

# Algorithm for Increasing Traffic Capacity of Level-Crossing Using Scheduling Theory and Intelligent Embedded Devices

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**Abstract** - In this paper the authors present heuristics algorithm for level-crossing traffic capacity increasing. The genetic algorithm is proposed for this task solution. The control of motion speed and operation with level-crossing barriers are proposed to create control centre and installed embedded intelligent devices on railway vehicles.

Algorithm is tested using computer. The results of experiments show big promises for rail transport schedule fulfilment and level-crossing traffic capacity increasing using proposed algorithm.

**Keywords** – genetic algorithm, intelligent transport system, level-crossing control, rail transport

## I. INTRODUCTION

Nowadays in cities number of vehicles is constantly increasing. Traffic jams are the main reason for a lot of problems for public transport like delays, inefficient usage of energy etc. Fulfillment of the schedule under such conditions is unforeseen and service level of public transport is going down. In cities, where the road and rail transport are mixed the conflicts between these types of transport are often obvious. Road transport is forced to wait at the closed level crossing while the train goes pass level crossing. This downtime negative impact on urban transport is one of the reasons of public transport delays. In Riga such a conflict takes place for many years is Sarkandaugava's level crossing, between the stations Mangali and Sarkandaugava. Morally and physically the outdated equipment and methods are still used to control this level crossing. Since this railway line is busy with passengers and rolling stocks transport, traffic jams in this part of city is significant and the current situation is disaffecting for Railway Company and for City council as well.

On the one hand the city traffic requests to ensure a continuous traffic flow on the streets, on the other hand rail transport has to ensure passengers and cargo in accordance with the schedule. Since the movement of these various transport systems is organized by various organizations, in practice often conflicts are possible. Which mode of transport should be the priority? Therefore some solutions to fulfill the schedule are necessary. There are some different ways to reach the goal.

The first possible solution is to organize railway transport flow at night, when the road transport unit's amount has fallen to a minimum. This method is not acceptable, since rail transport should be followed the schedule.

Another solution is to build a bridge over railway, but this project implementation will take much time and resources. Therefore this solution increases expenses of City council and

railway transport companies and this project is not confirmable in current economical situation.

In previous papers the authors proposed several solutions such as optimal speed and schedule control [8][9] and "green wave" [10], which allows the transport units to switch the traffic lights and transport units moving on the route without any additional braking on the traffic lights, thereby taking into account the schedule.

In this paper new improved algorithm for rail-crossing capacity increasing and schedule completion [3] is proposed and adopted to for industrial controller to control rail-crossing barrier appropriate railway safety requirements.

Optimal train traffic organization on the given rail line is very important to reduce vehicle standby time, i.e. increase the level crossing capacity. The existing control system analyzing shows, that the level crossing is closed before the deadline, required by the security rules. Current level-crossing control system does not take into account the train location on the route and speed of movement. Analysis of timetable shows, that according to the existing schedule the trains, going in opposite directions, passing through the rail-crossing one by one. Due to this lack the level-crossing total time in a closed position is longer than it might be.

## II. STATEMENT OF THE PROBLEM

Two hypotheses are run for problem solving;

1. The existing schedule adjustment could reduce the level-crossing time position in a closed position
2. Installing built-in intelligent devices on the trains and level-crossings could increase the level-crossings in open position time without violating security regulations and other directive requesting.

If railway transport units moving on the route appropriate optimal schedule and level-crossing go to stop mode considering into account trains current location and moving speed, this could decrease city transport standby time at railroad crossing, increase railroad crossing traffic capacity, eliminate often braking and acceleration, finally save energy [12].

The purpose of this research is to create algorithm for rail transport moving control on the route according predefined schedule to put into practice the programmable logical controller.

Object of research is the city and rail transport system.

Main tasks of the research are:

- to define structure of rail transport with built-in intelligent devices;
- to create mathematical model for existing control system;
- to develop algorithm for schedule fulfilment for rail transport;
- to create computer model of the proposed embedded control system;

Proposed rail transport control system consists of control centre, trains and level-crossings with built-in intelligent devices as shown in Fig.1. Control centre receive signals from each railway transport units about current location, moving speed and other parameters, according predefined schedule, data and algorithms control centre calculate and send through GSM transmitter relevant signals to each transport units about optimal moving speed and for each level-crossing closing units about optimal closing and opening time.

