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Traffic Flow Control Based on Simulation Model

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Note: The article analyzes the most effective traffic management systems of modern cities. Accordingly, in order to increase the capacity of the urban highway network, special attention is paid to the intensity of traffic at intersections and the mobility of vehicles moving in urban conditions, as well as the method of organizing transportation through modeling.

Keywords: intelligent transport, transport infrastructure of cities, land transport.

Based on traffic flows, their queues, intersection crossing time and optimization simulation model, the length of the traffic light stages is produced depending on the traffic conditions. The model is implemented using road occupancy sensors, whose signals reflect the current situation at a certain time [1,2,3,4,5,6,7] - (Fig. 1).

Acceptance criterion d=min, that is, the minimum delay time for vehicles to pass through the intersection is determined by the general expression of the phase time of the permitting signal t = 12 * k * m / n.

where k is the occupancy coefficient, takes the values 1, 2, 3, 5 and 10;

m and n are the number of lanes on intersections and main roads, respectively.

Validation or discrete event management includes:

- the average length of a passenger car (main road transport) is 4 m. There are 6 cars at a height of 30 m, 12 cars at a height of 60 m, 18 cars at a height of 90 m and 30 cars at a height of 150 m. at an interval of 30 m, taking into account the distance between cars of 1 m;
- At a speed of 60 km/h, the car covers a distance of 16.6 m in 1 second, that is, the presence of a vehicle in front of the sensor at a distance of 30 m causes the traffic light to turn on. The car covers a distance of 30 m in about 2 seconds (more time is required for signals from sensors installed 60, 90 and 150 m before the stop line);
- the maximum duration of the traffic light cycle does not depend on the number of traffic lanes, it can be up to 4 minutes. Green signal for 120 seconds, yellow for 2-5 seconds, and red for the remaining 115-118 seconds. If the maximum time of the prohibition signal is increased to 2 minutes, drivers consider the traffic light to be incorrect and start moving according to the rules of the unregulated intersection;
- the end of the crossing of the vehicle is determined by the last signal of the sensor on the stop line in the absence of signals from other sensors (in practice, when there are no signals from all sensors for 2-3 seconds).).

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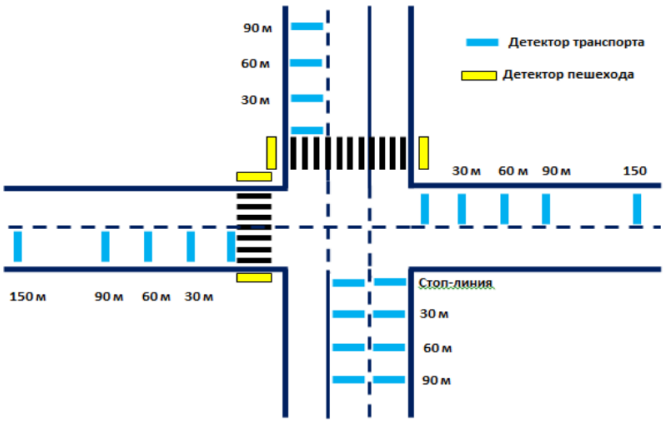

Rice. 1. Simulation model of the intersection

Based on this, the main principles (algorithm, optimizer) of the operation of the intelligent traffic light, which is directly controlled by the signals of the sensors of the occupancy of the road, are as follows:

For equal intersections - intersections of roads with the same number of lanes.

- when there are no vehicles at the crossing (Fig. 1), the traffic light on the main road remains in the last position (if it is green) or priority is given to the main road.

The permission signal can be stopped only when a vehicle appears at the intersection, but not earlier than 2 minutes. Similarly - if there are no vehicles on the main road and there is no intersection (one of the 30, 60, 90 sensors worked), the green signal for the intersection lights up.

- when vehicles are moving forward or backward in a queue or without a queue on the main road (triggering one or more sensors at a distance of 30, 60, 90 and 150 m from the intersection), if the green light of the traffic light is on, the green light will be on

$$t = 12*k \qquad (1)$$

Here: t is the time required for cars in a queue to pass through the intersection, s;

k - employment coefficient takes the following values:

- k = 1 for the sensor located at a distance of 30 m from the parking line (6 cars);
- for a sensor located at a distance of 60 m from the parking line k = 2 (12 cars);
- k = 3 for the sensor located at a distance of 90 m from the parking line (18 cars);
- k = 5 (30 cars) for a sensor located at a distance of 150 m from the parking line;

Thus, when a signal is received at a distance of 30 m from the sensor, a green light will flash through the sensor for the passage of six cars, the duration of which will be 12 seconds (3-4 seconds and 8-9 seconds for acceleration). seconds to cross the intersection). The time for other levels increases accordingly.

