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A Systematic Approach for Performance Evaluation using Process Mining: The POSIDONIA Operations Case Study

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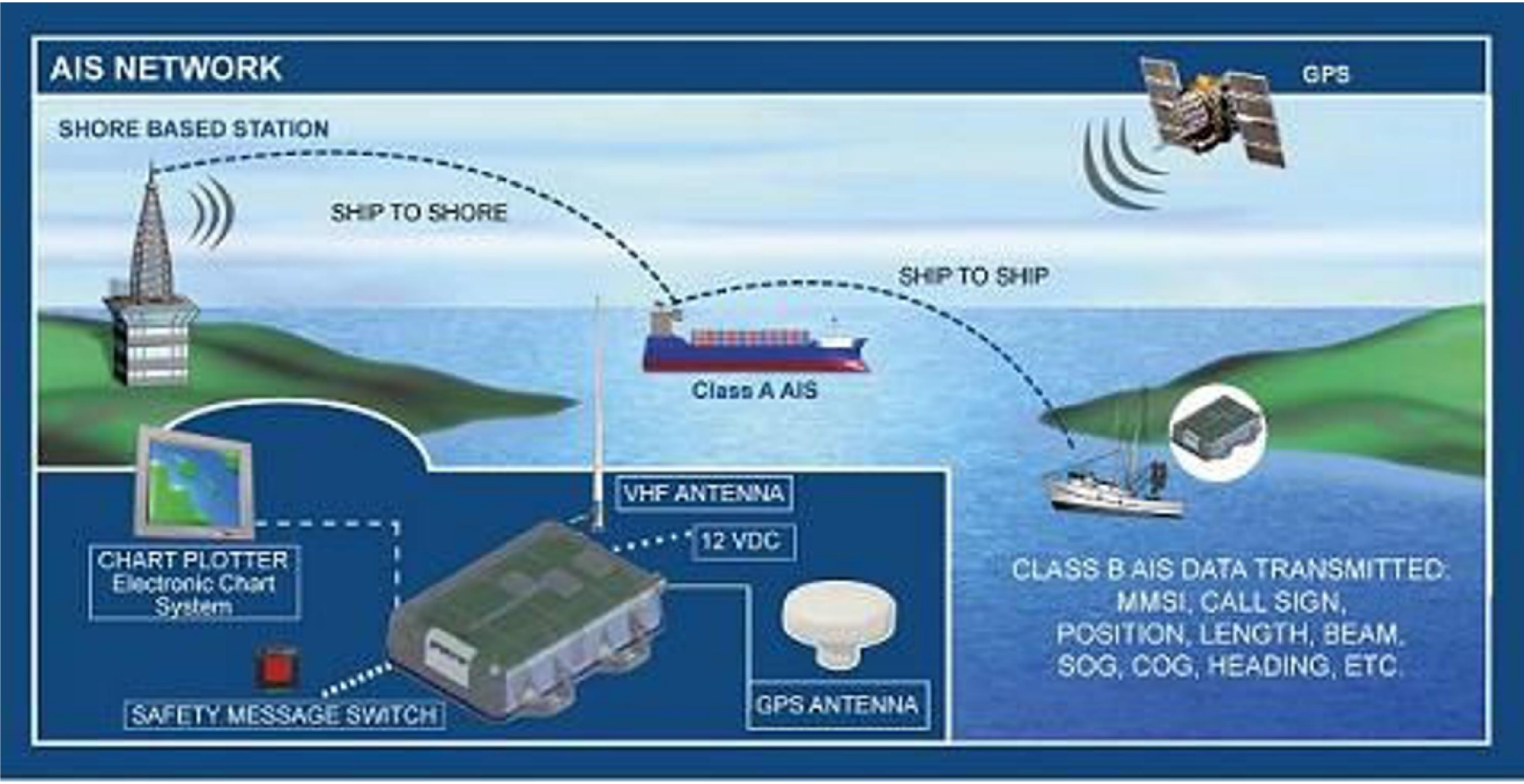
Outline

- POSIDONIA architecture and methodology of our approach
- Obtention of a normative model from a UML design
- Conformance checking of the normative model with respect to execution logs
- Enriching the normative model with temporal information from the logs
- Simulation for model validation and prediction
- Conclusions and future work

