LEADERS OF DIGITAL TRANSFORMATION

ROSATOM

TECHNICAL SPECIFICATION

TASK 17

Path planning service for a nuclear icebreaker along the Northern Sea Route

Technical task

Rosatomflot creates a single platform for digital services of the Northern Sea Route. Safety and convenience are the main criteria that cargo carriers use when choosing transportation routes. In order for them to make a choice in favor of the Northern Sea Route, a single platform for digital services is being created, which has no analogues in the world. With its creation, users will receive an "ice navigator" that allows them to calculate the travel time from point A to point B with an accuracy of several hours. With the help of a unique IT product, sailing on the Arctic highway will become as reliable and comfortable as on other popular transportation routes.

1. The main tasks that the service offered for development by the contestants solves:
   1.1. Ensuring an increase in NSR productivity by reducing the time spent on ice escorting transport ships (by optimizing caravans and reducing the time spent by cargo ships in NSR conditions) and more rhythmic operation of caravans / cargo ships + nuclear icebreakers;
   1.2. Determination of the optimal caravan formation point and automatic adaptive routing between points A and B
2. Provide the calculation:
   2.1. optimal routes of transport vessels and caravans, taking into account the changing ice conditions presented in the task conditions;
   2.2. configurations of distribution of transport vessels by caravans for their subsequent transportation by nuclear icebreakers along the NSR.

1. Brief description of the task:

Based on dynamic data on the ice situation on the NSR and a fixed graph of ship crossings (typical ship routes) along the NSR, it is proposed to solve the problem of optimal movement of transport vessels along the NSR, taking into account the needs for ice support (by nuclear icebreakers).

2. The task statement uses:

1. Dynamic data on the ice situation for a given time interval is presented in the file IntegrVelocity.xlsx: the first two sheets are coordinates, on subsequent data on "integral" with an interval of one week). Tables that represent a spatial grid, contain a description of an equidistant grid in a polar stereographic projection. It lists all its cells in rows and columns, each with the coordinates of the upper-left corner and the grid dimension of 25x25 kilometers. Temporary changes in the ice state are presented at weekly intervals. The values indicated in the cells were obtained by processing all the characteristics of the ice layers and normalized to the type of "integral gravity" of ice in terms of the achievable speed of the LK-60 icebreaker in each cell (when calculating the "integral gravity of ice", such ice parameters as cohesion, thickness, ice category, shape, hummocks, compression (force Zero and negative values in the cells indicate: ice impassable for ships, or land.
2. The task uses the transition graph presented in the Graphdata file.xlsx. The transition graph (a fixed graph of typical transport routes) represents statistically the most probable routes of ship traffic obtained from the history of navigation. Participants must use transitions along the edges of this graph. The weight of the edge is calculated independently based on the "integral gravity" of the ice (file: IntegrVelocity.xlsx) with the corresponding time sampling.
3. Auxiliary data provided for easy visualization (NSR coastline shape) - are located in GOaS_v1_20211214
4. The schedule of applications containing the list and (schedule) of traffic of transport vessels, the speed of movement of transport vessels and icebreakers in open water, the ice class of the vessel, are presented in the file: Ship traffic schedule.xlsx

5. Restrictions on the movement of vessels. Depending on the ice class of the vessel and the "integral gravity" of the ice (file: IntegrVelocity.xlsx) the vessel can move on a segment of the route **independently** or **under the escort of an icebreaker**, or **the movement of the vessel is prohibited**.

If the ship can move independently, it is allowed to include it in the caravan (no more than 3 vessels without taking into account the icebreaker itself) under the wiring of the icebreaker to ensure the maximum speed of passage.

6. Ice conditions (indicated in "integral gravity" of ice) slow down the ship's speed relative to the ship's speed in clear water.

   Table 1. Ship speed Dependence on ice class and ice conditions dependence.