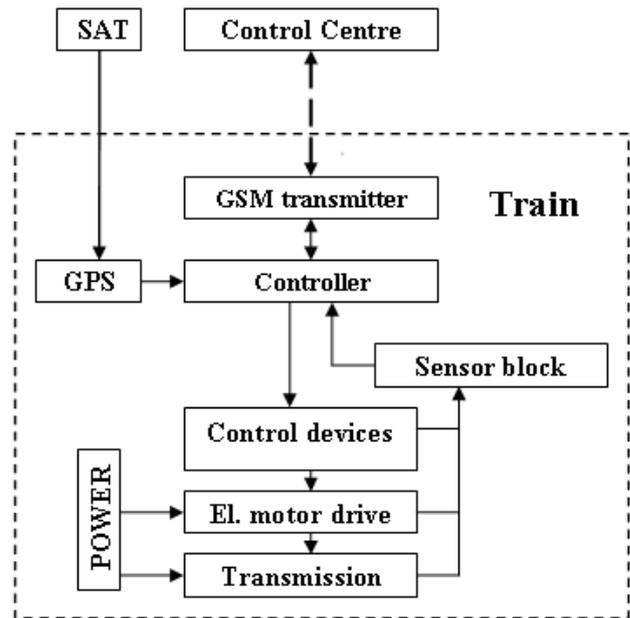


Fig. 2. Railway transport unit control scheme.

Level-crossing control scheme is shown in Fig.3.

Level-crossing built-in controller sends and receives signal from control centre through GSM transmitter. Received signal through Signalization Centralization and Blocking device operates level-crossing electrical elements, signal lights and gate barrier. Sensor block receives the signals from level-crossing electrical elements and other sensors about normal operations. In case of any damages appropriate signal will be sent to control centre immediately for decision making according to predefined safety precautions.

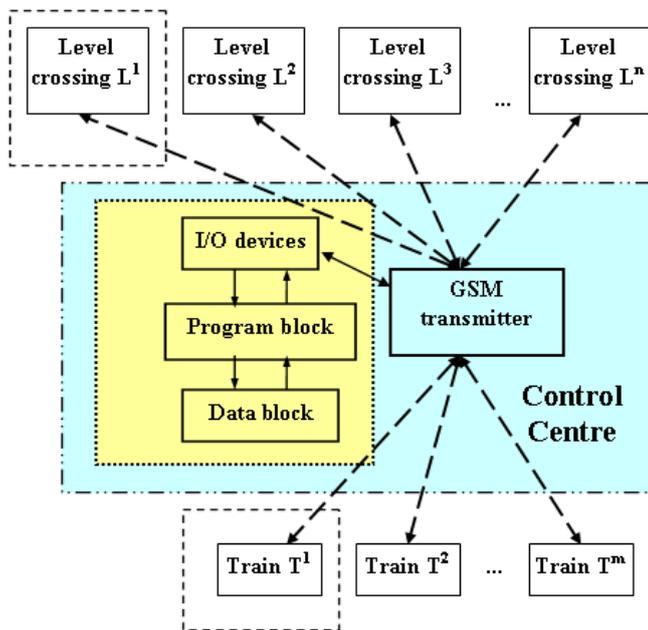


Fig. 1. Rail transport system control scheme.

Railway transport control scheme is shown in Fig.2.

Transport units receive GPS signal about current location and through transmitter send to control centre set of transport unit's characterized data. Trains continuously receive from control centre several signals about optimal moving speed on the route to provide better service and fulfill schedule. Control centre appropriate to the unforeseen changes or emergency cases is able to react quickly and develop corrected action plan according to predefined characteristics for each transport system elements, passenger trains, cargo, rolling stocks, traffic control lights and level-crossings [8].