At the end of the passage of vehicles (when the signals from other sensors are not transmitted, when the last signal is received from the sensor in the parking lane, i.e. when there are no signals from all sensors, or when 2 minutes have passed), the red light lights up at the traffic light:

- if at the same time vehicles appear in the forward or reverse direction in intersecting lanes (in the busiest lane there are signals from sensors at a distance of 30 and / or 60 and / or 90 and / or 150 m), from traffic then the road crossing has passed through the intersection of the means of

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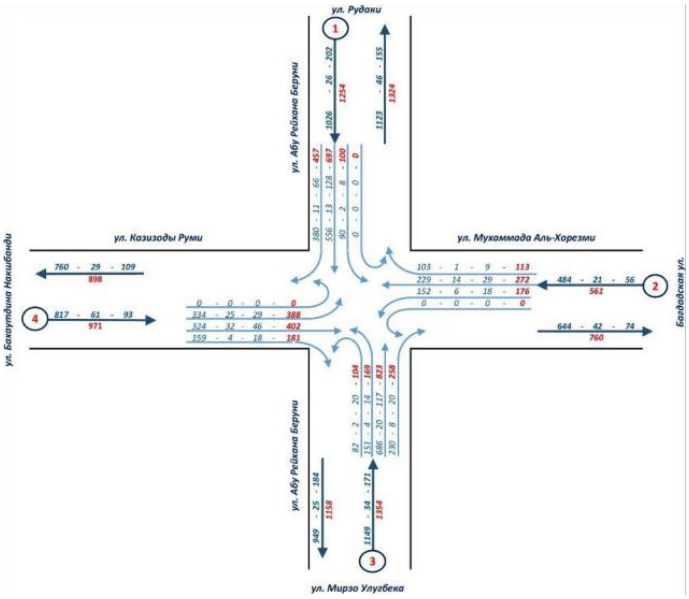
the main route. In the time t = 12 ks, the green light is lit for the more loaded tape in proportion to the occupancy factor (Fig. 2).



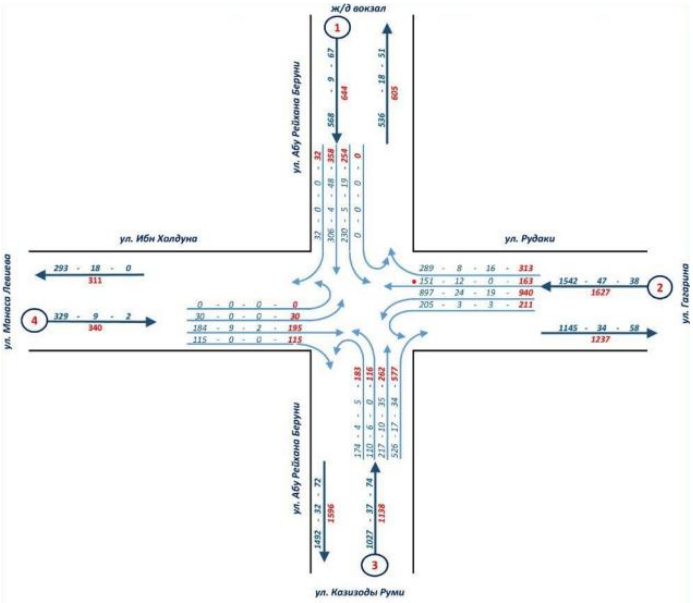
Rice. 2018-03-22 _ Crossing at the same level as a vehicle at intersections

At the end of the passage of the vehicle (when there are no signals from other sensors, when the last signal is received from the sensor in the parking lane, that is, when there are no signals from all sensors, or when 2 minutes have passed). passed), the traffic light turns red.

For unequal intersections - at intersections with a different number of lanes (Fig. 3), the traffic lights change according to paragraph 1, but for directions with fewer lanes, the number of green signal times decreases proportionally to smaller sections. direction of transition to additional sections in the main direction:

t = 12*k*m/n, (2)

Here: m is the number of lines of the intersected road; n is the number of rows of the main path.



