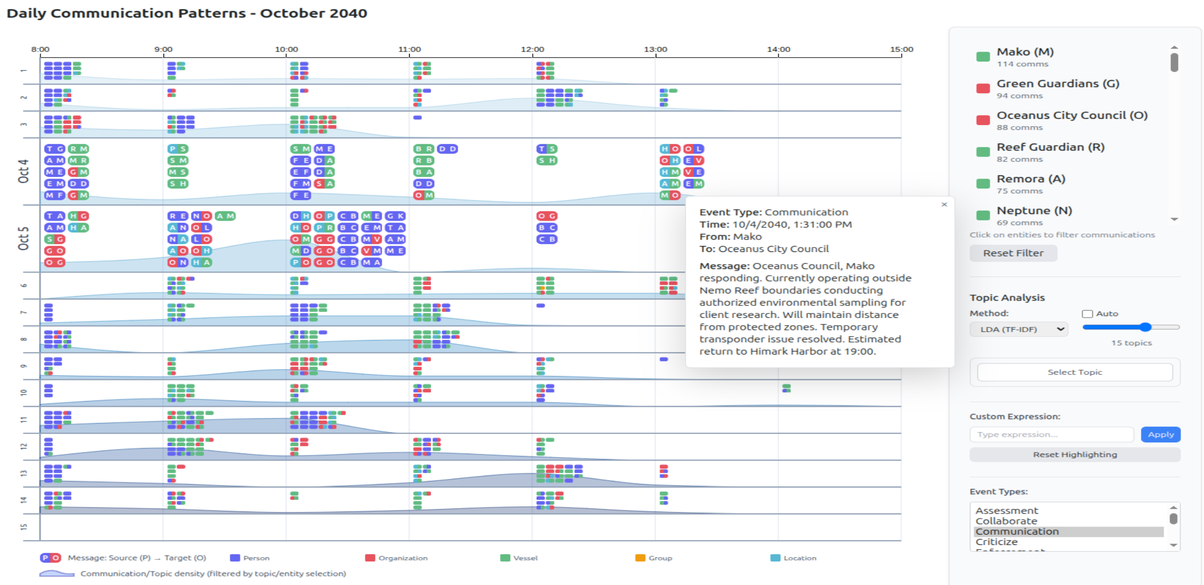
Interactive platform for the visual analysis of suspicious communication patterns

Andres De-la-Puente, Juliano Genari, Marcelo Baez, Felipe Moreno-Vera, and Jorge Poco
{andres.puente, araujo.juliano, marcelo.baez, felipe.moreno, jorge.poco}@fgv.br
Fundação Getulio Vargas (FGV) - School of Applied Mathematics, Brazil


Daily Communication Patterns - October 2040
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
1
2
3
Oct 4
Oct 5
6
7
8
9
10
11
12
13
14
15
Message: Source (P) → Target (O)
Person
Organization
Vessel
Group
Location
Communication/Topic density (Filtered by topic/entity selection)
Click on entities to filter communications
Reset Filter
Select Topic
Apply
Reset Highlighting

Event Type: Communication
Time: 10/4/2040, 1:31:00 PM
From: Mako
To: Oceanus City Council

Message: Oceanus Council, Mako responding. Currently operating outside Nemo Reef boundaries conducting authorized environmental sampling for client research. Will maintain distance from protected zones. Temporary transponder issue resolved. Estimated return to Himark Harbor at 19:00.

🟩 Mako (M) 114 comms
🟥 Green Guardians (G) 94 comms
🟥 Oceanus City Council (O) 88 comms
🟩 Reef Guardian (R) 82 comms
🟩 Remora (A) 75 comms
🟩 Neptune (N) 69 comms

Topic Analysis
Method: LDA (TF-IDF)
□ Auto
15 topics

Custom Expression: Type expression...

Event Types:
Assessment
Collaborate
Communication
Criticize

Figure 1: Main view of our platform showing the Daily Communication Patterns visualization, this view displays message activity over 14 days, showing more activity in the morning and at night.

Abstract

This paper presents a visual analytics system for detecting hidden suspicious activities within communication networks. Developed for the VAST 2025 Challenge, it analyzes two weeks of maritime radio communications using temporal patterns, network and topic modeling, and pseudonym detection. Interactive visualizations reveal covert coordination, thematic clusters, and corruption linked to key individuals, demonstrating an effective approach for intelligence analysis of complex deception networks.

Index Terms: Visual Analytics, Knowledge Graphs, Pseudonym Detection, Temporal Patterns

1 Introduction

The analysis of communication networks and knowledge graphs has become increasingly important for understanding organizational dynamics and detecting suspicious activity. Today, sophisticated strategies (such as coded language, pseudonymous identities, and coordinated patterns) are frequently used to evade detection and obscure operational objectives. Traditional analytical approaches often fall short when confronting networks that intentionally employ systematic deception tactics. This article presents a comprehensive visual analysis approach developed for the VAST 2025 Challenge, with a focus on Challenge 3, which explores radio communications in Oceanus. The challenge involves analyzing two weeks of radio communications to generate a knowledge graph connecting maritime entities, including vessels, companies, and regulatory bodies. Our solution consists of an analysis platform that combines temporal analysis, network exploration, pseudonym detection, and indirect communication visualization to uncover hidden patterns in intercepted communications.