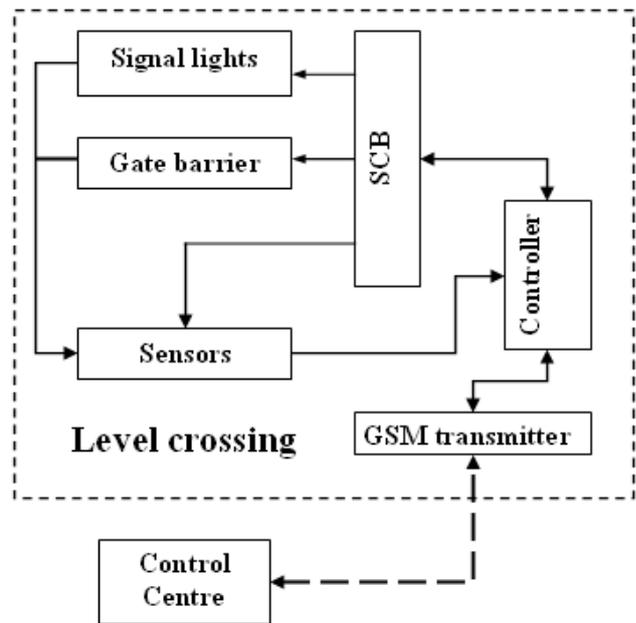


Fig. 3. Level-crossing control scheme.

### III. MATHEMATICAL MODEL FOR ALGORITHM

#### A. Main railway objects

The following objects are given

ST = {ST<sub>1</sub>, ST<sub>2</sub>, ..., ST<sub>k</sub>} - set of stations

LC = {LC<sub>1</sub>, LC<sub>2</sub>, ..., LC<sub>m</sub>} - set of level crossings, where each level crossing is between two stations ST<sub>i</sub>, ST<sub>j</sub>.

RS = {RS<sub>1</sub>, RS<sub>2</sub>, ..., RS<sub>n</sub>} - set of rolling stocks

SCH = {Td<sub>ST</sub><sup>RS<sub>1</sub></sup>, Td<sub>ST</sub><sup>RS<sub>2</sub></sup>, ..., Td<sub>ST</sub><sup>RS<sub>n</sub></sup>}

- set of scheduled departure time for each rolling stock at the station ST before level-crossing (depends on movement direction).

#### B. Infrastructure constants

S<sub>ST<sub>i</sub>,ST<sub>j</sub></sub> - distance between stations ST<sub>i</sub>, ST<sub>j</sub> (m)

S<sub>ST,LC</sub> - distance from station ST to level-crossing LC, (m)

t<sub>calc</sub><sup>clos</sup> - minimal time to close the level-crossing, (s)

d - directions –  $d \in \{odd, even\}$

R<sup>d</sup> = {R1, R2, ...} - set of routes in each direction d

S<sub>R</sub><sup>d</sup> - distance from level-crossing to closure control point for each route R in each direction d, (m)

S<sub>O</sub><sup>d</sup> - distance from level-crossing to opening control point for each route in each direction, (m)

t<sub>R</sub><sup>d</sup> - time delay between crossing the closure control point and level-crossing closure for each route in each direction, (s)

t<sub>O</sub><sup>d</sup> - time delay between level-crossing closure and route opening for each route in each direction, (s)

S<sub>St</sub><sup>d</sup> - distance from opening control point to the station for each route in each direction, (m)

#### C. Rolling stock RS constants

id<sup>RS</sup> - id number

t<sup>RS</sup> - type

d<sup>RS</sup> - direction

R<sup>RS</sup> - route

Lw<sup>RS</sup> - length of wagon, (m)

NwRS - number of wagons

LRS - length of train, (m)

VRS - initial speed, (m/s)

VmaxRS - max speed, (m/s)

TdRS - scheduled departure time, (min)

TaRS - scheduled arrival time, (min)

aRS - acceleration, (m/s<sup>2</sup>)

bRS - deceleration, (m/s<sup>2</sup>)