Rice. 3 . Rough intersection with a car at intersections

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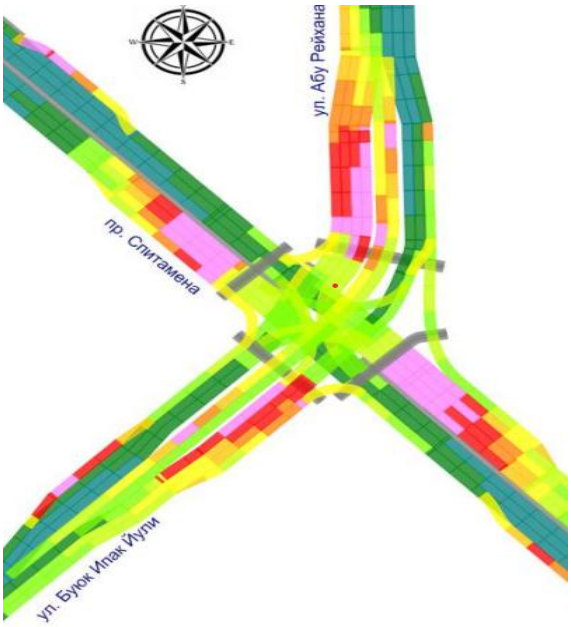
Thus, for Figure 3 , the minimum signal time for a car appearing at a distance of 150 m from the intersection will be t = 12 * 5 * 3/5 = 36 s. When new vehicles arrive (in the forward or reverse direction), the duration of the green signal increases to 2 minutes. At the end of the passage of a vehicle through any intersection, until the vehicle appears at one of the levels of the intersection, a red traffic light is lit for it. For example, if there is no signal from a sensor at a distance of 150 m, a signal may be present at a sensor at a distance of 90 m if the vehicle appears from a secondary road or leaves a yard.

If there is traffic on one of the intersecting roads - if there are vehicles on the sensors at a distance of 30, 60, 90 and 150 m from the intersection (along the busiest lane), the traffic light in this direction will turn green. for a maximum of 120 seconds. For another road with low traffic intensity, the traffic light switches to a permissive signal according to equation (1) or (2) , that is, the green light is lit when necessary for the passage of these vehicles (4 - picture). and at the end of their transition, it switches to a red signal.



Rice. 4. The main road of the intersection is congested

When there is traffic at both intersections - the presence of vehicles at the sensors located at a distance of 30, 60, 90 and 150 m from the intersection in the busiest sections (Figure 5), turns on the traffic light and changes the prohibitory signals. a time period proportional to the number of lines in the intersection. Alternatively, the maximum green duration for a main road with more lanes is 120 seconds, for an intersection with fewer lanes, the time is chosen in proportion to the number of lanes of the intersecting roads:

t = 120 m/n, (3)

At the end of movement in any direction, a red signal is set for it, and the duration of the green signal for the crossing direction is increased accordingly.

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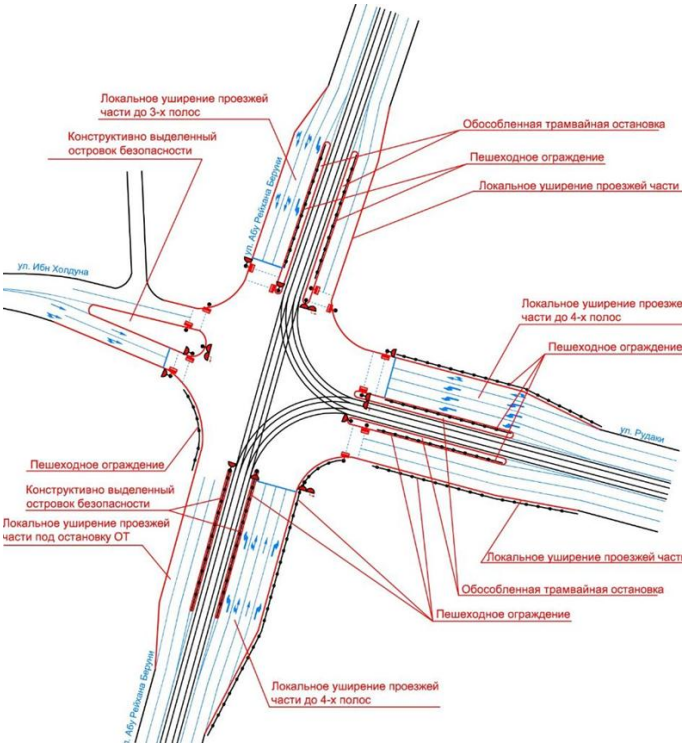
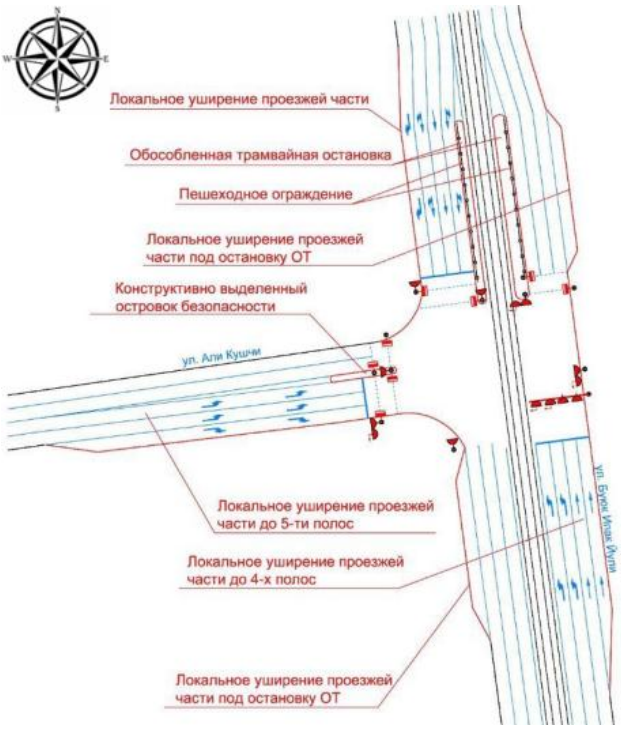