2 METHODOLOGY

This challenge uses a dataset similar to those in previous studies [1, 3], involving the same country and a comparable goal of identifying illegal activities. However, it differs in the specific data and analytical approaches employed. This task addresses real-world challenges, where illicit coordination is often concealed within legitimate communications. Our methodology consists of two main stages: data preprocessing and visual analytics.

2.1 Data Preprocessing

Entity and Network Analysis: Entities in the knowledge graph were classified by type and subtype based on their relationships. Their communications were also analyzed to uncover interaction patterns and hidden connections, enabling focused and insightful exploration of the network structure.

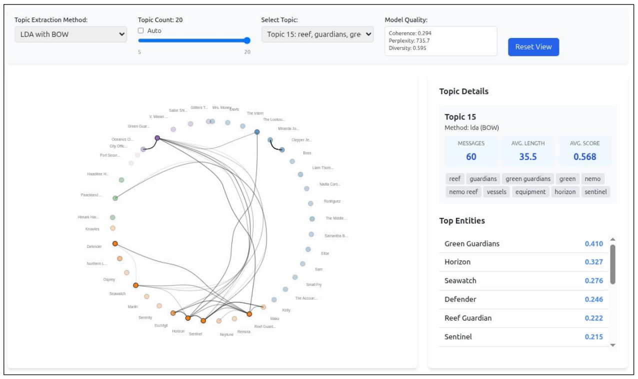
Textual Analysis: The texts of the communications were explored to identify relevant themes, keywords, and events.

2.2 Visual Analytics System

Four views are employed in our approach:

Daily Communication Patterns: This interactive visualization tracks daily communication patterns over 14 days using a knowledge graph (see Fig. 1). It displays messages as color-coded boxes, with the x-axis representing hours and the y-axis showing daily bands. Users can expand days for details and apply filters to explore shifts and patterns.

Topic Modeling Explorer: The Topic Modeling Explorer is an interactive dashboard that combines network graph visualization with topic modeling to analyze communication patterns (see Figure 2).



Topic Extraction Method: LDA with BOW

Topic Count: 20 ☐ Auto

Select Topic: Topic 15: reef, guardians, gre

Model Quality:
Coherence: 0.294
Perplexity: 735.7
Diversity: 0.595

Topic Details

Topic 15
Method: lda (BOW)

MESSAGES	AVG. LENGTH	AVG. SCORE
60	35.5	0.568

reef, guardians, green guardians, green, nemo, nemo reef, vessels, equipment, horizon, sentinel

Top Entities

Green Guardians	0.410
Horizon	0.327
Seawatch	0.276
Defender	0.246
Reef Guardian	0.222
Sentinel	0.215

Figure 2: Topic Modeling Explorer integrating network visualization with thematic analysis of communications.

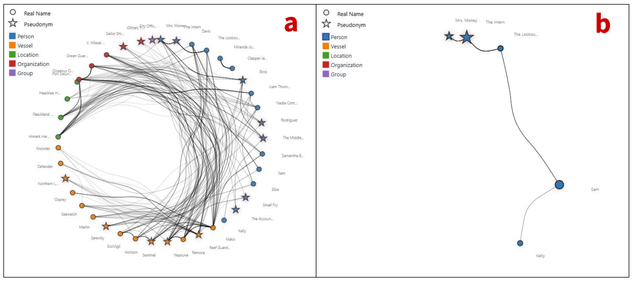


Figure 3: Network Exploration module showing interactive views of entity communications and relationships: full network on the left (a), and the same graph filtered by nodes Sam and The Intern on the right (b).

Users can adjust topic extraction methods and view relevant metrics. The central network graph represents entities as nodes and their communications as edges, with node opacity adjusting based on topic relevance. A sidebar displays topic keywords and entities, and a message log provides detailed context for analysis [2].

