embracing best practices, businesses can ensure their logistics operations remain a competitive advantage in the global marketplace.

Research on traffic lights began before the Second World War and continues to this day. They are still relevant, since modern methodological support for the operation of traffic lights, even with a rigid cycle, does not guarantee a high-quality result of the application of currently known calculation formulas in practice. Even more unanswered questions remain in the operation of adaptive traffic lights, for which global guidelines do not provide any recommendations for setting rational control parameters.

ADAPTIVE TRAFFIC LIGHT WITH A RIGID CYCLE

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The object of study in my research is an adaptive traffic light with a rigid cycle. This variant of adaptation is called weak or semi-adaptation. An example of the operation of such a traffic light, in terms of servicing one direction of traffic at an intersection, is shown graphically on the slide. It shows 136 traffic light cycles lasting 95 seconds with random moments of signal switching, i.e. more than 3.5 hours of traffic light operation. This example was provided to KhNADU by the staff of the Technical University of Dresden. I digitized it, which made it possible to see an interesting pattern in signal switching at the transition from one traffic direction to another, which in this figure occurs when the green signal is turned off.

Since the number of cars arriving at an intersection during a traffic signal cycle is a random variable distributed in a simple flow according to the Poisson law, there are times when more cars arrive at an intersection than can leave the intersection during the permissive traffic signal. These cars leave during the next cycle, i.e., they increase the number of cars that arrive at the intersection the next time, which is distributed according to the Poisson law. This addition changes the law of distribution of the number of cars and, according to the hypothesis, leads to an increase in the number of cases when the queueing lasts for the entire period of the green light, which in adaptation increases the probability of switching signals at a later time.

This situation is illustrated on the slide for the case when the capacity of the traffic direction is 9 cars, the intensity of the incoming flow is 7 cars/cycle. The difference in the probability distributions of the number of cars arriving at the intersection (green) and leaving it (red) during a cycle is clearly visible.

This graph is based on the generation of 1000 values of the Poisson distribution of the number of cars, and is one of the experiments in a full-factor simulation experiment to study the distribution of the number of cars served at a controlled intersection with a constant cycle time. It provides insight into the transformation of the input Poisson distribution into a new distribution that looks quite simple, but in fact defies analytical description and is very difficult to model statistically.

During the experiment, the range of directional capacity from 4 to 30 units was covered, which ensured that almost the full majority of possible durations of the permissive phase in the traffic light cycle from 8 to 60 seconds were viewed. For each capacity, 1000 values of the number of cars in the incoming flow were generated for each integer value of its intensity. The total number of experiments was 459, which allowed us to get an initial idea of the desired pattern and to identify the main parameter that determines the scale of the Poisson distribution transformation, namely the load level, which is defined as the ratio of the intensity of the incoming flow to the capacity of the studied direction.

The results of the experiment demonstrate a significantly accelerated dependence of the proportion of cycles with maximum directional load as the load approaches unity from the bottom. It is shown in blue on the graph. This dependence confirms the possibility of explaining the increased probability of signal switching in adaptation at its late stage, but requires the search for an adequate statistical model to ensure that it can be used in the adaptive traffic light model.

The number of cases when the incoming flow exceeds the capacity of the direction, which is displayed in red, in this process is close to 0.5; which is also an interesting result, since it indicates the need to take into account the cars that are not served during one traffic light cycle in the models of delay at controlled intersections.