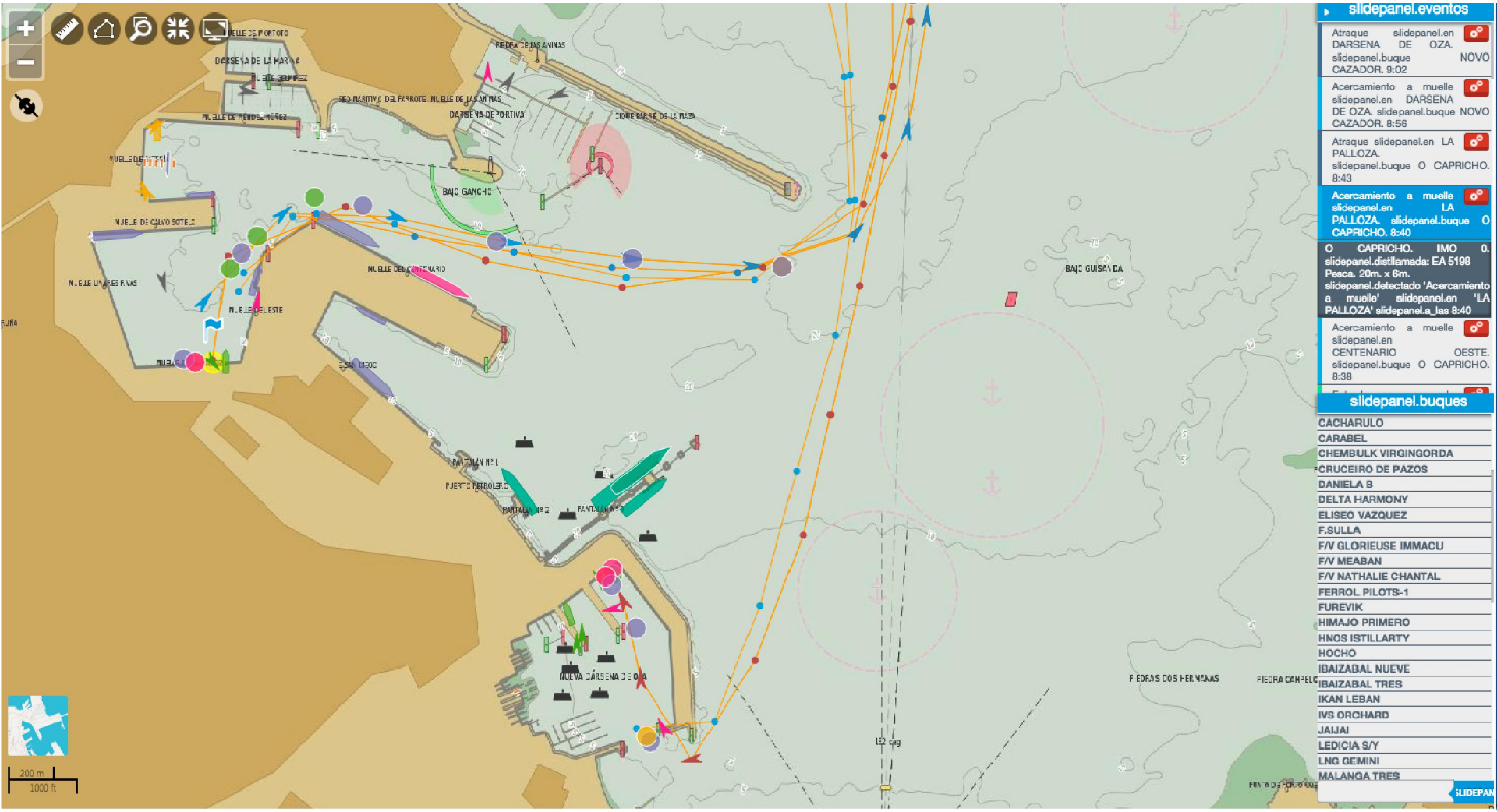
Introduction

- Systematic approach to get a good performance model
  - The quality of the model is based on the fitness estimation of the model with the system data log
- Applied to POSIDONIA: a customizable Integrated Port Operations Management System

POSIDONIA


AIS NETWORK
GPS
SHORE BASED STATION
SHIP TO SHORE
SHIP TO SHIP
Class A AIS
VHF ANTENNA
12 VDC
CHART PLOTTER
Electronic Chart
System
SAFETY MESSAGE SWITCH
GPS ANTENNA
CLASS B AIS DATA TRANSMITTED:
MMSI, CALL SIGN,
POSITION, LENGTH, BEAM,
SOG, COG, HEADING, ETC.