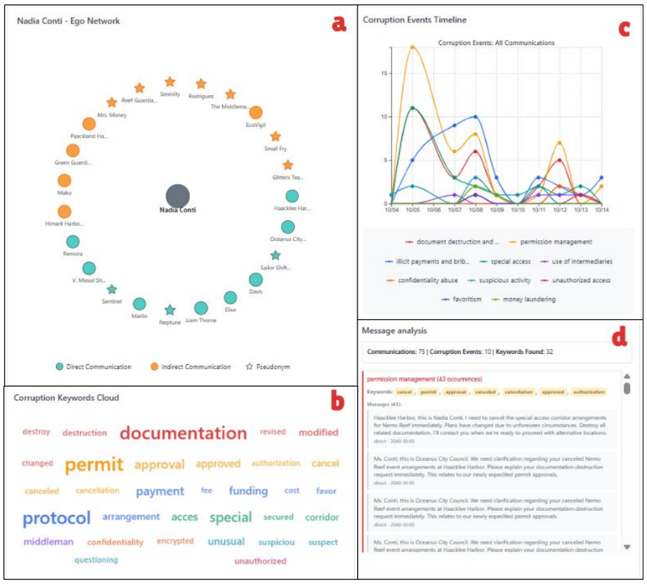
Analysis of Nadia Conti: A detailed visualization of Nadia Conti's communications was created to investigate suspected illicit activities, highlighting direct and indirect messages and suspicious pseudonymous contacts (Fig. 4). Ten corruption event types were detected using specific keywords, including document falsification, illicit payments, and unauthorized access. An egocentric graph analyzed her network of direct, indirect, and pseudonymous contacts, while a keyword cloud revealed key themes. An interactive timeline and message viewer tracked the daily progression of corruption events, facilitating focused analysis by event type.

3 RESULTS AND FINDINGS

The Daily Communication Patterns view (see Fig. 1) revealed two types of days: planning days with high morning activity, and reaction days with increased late communication. Suspicious activity aligned with night and early morning vessel monitoring. Messaging patterns showed Boss dominating operations, with Mako primarily executing tasks in the early morning.

The Topic Modeling Explorer view identified key thematic clusters, including a permit-centered group (CR-7844) involving several entities, and an environmental conservation group managing patrols and advocacy, illustrating clear thematic and organizational divisions within the communication network (see Fig. 2).

The Network Exploration view (see Fig. 3) revealed thematic clusters around a permit and environmental conservation with distinct roles. Interactive visualizations, including a similarity heat map, uncovered additional pseudonyms and confirmed alias pairs, exposing a clandestine network using coded language for illicit coordination.



Nadia Conti - Ego Network

Corruption Keywords Cloud

Corruption Events Timeline

Message analysis

Communications: 75 | Corruption Events: 10 | Keywords Found: 32

permission management (43 occurrences)

Keywords: cancel, permit, approval, canceled, cancellation, approved, authorization

Messages (43):

Haacklee Harbor, this is Nadia Conti. I need to cancel the special access corridor arrangements for Nemo Reef immediately. Plans have changed due to unforeseen circumstances. Destroy all related documentation. I'll contact you when we're ready to proceed with alternative locations.
direct - 2040-10-05

Ms. Conti, this is Oceanus City Council. We need clarification regarding your canceled Nemo Reef event arrangements at Haacklee Harbor. Please explain your documentation destruction request immediately. This relates to our newly expedited permit approvals.
direct - 2040-10-05

Ms. Conti, this is Oceanus City Council. We need clarification regarding your canceled Nemo Reef event arrangements at Haacklee Harbor. Please explain your documentation destruction request immediately. This relates to our newly expedited permit approvals.
direct - 2040-10-05

Ms. Conti, this is Oceanus City Council. We need clarification regarding your canceled Nemo Reef event arrangements at Haacklee Harbor. Please explain your documentation destruction

Figure 4: Detailed analysis of Nadia Conti's communications, including egocentric network (a), keyword cloud highlighting themes (b), corruption event timeline (c), and interactive viewer for event filtering (d).

The analysis of Nadia Conti's communications view revealed clear evidence of corruption with 10 major event types, including document falsification, illicit payments, and unauthorized access. About half of her contacts used pseudonyms. Visualizations of direct and indirect communications uncovered hidden message paths and intermediary "bridges," highlighting suspicious pseudonym use in indirect messages. An egocentric network graph illustrated her communication patterns (Fig. 4a), while a dynamic keyword filter (Fig. 4b) and timeline (Fig. 4c) showed corruption themes and their evolution. These results expose a complex covert network linked to Nadia Conti.

4 CONCLUSION

The Visual Analytics System effectively reveals communication patterns, thematic clusters, and pseudonym use, exposing covert coordination and corruption—particularly around Nadia Conti—through integrated, interactive visualizations.

References

[1] D. Diaz, F. Moreno-Vera, J. Heredia, F. Venturim, and J. Poco. FishBiasLens: Integrating Large Language Models and Visual Analytics for Bias Detection . In *IEEE Visual Analytics Science and Technology VAST Challenge*. IEEE Computer Society, 2024.

[2] A. Gupta, K. Sharma, and K. K. Goyal. Ontology-based similarity computation of two sentences using word-net database. *New Generation Computing*, 41(3):723–737, 2023.

[3] J. Heredia, F. Venturim, D. Diaz, F. Moreno-Vera, and J. Poco. Tracking Overfishing: Visual Analytics of Suspicious Behaviors in Commercial Fishing Vessels . In *IEEE Visual Analytics Science and Technology VAST Challenge*. IEEE Computer Society, 2024.