#### D. Equations for each RS

$$t_a = (V_{\max} - V) / a \quad (1)$$

- acceleration time to maximal speed, s

$$S_a = (V_{\max} - V) \cdot t_a / 2 \quad (2)$$

- acceleration distance to maximal speed, (m)

$$S_{const} = |(S_{ST,LC} - S_c^d) - S_a| \quad (3)$$

- distance of movement with constant speed to the closure control, (m)

$$t_{const} = S_{const} / V_{\max} \quad (4)$$

- time of movement with constant speed to the closure control, (s)

$$t_{total} = t_a + t_{const} \quad (5)$$

- total time from starting movement to the closure control, (s)

**IF**  $S_{ST,LC} \geq S_c^d$  **THEN**

$$t_{clos} = Td \cdot 60 + t_{total} + t_c^d \quad (6)$$

- level-crossing closing time, (s)

**ELSE**:

$$t_{clos} = Td \cdot 60 - t_{total} + t_c^d \quad (7)$$

- level-crossing closing time, (s)

$$S_{clos} = S_a + S_{const} + t_c^d \cdot V_{\max} \quad (8)$$

- distance from movement starting to closing point, (m)

$$S_{clos,LC} = S_{ST,LC} - S_{clos} \quad (9)$$

- distance from closing point to level-crossing, (m)

$$t_{clos,LC} = S_{clos,LC} / V_{\max} \quad (10)$$

- time of movement from closing point to level-crossing, (s)

$$t_b = V_{\max} / b \quad (11)$$

- braking time from maximal speed, (s)

$$S_b = t_b \cdot V_{\max} / 2 \quad (12)$$

- braking distance from maximal speed, (m)

**IF**  $S_b > S_{st}^d$  **AND**  $t^{RS} = \text{'with stop'}$  **THEN**

$$t_{const}^{last} = (Td - Ta) \cdot 60 - t_a - t_b \quad (13)$$

- last wagon movement time with constant maximal speed, (s)

$$S_{const}^{last} = V_{\max} \cdot t_{const}^{last} \quad (14)$$

- last wagon movement distance with constant maximal speed, (m)

$$S_o^{last} = S_{ST1,ST2} + L - S_{st}^d - S_a - S_{const}^{last} \quad (15)$$

- distance from last wagon braking point to opening control point, (m)

$$t_{br,op}^{last} = \frac{-V_{\max} + \sqrt{V_{\max}^2 + 2 * (-b) * S_o^{last}}}{(-b)} \quad (16)$$

- time from last wagon braking point to opening control point, (s)

$$t_{open} = t_{clos} + t_a + t_{const}^{last} + t_{br,op}^{last} \quad (17)$$

- level-crossing opening time, (s)

**ELSE**:

$$S_{clos,open} = (S_{ST,LC} - S_{clos}) + S_o^d + L \quad (18)$$

- distance from real closing point to opening point, (m)

$$t_{open} = t_{clos} + S_{clos,open} / V_{max} \quad (19)$$

- level-crossing opening time, (s)

$$\begin{aligned} & \text{IF } t_{o_R}^d > 0 \text{ THEN} \\ & \quad t_{clos} = 0 \end{aligned} \quad (20)$$

- level-crossing closing time, (s)

$$S_{clos} = S_{ST,LC} \quad (21)$$

- distance from movement starting to closing point, (m)

$$S_{clos,open} = S_{clos,LC} + S_{o_R}^d + L \quad (22)$$

- distance from closing point to opening point (m)

$$\begin{aligned} & \text{IF } S_a \leq S_{clos,open} \text{ THEN} \\ & \quad j = \text{rand}(1, \overline{k}), \quad i = \text{rand}(1, \overline{p}) \end{aligned}$$

$$t_{open} = t_{clos} + t_a + (S_{clos,open} - S_a) / V_{max} \quad (23)$$

ELSE :

$$t_{open} = t_{clos} + \sqrt{2S_{clos,open} / a} \quad (24)$$

- level-crossing opening time, (s)

#### IV. ALGORITHM FOR TASK SOLUTION

Genetic algorithm for task solution is proposed.