POSIDONIA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Acercamiento a muelle slidepanel.en DARSENA DE OZA. slidepanel.buque NOVO CAZADOR. 8:56
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slidepanel.buques
CACHARULO
CARABEL
CHEMBULK VIRGINGORDA
CRUCEIRO DE PAZOS
DANIELA B
DELTA HARMONY
ELISEO VAZQUEZ
F.SULLA
F/V GLORIEUSE IMMACU
F/V MEABAN
F/V NATHALIE CHANTAL
FERROL PILOTS-1
FUREVIK
HIMAJO PRIMERO
HNOS ISTILLARTY
HOCHO
IBAIZABAL NUEVE
IBAIZABAL TRES
IKAN LEBAN
IVS ORCHARD
JAIJAI
LEDICIA S/Y
LNG GEMINI
MALANGA TRES
DARSENA DE LA MARINA
DARSENA DEPORTIVA
BANC GANCHO
BANC GUISANDA
NUEVA DÁRSENA DE OZA
PIEDRAS DOS HERMANAS
FIEDRA CAMPELO
200 m
1000 ft

Approach

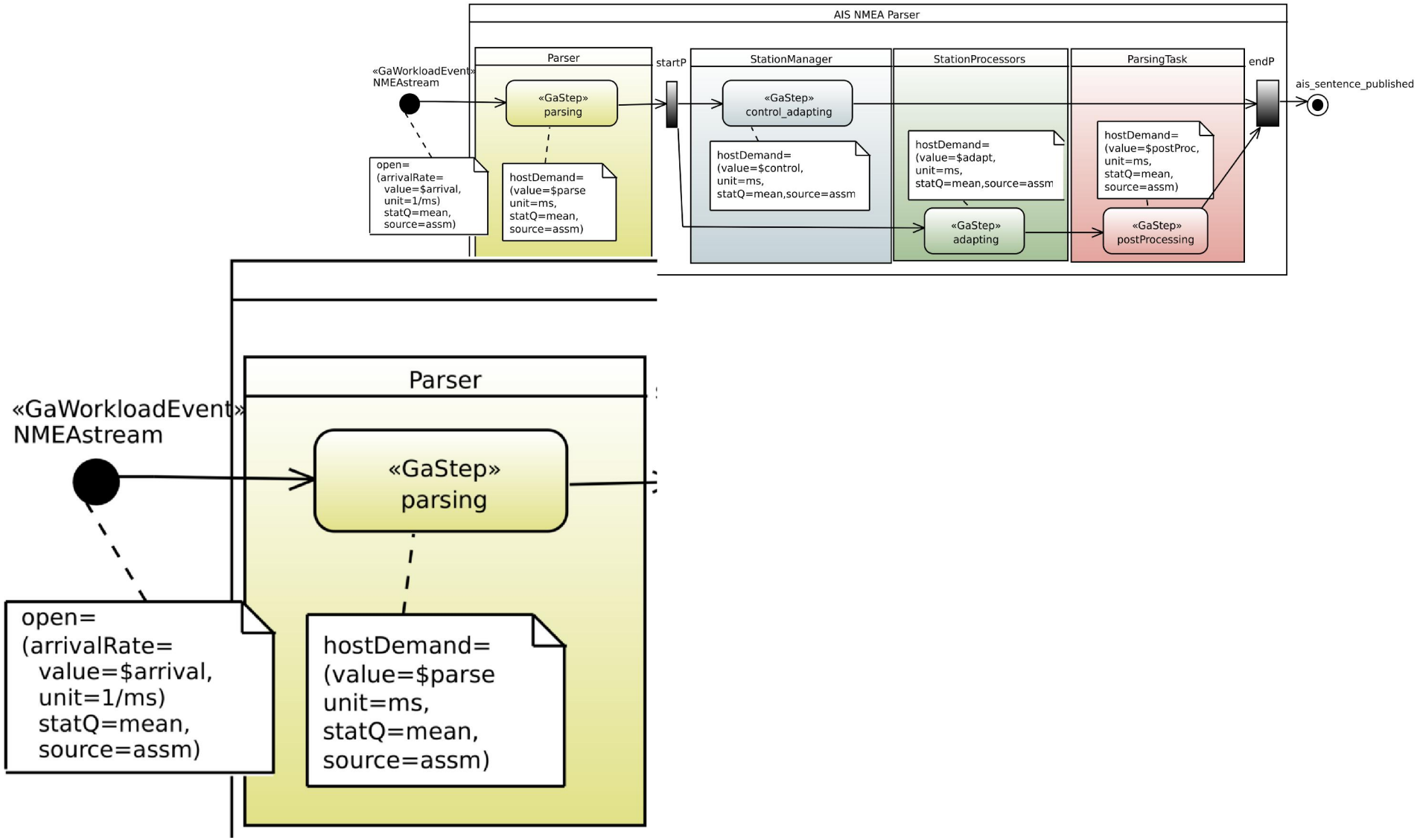
Algorithm 1 Approach

Require: UML design $(\mathcal{A}D, DD)$, data log $(\mathcal{L})$
Ensure: Performance model $(\mathcal{G}SPN)$ & results $(\mathcal{R})$

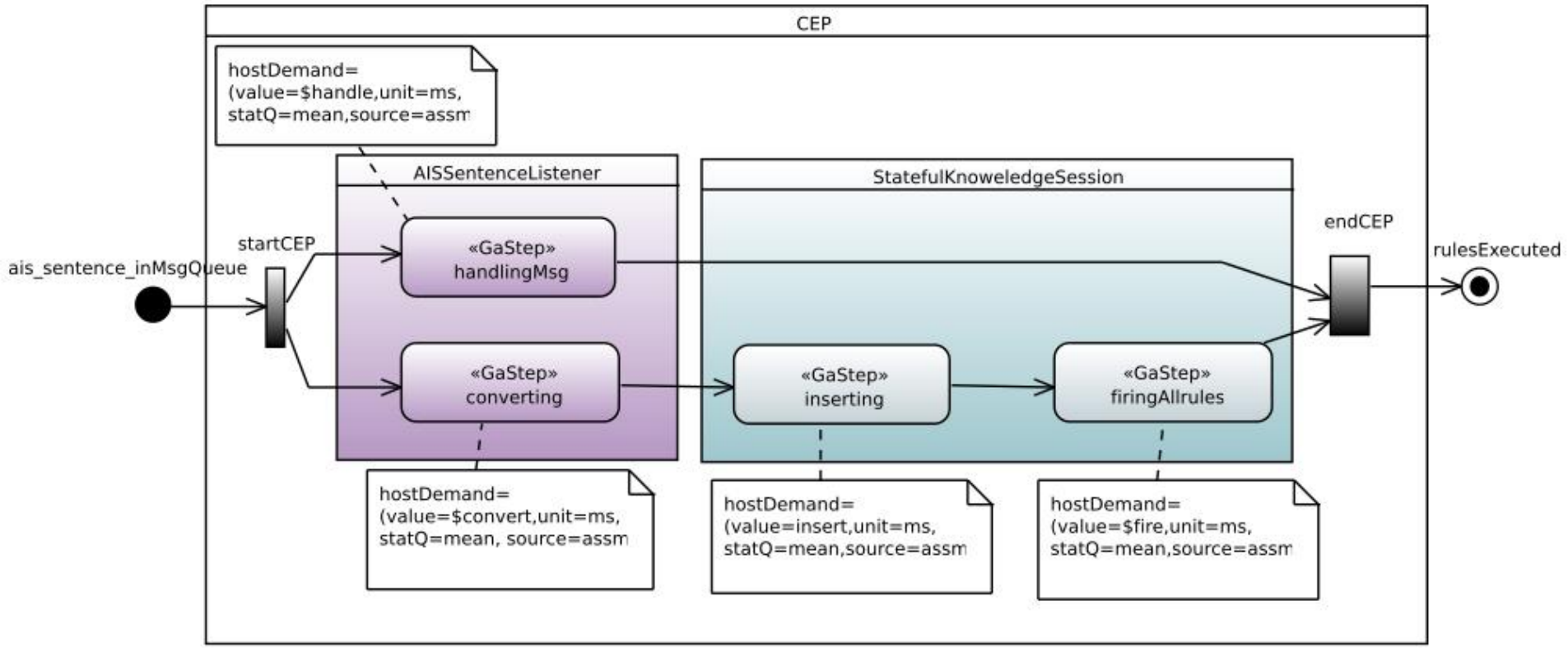
1: Get a normative model $\mathcal{N}$ from $\mathcal{A}D, DD$
2: Pre-process data log to get event log $\mathcal{E}L$
3: **repeat**
4: Filter $\mathcal{E}L$
5: Check for conformance $\mathcal{N}$ and $\mathcal{E}L$
6: **until** fitness $\geq thres$
7: Enhance $\mathcal{N}$ with timing perspective: $\mathcal{G}SPN$
8: Performance analysis with $\mathcal{G}SPN$: $\mathcal{R}$

