LITHUANIAN COMPUTER SOCIETY
VILNIUS UNIVERSITY, INSTITUTE OF DATA SCIENCE AND DIGITAL TECHNOLOGIES
LITHUANIAN ACADEMY OF SCIENCES

DAMSS
DATA ANALYSIS METHODS FOR SOFTWARE SYSTEMS

16th Conference on

DATA ANALYSIS METHODS for Software Systems

November 27–29, 2025

Druskininkai, Lithuania, Hotel "Europa Royale"
https://www.mii.lt/DAMSS

VILNIUS UNIVERSITY PRESS
Vilnius, 2025

Contacts:

Dr. Jolita Bernatavičienė
jolita.bernataviciene@mif.vu.lt
Prof. Olga Kurasova
olga.kurasova@mif.vu.lt
Tel. (+370 5) 2109 315

https://doi.org/10.15388/DAMSS.16.2025
ISBN 978-609-07-1200-9 (digital PDF)

Clustering Dynamic Proximity Graphs to Profile Vessel Traffic Density over Time in a Baltic Sea Case Study

Robertas Jurkus[1], Povilas Treigys[2], Julius Venskus[1]

[1] Institute of Applied Mathematics
Vilnius University
[2] Institute of Data Science and Digital Technologies
Vilnius University

robertas.jurkus@mif.vu.lt

Maritime traffic in dynamically evolving coastal regions such as the Baltic Sea is characterised by continuously shifting vessel interactions that reflect operational intent, navigational constraints, and seasonal or traffic-driven changes in behaviour. Understanding these interactions not at the level of individual trajectories, but as evolving maritime interaction networks, is increasingly recognised as a critical foundation for situational awareness, traffic monitoring, and future autonomous navigation support systems. In this study, we model vessel interactions as time-indexed proximity graphs, where nodes represent vessels and edges are formed whenever two vessels are within a defined nautical-mile encounter threshold. Instead of analysing individual vessels in isolation, we extract connected graph components at each time step, representing localised, interaction-driven traffic formations. For each such component, we compute a rich set of graph-level structural descriptors, including node density, degree distribution statistics, clustering properties, connectivity and path efficiency measures, and centrality-based interaction intensity indicators. These feature vectors, one per traffic formation per time step, are then processed using unsupervised clustering methods, allowing us to discover and categorise recurring traffic regimes without imposing prior assumptions regarding vessel types, traffic rules, or temporal segmentation. The resulting clusters capture distinct and interpretable maritime traffic states, ranging from sparse and fragmented motion to dense, hub-like and coordinated interaction structures. This provides a data-driven characterisation of macroscopic traffic behaviour over time

and enables the identification of stable or recurrent traffic patterns that could aid in traffic monitoring, seasonal analysis, and maritime traffic complexity assessment. A Baltic Sea AIS (Automatic Identification System) case study confirms the practical viability and scalability of the proposed framework and highlights its potential as a foundation for higher-level maritime intelligence, including situational classification, strategic planning, or predictive traffic state modelling in future work.

Acknowledgements. This project has received funding from the Research Council of Lithuania (LMTLT), agreement No S-MIP-24-117.