##### A. General steps of genetic algorithm

Step1. Randomly generated schedule

According to genetic algorithm operation sequence, the first step is random initialization of possible schedule population.

$$SCH = \{sch_1, sch_2, \dots, sch_p\},$$

$$sch_i = \{x_1, x_2, \dots, x_k\}$$

Step2. Evaluate schedule according fitness function

Each randomly generated schedule is evaluated by fitness function

$$V^S = \{F(sch_1), F(sch_2), \dots, F(sch_p)\}$$

Step3. Arrange schedules according evaluate

At this step randomly generated schedules are rearrange appropriately to this evaluating value

$$\overline{SCH} = \{\overline{sch}_1, \overline{sch}_2, \dots, \overline{sch}_p\},$$

$$F(\overline{sch}_1) = \max(V^S)$$

Step4. Select the best schedules for elite set

From rearranged schedules predefined amount of best schedules are selected for elite set

$$Sch_E \subset \overline{Sch}$$

Step5. Select schedules for crossover

Predefined amount of schedules is selected for crossover from elite set

$$Sc = \overline{Sch}$$

Step6. Use crossover for new schedules generation

Appropriate predefined crossover conditions create the new generation of schedules

Step7. Mutation, random changes in schedules

$$x_j^{s'i} = x_j^{s'i} + 1, \quad sch'_i \in SCH',$$

$$i, j = \overline{1, p} \quad \overline{sch}_i \Pi \overline{sch}_j \rightarrow sch'_i = sch_{ij}; sch'_j = sch_{ji}$$

Step8. Evaluate new schedules population according to fitness function

$$V^{S'} = \{F(sch'_1), F(sch'_2), \dots, F(sch'_p)\}$$

Step9. Combine result of new population and elite set

$$SCH = SCH_E \cap \overline{SCH}';$$

Step10. Arrange new populated schedules according to evaluation

$$\overline{SCH}' = \{\overline{sch}'_1, \overline{sch}'_2, \dots, \overline{sch}'_p\}, F(\overline{sch}'_1) = \max(V^{S'})$$

Step11. Deleting the worst schedules

$$SCH = SCH / \{sch_{p+1}, sch_{p+2}, \dots\}$$

Step12. Stop criterion. The whole process will stop when the generation equals to the-defined time, numbers of population and other criteria.

##### B. Fitness function for Genetic Algorithm

Fitness function is expressed as following

$$F(X) = f(\Delta t, T_\Sigma) \rightarrow \min$$

where:

X = {x<sub>1</sub>, ..., x<sub>n</sub>} - deviation of the original schedule SCH (s)

$$\Delta t = \sum_{i=1}^n x_i^2 / n \rightarrow \min \quad \text{- average deviation from original schedule SCH (s)}$$

$$T_\Sigma = \sum_{j=1}^u \Delta t_{closed} \rightarrow \min \quad \text{- total summary time,}$$

when level-crossing is in close position (s),

u - number of intervals between level-crossing closing and opening

C. Restrictions related to railway safety

Check of the new schedule to avoid time crossings on the same railway track

Compare each train  $i = \overline{1, n}$  with other  $j = \overline{1, n}$  trains in the same direction - :

$$d_i = d_j, \quad i \neq j$$

1. step.  $Td_{check} = Td_{i+x_j}$ ;  $Ta_{check} = Ta_{i+x_i}$ ;

2. step. IF  $(Td_{j+x_j} < Td_{check} \text{ AND } Ta_{j+x_j} > Ta_{check})$  OR  
 $(Td_{j+x_j} > Td_{check} \text{ AND } Ta_{j+x_j} < Ta_{check})$  OR  
 $(Td_{j+x_j} > Td_{check} \text{ AND } Ta_{j+x_j} > Ta_{check} \text{ AND } Td_{j+x_j} < Ta_{check})$   
 OR  
 $(Td_{j+x_j} < Td_{check} \text{ AND } Ta_{j+x_j} < Ta_{check} \text{ AND } Td_{check} < Ta_{j+x_j})$   
 THEN

Schedule failed  
 ELSE  
 Schedule successful

V. COMPUTER EXPERIMENT IN DEVELOPING OF ALGORITHM

A. Existing system structure investigation

The level-crossing of Sarkandaugava in Riga is selected for the computer experiment with the 24-hour train schedule.