STEP 1: NORMATIVE MODEL FROM A UML DESIGN

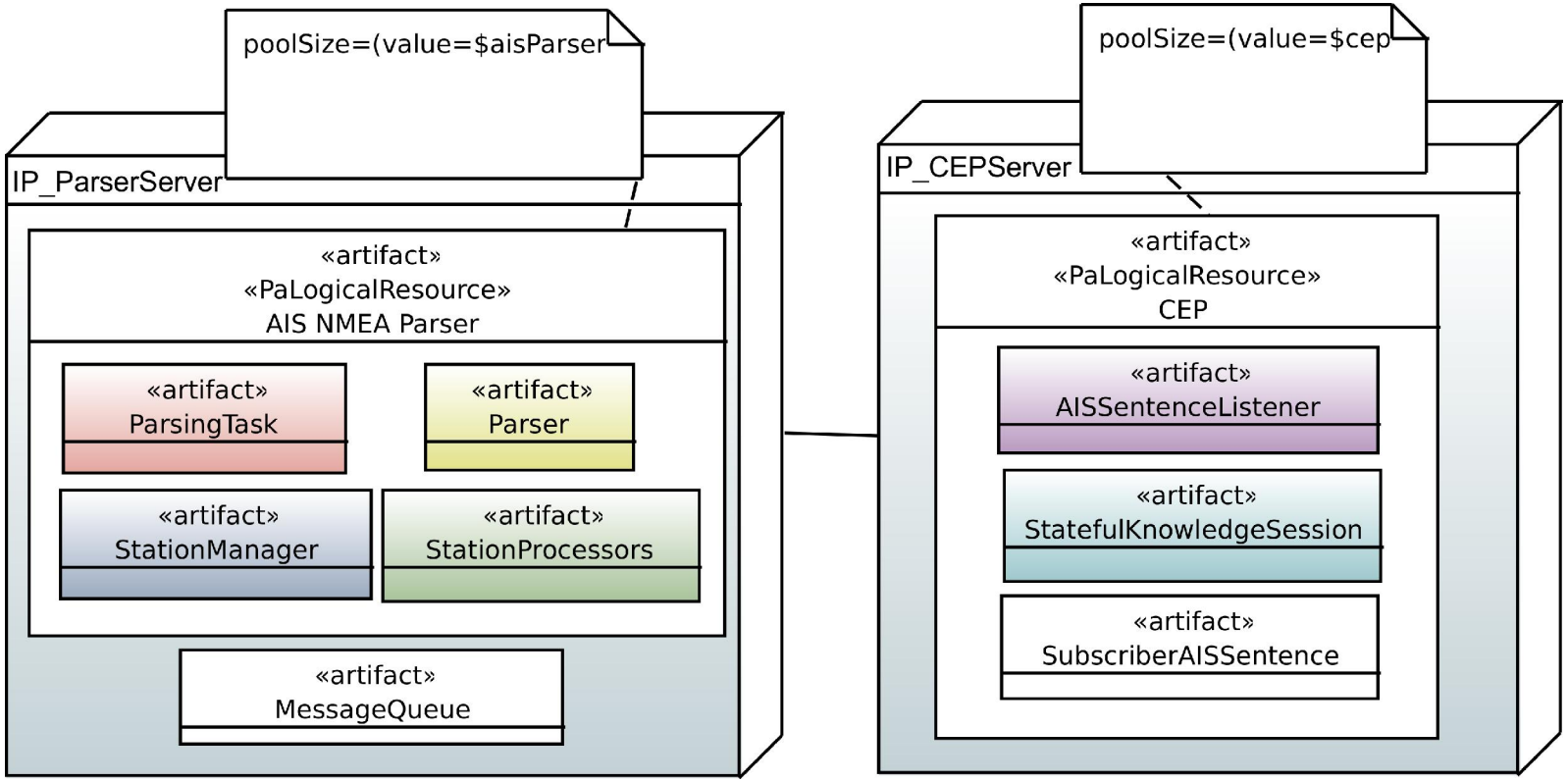
Parser: Activity Diagram



CEP: Activity Diagram

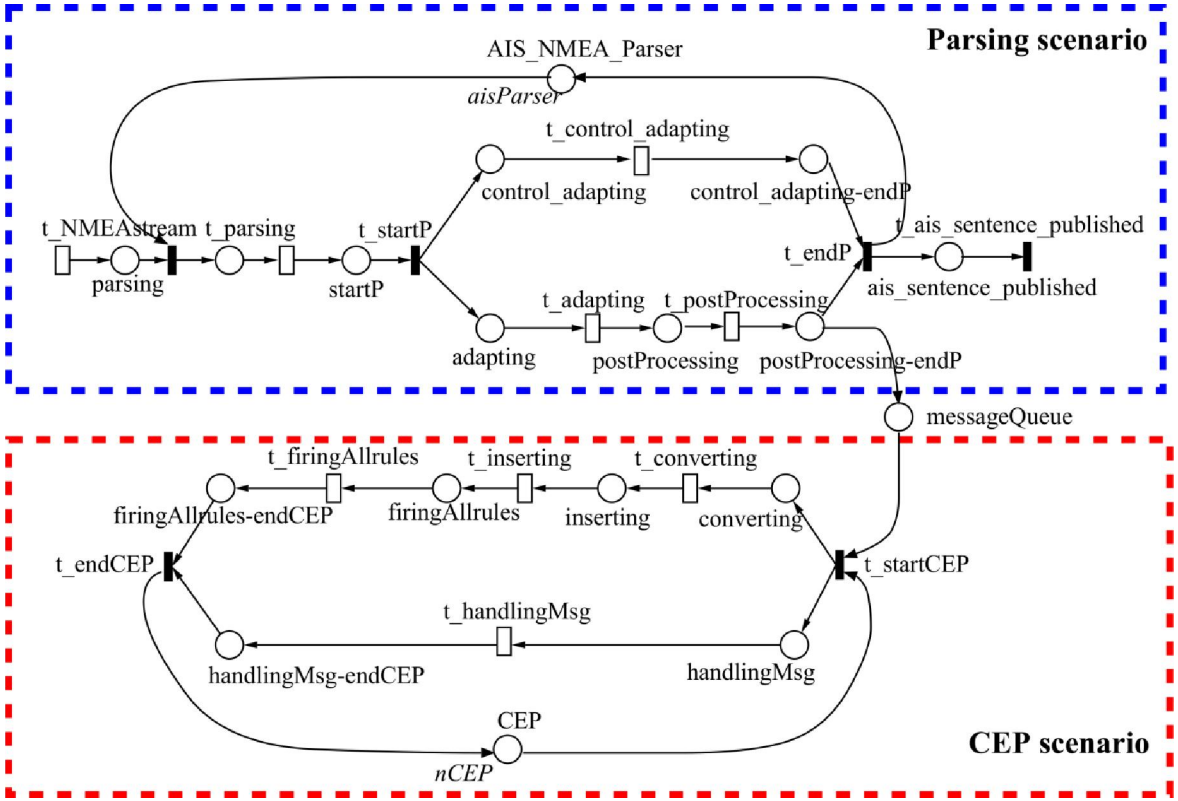


POSIDONIA Deployment



POSIDONIA Normative Model

- Automatic transformation from UML to a Generalized Stochastic Petri net with parameters
- Obtained by the DICE simulator



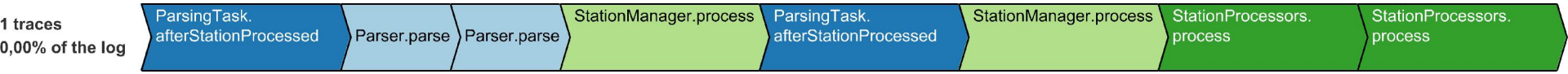
STEP 2: FILTER THE LOG FROM A RUNNING SYSTEM

POSIDONIA Normative Model: Palma Port

- Execution of POSIDONIA in the Palma port
- Initial log size (aprox. 2h)
  - Parser = 4 x 69920 traces
  - CEP = 56698 traces
- The filtering phase detects erroneus traces
  - Some of them are false positives due to the clock precision of the conformance checking tool
- Conformance checking fitness score:
  - 100% over the normative model after filtering (ProM tool)

POSIDONIA Normative Model: Palma Port

- Parser
  - 0,025% (18 traces/parser) start with a wrong event
  - 0,016% (11 traces/parser) finish with a wrong event