Ice class	**Integral weight of ice (LK-60)**		
	21-20	19-15	14-10
No ice class, Ice1-Ice3	Independent movement. The maximum speed is shown in the table (Speed, knots (in clear water))	Traffic under wiring*	No traffic allowed *
Arc4-Arc6	Independent driving. The maximum speed is shown in the table (Speed, knots (in clear water))	Traffic under the wiring. Speed under wiring: Deceleration relative to its own maximum speed – 20%	Movement under wiring. Speed under wiring: Deceleration relative to its own maximum speed-30%

Ice class	Integral weight of ice (LK-60)		
	21-20	19-15	14-10
Arc7	Self-driving. The maximum speed is shown in the table (Speed, knots (in clear water))	Independent movement. Speed under wiring: Deceleration relative to its own maximum speed – 40%	Movement under wiring. Speed under wiring: Deceleration relative to its own maximum speed-85%
Arc9 50 years of Victory, Yamal	Independent movement. The maximum speed is shown in the table (Speed, knots (in clear water))	Independent movement. Speed: 19-15 knots	Independent movement. Speed: 14-10 knots
Arc9 Vaigach, Taimyr	Independent movement. The maximum speed is shown in the table (Speed, knots (in clear water))	Independent movement. Speed: Deceleration relative to 19-15 knots - 10%	Independent movement. Speed: Deceleration relative to 14-10 knots - 25%

* - if the vessel is set to move under the harness, then independent movement is not allowed. If the vessel is prohibited from moving, then neither independent movement nor movement under the icebreaker's wiring is allowed.

7. The total speed of the caravan movement in the ice is calculated based on the technical capabilities of the weakest vessel, taking into account its ice class (see the table " Ship traffic schedule.xlsx") and the specified

deceleration (see Table 1).

Information about icebreakers (Table 2):

Table 2. List of icebreakers

Name	**Speed, knots (in pure water)**	**Ice class**	**Initial position of icebreakers for February 27 2022**
50 years of Victory	22	Arc 9	Long Strait
Yamal	21	Arc 9	Murmansk Roadstead
Taimyr	18.5	Arc 9	Zhelaniya cape
Vaigach	18.5	Arc 9	Pobeda field

3. Task

Participants of this Hackathon need to create an optimal schedule for the movement of vessels along the NSR, their icebreaking escort, and the formation of caravans. The limit for solving the problem will be the number of icebreakers. Objective function: Minimize the time from application submission to the arrival of the transport vessel at the final destination for all vessels.

It is expected that the visualization of ship traffic, the severity of ice conditions and the obtained optimal ship traffic schedule will be implemented in the form of a Gantt chart.

4. Evaluation criteria:

1. Visualization of the results:

You are welcome to display the task components (objects – graph vertices, graph edges, cartographic background, starting and ending points of the route, animation of ship movement, dynamic display of the ship movement schedule under individual icebreaker support and in a caravan in the form of a Gantt chart)

2. Achieving optimal performance targets:

Minimization of time spent by transport vessels en route, minimization of downtime of transport vessels and nuclear icebreakers.

3. Ability to control input parameters, constraints, and the target function
4. The team's approach to solving the problem:

The presence of a role model and distribution of tasks in the team, the correct selection and distribution of competencies.

5. Technical development of the solution:

A brief overview of best practices for solving the optimal planning problem, reasonable non-standard approaches, a text and graphic description of the solution in the form of flowcharts, and analytics on the technology stack for solving such problems are welcome.

6. Matching the solution to the task at hand
7. Effectiveness of the solution within the given task:

The speed of finding a solution for the given problem is estimated

8. Performance of the team at the pitch session (only for the final examination)

Well-coordinated, prompt team work on pitching, availability of presentation materials, quality of answers to questions.

5. Requirements for submitting solutions on the platform:

1. Link to the repository with the code
2. Link to the presentation
3. Link to the prototype for checking the completed work
4. Link to the accompanying documentation (.doc/. pdf)

6. Presentation requirements:

1. The presentation is presented in pptx or pdf format.
2. The presentation should be easy to read and show the key points of solving the problem

7. Requirements for accompanying documentation:

Documentation is provided in docx or pdf format.