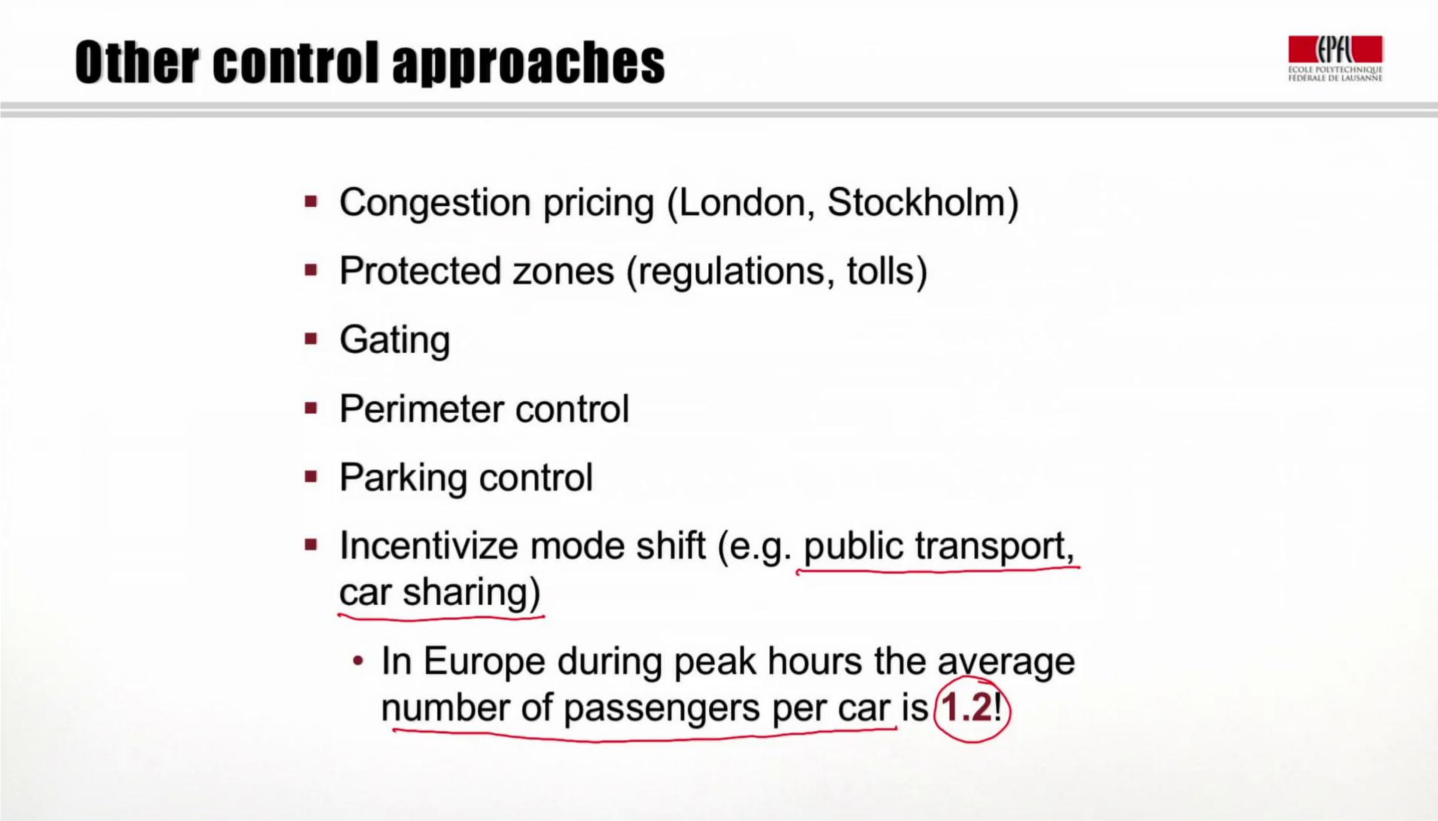


So far we discussed how to optimally control the traffic lights in a city. In this slide I would like to demonstrate some other alternatives in order to manage congestion. One popular technique is congestion pricing and for this we have the successful examples of London and Stockholm. Another way that cities tried to fight congestion is to create some protected zones and to put some special regulations. For example you can allow the odd plate number sort of even plate numbers in different days or you can install tolls which goes back to the congestion pricing. Another popular technique is to do gating so you define some critical gates in your network and you try to meter the incoming flow in these locations which is very similar to perimeter control where we control the perimeter of different regions of the city. Of course another way to fight congestion and manage the mobility of people is to do smart parking control. And finally I would like to discuss the incentives that we can provide to the people in order to change their mode of transport. So to incentivize them to use public transport or car sharing systems which are very popular nowadays.

Notes

Summary

15m 45s



So, I would like to point out that during the peak hours in Europe the average number of passengers per car is one point two and this number is quite small. I would like to point out that in Europe during the peak hours the average number of passengers per car is one point two. This number is quite small and if we could increase it we would get rid of many cars that are on our streets so we could do this by incentivizing people to use public transport and car sharing systems. So these are some other alternatives that we can use to manage congestion apart from the traffic light.

Notes

Summary

17m 17s

Actuated and coordinated control – Summary

In this video we have seen that some cities use local actuation in order to manage traffic congestion. Although these actuations provide some degree of intelligence in the way that traffic lights work. They are not the systematic central and centralized approach someone could work towards developing systematic approaches that can manage traffic congestion in an optimal way. You can refer to the course material for more information on these topics. Thank you for watching.

Notes

Summary

18m 02s