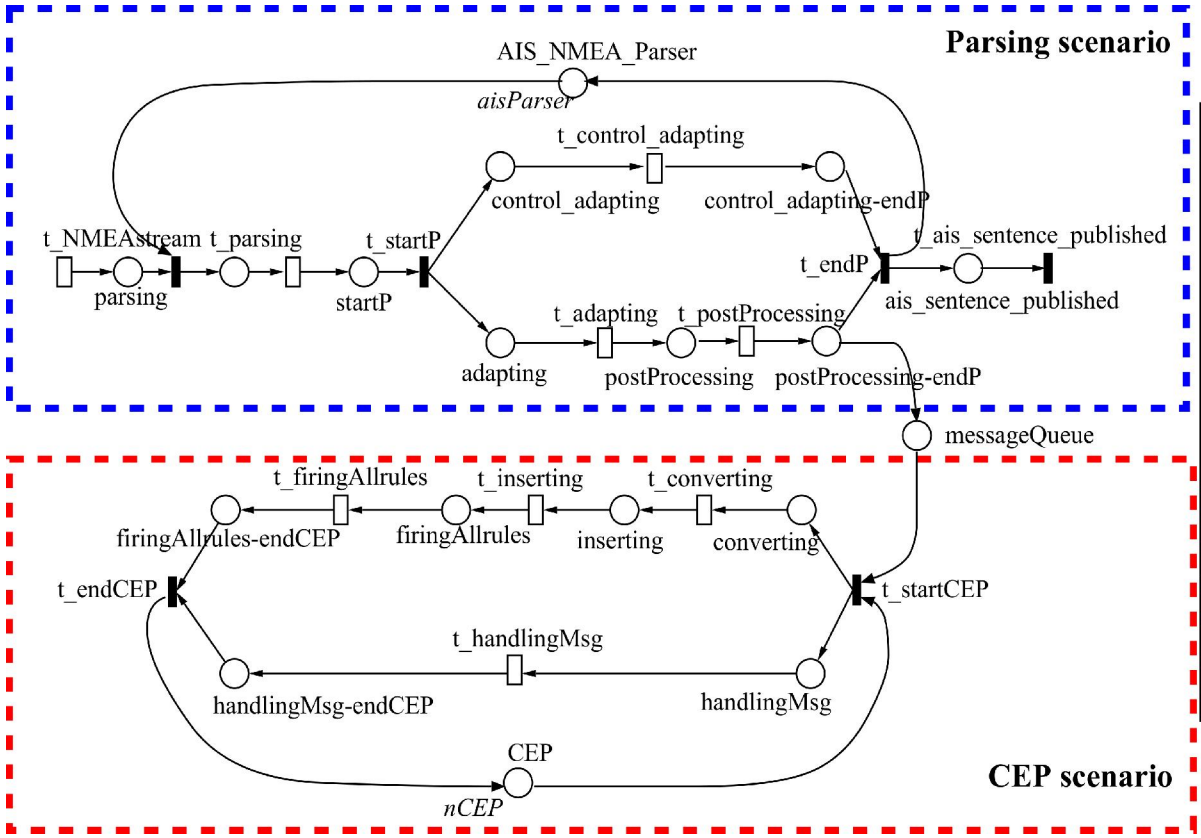


- CEP
  - 5,5% (3065 traces/CEP) are incomplete
  - They include conversion and handling of the message, but not the insertion and firing of the rules

STEP 3: ENHACE THE MODEL WITH TEMPORAL INFORMATION

POSIDONIA Normative Model: Palma Port

- Semi automatic labeling of the GSPN with ProM
- Extraction of temporal information from the log



Transition name	*Time parameter*	*Value(ms)*
t_NMEAstream	1/arrival	0.022(1/ms)
t_parsing	parse	15.780
t_control_adapting	control	0.725
t_adapting	adapt	0.093
t_postProcessing	postProc	0.237
t_handlingMsg	handle	136.800
t_converting	convert	0.160
t_inserting	insert	12.800
t_firingAllrules	fire	102.340
Place name	*Marking parameter*	*Value*
AIS_NMEA_Parser	aisParser	4
CEP	cep	1