The structure of level-crossing and elements location on the route are shown in Fig.4.

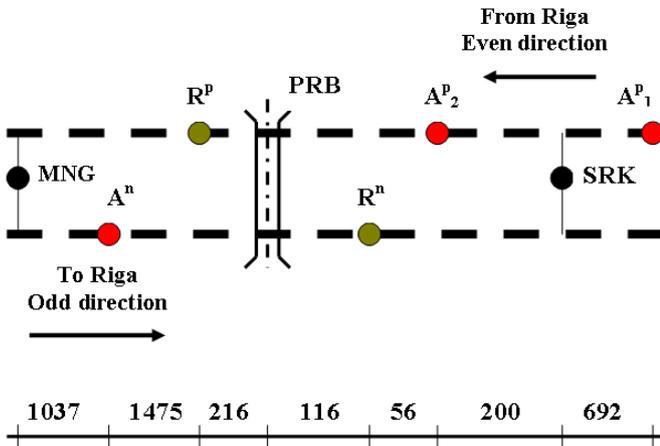


Fig. 4. The structure of level-crossing.

ST = {MNG, SRK} - two stations Mangali (MNG) and Sarkandaugava (SRK)  
 LC = {PRB} - one level-crossing PRB  
 RS = {RS<sub>1</sub>, RS<sub>2</sub>, ..., RS<sub>90</sub>} - 90 trains between two stations in 24 hours time period.

$R^{odd} = \{R^{odd}_1\}$  - one route in odd direction  
 $R^{even} = \{R^{even}_1, R^{even}_2\}$  - two routes in even direction  
 $S_{MNG,SRK} = 3100$  m  
 $S_{MNG,LC} = 2728$  m  
 $S_{SRK,LC} = 372$  m

Train types  $t^{RS} \in \{\text{cargo, pas}\}$ .  
 'Cargo' - rail transport units without stop at SRK station.  
 'Pas' - rail transport units with stop at SRK station.  
 Routes' characterized parameters are shown it Table I.

TABLE I.  
 ROUTES' PARAMETERS

	Sc	So	Sst	tc	to
$R^{1}_{odd}$	1691	116	256	40	0
$R^{1}_{even}$	1064	216	2512	0	0
$R^{2}_{even}$	172	216	2512	0	13,5

Since in existing structure of level-crossing in Sarkandaugava the approaching points An, Ap1 and Ap2 are located too far or too close from the level-crossing, some time constants are necessary for secure level-crossing operate in close mode. Table I. with tc marked the delaying time constant for closing in odd direction, and with t0 marked the untimely time constant for closing in even direction.

All necessary numerical values of all 90 rolling stocks on Sarkandaugava-Mangali stage for calculations are combined in Table II.

B. Parameters of genetic algorithm

Following parameters are selected to implement genetic algorithm.

- Random selection
- Uniform crossover
- Crossover rate = 0.8
- Mutation rate = 0.02
- Bits for one variable = 5
- Population size = 100
- Number of generations = 1000
- Limits for x:  $-5 < X < 5$

In order to avoid too big changes in schedule it is set to permissible summary average deviation from the original schedule which should not exceed 10 minutes.