Rice. 5 . Uneven intersection with traffic on both sides

5. T-crossing - the green light can always be on for right lanes in the straight direction and for right turns from straight and intersecting directions, but the pedestrian crossing or It stops at the signal of the corresponding pedestrian detector (Fig. 6).).



Rice. 6. T-joint

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In accordance with the established principles, a computer program was developed in VisualStudio C# for intelligent traffic light control at the T-shaped intersection of Amir Temur and Novy Shavot streets in Urganch, Fig. 7.

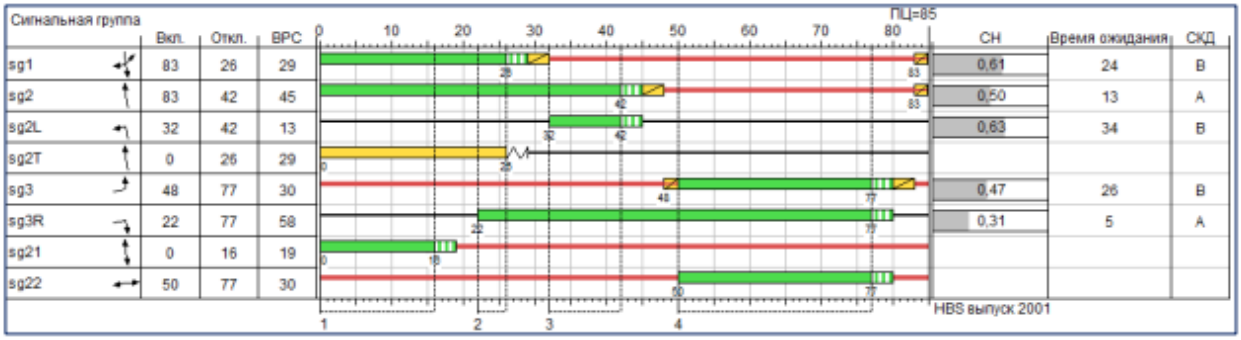

Figure 7. Signal time plan T-intersection (Amir Temur and New Shavat streets in Urganch)

Pedestrian crossing. If a pedestrian occupies the traffic light zone, after 5 seconds (time of complete stoppage of the traffic flow from 60 km per hour), a green signal for him to cross and a red signal for cars will be turned on. In high-speed sections (outside the city), a green signal is given for 10-15 seconds (enough time for the flow of cars to slow down at high speed).

After receiving signals to turn off both (forward and rear) crossing detectors, the green signal for pedestrians tn, the time of the last pedestrian crossing the road and the time of crossing the widest part of the road (4 m) turns off after. The number of rows multiplied by 5 seconds is n.

$t_n = 5*n,$ (4)

In order to exclude the situation of continuous activation of the crossing with the constant approach of pedestrians, the time of receiving CHSIBT signals from the crossing sensor is limited to two minutes, that is, the maximum duration of the pedestrian crossing is 120 s.

The CHSIBT controller constantly receives information from the sensors and determines the duration of the enabling and prohibiting signals during the warning signal of the traffic light (2 - 5 seconds). The time for adjusting the frequency of receiving information from sensors can vary from 0.1 to 0.5 s.

At intersections with discrete-event control, signals from the sensor system are optimized for the simulation model of the intersection and the algorithm for regulating its operation ((algorithm of clauses 1-6 with equations 1) - (4)). According to this acceptance criterion, the duration of the traffic light phases depends on the traffic conditions.

For each specific intersection, an algorithm for changing the phases of its traffic lights should be developed, taking into account the individual characteristics of the intersection.

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