STEP 4: PERFORMANCE ANALYSIS WITH GSPN

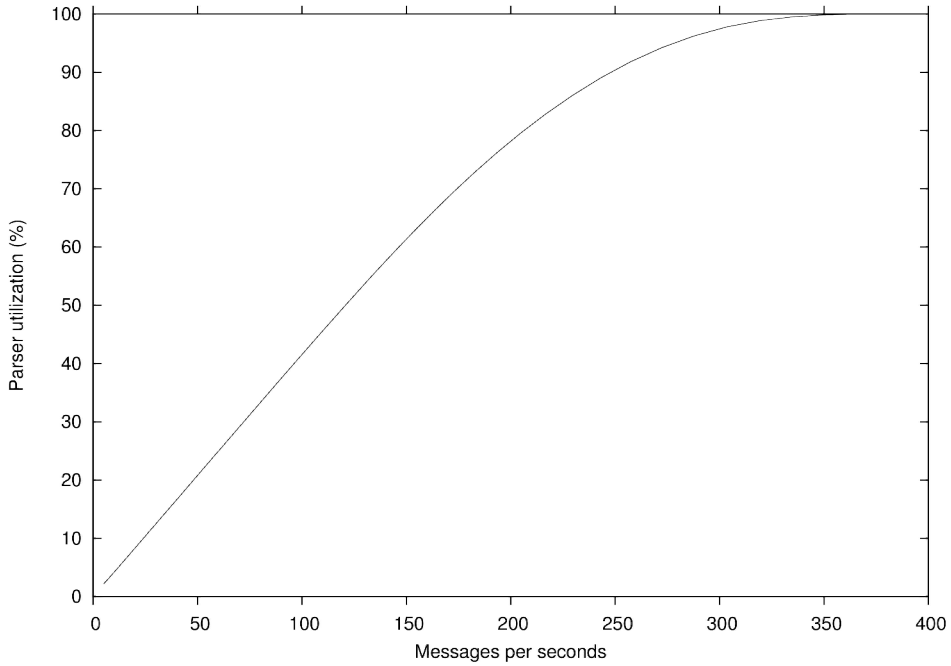
POSIDONIA Normative Model: Simulation

- Event-driven simulator of GreatSPN tool
  - Validation of the temporal model with the current system configuration (good accuracy)
  - Prediction of the behaviour of the system
- Experiment configuration

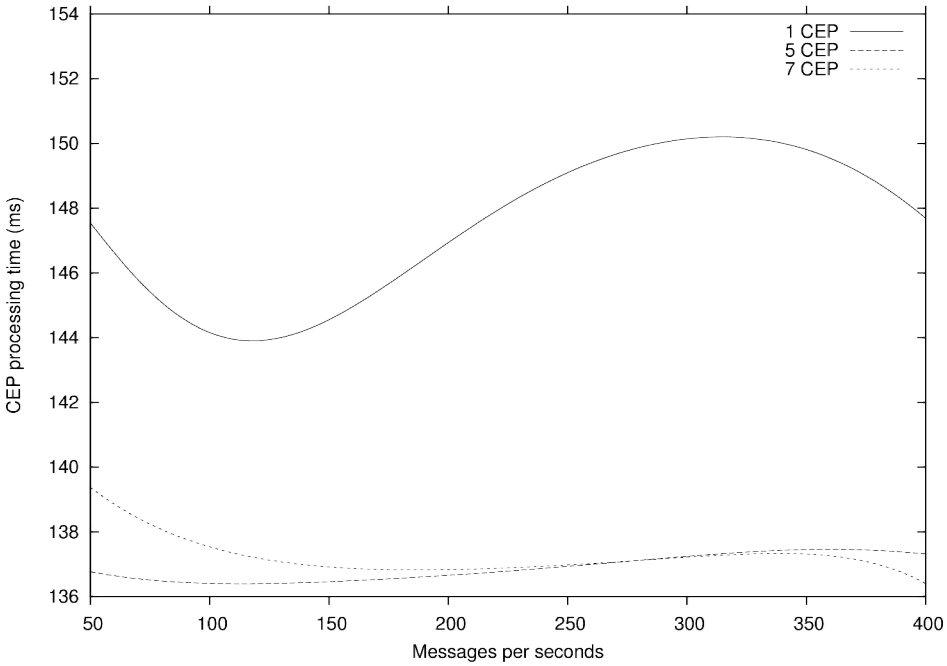
Parsers (threads)	CEP	Mean arrival time (msg/sec.)
1 (4)	1	5
1 (4)	1	7
1 (4)	1	8
1 (4)	5	40
1 (4)	7	15

POSIDONIA Normative Model: Simulation

- Utilization



- Processing time



Conclusions

- Proposed a systematic approach to get a performance model by applying M2M transformation and process mining techniques
- Exemplified with the POSIDONIA Operations case study
- Used complementary tools (GreatSPN, ProM)
- The work has been done inside the DICE project

Future Work

- Investigate the efficiency and scalability of process mining techniques with bigger logs
- Refinement of the CEP business rules