TABLE II  
LIST OF ROLLING STOCKS

	<i>id</i>	<i>t</i>	<i>d</i>	<i>R</i>	<i>L<sub>w</sub></i>	<i>N<sub>w</sub></i>	<i>L</i>	<i>V</i>	<i>V<sub>max</sub></i>	<i>a</i>	<i>b</i>	<i>STd</i>	<i>Td</i>	<i>Sta</i>	<i>Ta</i>
RS <sub>1</sub>	3648	cargo	even	Reven1	20	45	900	8.61	8.61	-	-	SRK	902	MNG	908
RS <sub>2</sub>	3650	cargo	even	Reven1	20	40	800	7.38	7.38	-	-	SRK	938	MNG	945
RS <sub>3</sub>	3654	cargo	even	Reven1	20	40	800	7.38	7.38	-	-	SRK	1015	MNG	1022
RS <sub>4</sub>	3649	cargo	odd	Rodd1	20	57	1140	0	5.17	0.1	-	MNG	904	SRK	914
RS <sub>5</sub>	3651	cargo	odd	Rodd1	20	35	700	0	12.92	0.1	-	MNG	929	SRK	933
RS <sub>6</sub>	3655	cargo	odd	Rodd1	20	35	700	0	12.92	0.1	-	MNG	999	SRK	1003
RS <sub>7</sub>	3657	cargo	odd	Rodd1	20	57	1140	0	5.17	0.1	-	MNG	1030	SRK	1040
RS <sub>8</sub>	3663	cargo	odd	Rodd1	20	57	1140	0	5.17	0.1	-	MNG	1137	SRK	1147
RS <sub>9</sub>	6136	pas	even	Reven2	-	-	120	0	20.7	0.6	0.8	SRK	928	MNG	931
RS <sub>10</sub>	6138	pas	even	Reven2	-	-	120	0	20.7	0.6	0.8	SRK	966	MNG	969
RS <sub>11</sub>	6140	pas	even	Reven2	-	-	120	0	20.7	0.6	0.8	SRK	980	MNG	983
RS <sub>12</sub>	6142	pas	even	Reven2	-	-	120	0	20.7	0.6	0.8	SRK	1003	MNG	1007
RS <sub>13</sub>	6144	pas	even	Reven2	-	-	120	0	20.7	0.6	0.8	SRK	1045	MNG	1048
RS <sub>14</sub>	6146	pas	even	Reven2	-	-	120	0	20.7	0.6	0.8	SRK	1066	MNG	1069
RS <sub>15</sub>	6148	pas	even	Reven2	-	-	120	0	20.7	0.6	0.8	SRK	1085	MNG	1088
RS <sub>16</sub>	6150	pas	even	Reven2	-	-	120	0	20.7	0.6	0.8	SRK	1116	MNG	1119
RS <sub>17</sub>	6133	pas	odd	Rodd1	-	-	120	0	20.7	0.6	0.8	MNG	919	SRK	922
RS <sub>18</sub>	6135	pas	odd	Rodd1	-	-	120	0	20.7	0.6	0.8	MNG	947	SRK	950
RS <sub>19</sub>	6137	pas	odd	Rodd1	-	-	120	0	20.7	0.6	0.8	MNG	981	SRK	984
RS <sub>20</sub>	6139	pas	odd	Rodd1	-	-	120	0	20.7	0.6	0.8	MNG	1008	SRK	1011
RS <sub>21</sub>	6141	pas	odd	Rodd1	-	-	120	0	20.7	0.6	0.8	MNG	1024	SRK	1027
RS <sub>22</sub>	6143	pas	odd	Rodd1	-	-	120	0	20.7	0.6	0.8	MNG	1045	SRK	1048
RS <sub>23</sub>	6145	pas	odd	Rodd1	-	-	120	0	20.7	0.6	0.8	MNG	1065	SRK	1068
RS <sub>24</sub>	6147	pas	odd	Rodd1	-	-	120	0	20.7	0.6	0.8	MNG	1090	SRK	1093
RS <sub>25</sub>	6149	pas	odd	Rodd1	-	-	120	0	20.7	0.6	0.8	MNG	1120	SRK	1123
...															
RS <sub>89</sub>	3668	cargo	even	Reven1	20	40	800	7.38	7.38	-	-	SRK	1388	MNG	1394
RS <sub>90</sub>	3671	cargo	odd	Rodd1	20	57	1140	0	5.17	0.1	-	MNG	1397	SRK	1407

C. Result of genetic algorithm implement

As it is shown in Fig.5 all selected genetic algorithm parameters are entered in appropriate machine code.

Schedule deviation

x min - 5 x max 5

Select function to optimize:

Sarkandaugava train schedule

Parameters of Genetic Algorithm

Bits of 1 variable: 5

Crossover rate: 0.8

Mutation rate: 0.02

Population size: 100

Number of loops: 1000

- Random Parent Selection
- Roulette Wheel Parent Selection 1
- Roulette Wheel Parent Selection 2

- Single Point Crossover
- Dual Point Crossover
- Uniform Point Crossover

According to the genetic algorithm steps the computer experiment results are summarized in Table III.

VI. CONCLUSIONS

Analyzing the data from algorithm the conclusions are:

- being compared with the original schedule the changed schedule total level-crossing time in the closed position has been decreased from 248min (14892sec) to 174min (10447 sec)
- changed schedule average deviation is not over 5 minutes
- genetic algorithm can be used to solve public and cargo transport flow organization tasks

Schedule changes in ratio + / - 5 min give possibility to reduce significantly the level-crossing being in closed position, thereby significantly increasing the capacity of the level-crossing.

Reducing of level-crossing being in closed position gives several possibilities:

- increasing of city transport flow through level-crossing
- increasing of rail passengers and cargo transport flow on the route Mangali – Sarkandaugava without negative effect on current city transport flow

To define saving up energy and further embedded devices usage for intelligent transport system creating is necessary to implement additional researches.

Fig. 5. Entering genetic algorithm parameters.

TABLE III  
COMPUTER EXPERIMENT RESULTS

Calculated in 33422 seconds.

Original total time of closed level-crossing Torig = 14892.070033683 s

Total time of closed level-crossing Tsum = 10447.344239586 s

Train	Direction	Route	Original depart time	Original arrival time	Deviation	Result depart time	Result arrival time	Level-crossing closed
3605	odd	R1	1:09	1:19	-3	1:06	1:16	1:10:52 - 1:19:16
3607	odd	R1	1:31	1:35	3	1:34	1:38	1:38:09 - 1:39:39
3611	odd	R1	2:38	2:48	3	2:41	2:51	2:45:52 - 2:54:16
3615	odd	R1	3:08	3:12	2	3:10	3:14	3:14:09 - 3:15:39
3619	odd	R1	4:12	4:16	2	4:14	4:18	4:18:09 - 4:19:39
3621	odd	R1	4:37	4:47	-2	4:35	4:45	4:39:52 - 4:48:16
6101	odd	R1	6:00	6:03	-2	5:58	6:01	6:00:05 - 6:02:34
3627	odd	R1	6:32	6:42	-4	6:28	6:38	6:32:52 - 6:41:16
3629	odd	R1	6:50	6:54	4	6:54	6:58	6:58:09 - 6:59:39
6103	odd	R1	6:58	7:01	4	7:02	7:05	7:04:05 - 7:06:34
6105	odd	R1	7:30	7:33	-2	7:28	7:31	7:30:05 - 7:32:34
6107	odd	R1	7:45	7:48	1	7:46	7:49	7:48:05 - 7:50:34
6109	odd	R1	8:30	8:33	3	8:33	8:36	8:35:05 - 8:37:34
6111	odd	R1	9:29	9:32	-1	9:28	9:31	9:30:05 - 9:32:34

TABLE III. (CONTINUATION)

Train	Direction	Route	Original depart time	Original arrival time	Deviation	Result depart time	Result arrival time	Level-crossing closed
6150	even	R2	18:36	18:39	3	18:39	18:42	18:38:47 - 18:39:38
3658	even	R1	19:20	19:26	3	19:23	19:29	19:21:40 - 19:25:41
6152	even	R2	19:42	19:45	-1	19:41	19:44	19:40:47 - 19:41:38
6154	even	R2	20:21	20:24	2	20:23	20:26	20:22:47 - 20:23:38
6156	even	R2	20:58	21:01	-5	20:53	20:56	20:52:47 - 20:53:38
3662	even	R1	22:00	22:07	-5	21:55	22:02	21:53:26 - 21:58:22
6158	even	R2	22:37	22:40	1	22:38	22:41	22:37:47 - 22:38:38
3668	even	R1	23:08	23:14	3	23:11	23:17	23:09:40 - 23:13:41
6160	even	R2	23:36	23:39	-2	23:34	23:37	23:33:47 - 23:34:38

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