Supply and Maintenance Predictive Modeling and Simulation Analysis Tool

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Big Picture, Challenges, and Goals

- ❑ Marines in combat require a rapid and flexible logistics capability. The USMC's supply and maintenance chain is imperative to apply advanced data sciences and deep analytics which are responsive to the 21st century battlefield.
- ❑ Current status
  - Uses some predictive methods to predict equipment reliability, infers numbers of spare parts to improve stock performance, synchronizes budget execution, and decreases maintenance cycle time.
  - Maximizes throughput capacity at nodes and arcs of logistical networks, to determine the most reliable networks and predict the rate of flow.
  - Forecasts the rate of combat power entering an area of operation, to avoid congestion or delays in operations.
- ❑ More Needs
  - Ability to analyze big data feed from a long chain maintenance, requisition, transportation, manpower, lesson learned, and finance processes, activities, and decisions.
  - Needs models to predict probability of fail (POF), probability of demand (POD), customer wait time, or adequate spare part inventory.
  - Needs optimization models to achieve desired measures of performance (MOP), e.g., minimizing the downtime of personnel and equipment.
  - Needs simulation tools to handle uncertainty and unknown operational conditions

Research Data Set and Pre-processing

- ❑ Global Combat Support System-Marine Corps (GCSS-MC)
  - GCSS-MC provides a deployable, single point of entry for all logistics requirements. GCSS-MC rides on the existing Marine Corps tactical data network and has substantially improved the combat effectiveness of the MAGTF.
  - GCSS-MC also introduces cutting edge enabling technology in support of logistics operations, while facilitating the modernization of aged logistics processes and procedures.
- ❑ LAV (1/2013 to 1/2020)
  - Land Armored Vehicle (LAV)
  - E0949 GCSS-MC Mx Data Pull-analysis

- Aggregate all service tickets

SR_NUMBER	TAMCN	SERVICE_REQUEST_TYPE	DEFECT_CODE	OPERATIONAL_STATUS	ECHELON	MASTER_PRIORITY_CODE	OWNER_UNIT	DATE_CLOSED	OPENED_DATE
11280122	E09497M	Maintenance - CM	PWRT.MDRV	Operational - Degraded	2	06 B-Urgent	M11700	06-SEP-19	10-MAR-14
11280122	E09497M	Maintenance - CM	PWRT.MDRV	Operational - Degraded	2	06 B-Urgent	M11700	06-SEP-19	10-MAR-14
11280122	E09497M	Maintenance - CM	PWRT.MDRV	Operational - Degraded	2	06 B-Urgent	M11700	06-SEP-19	10-MAR-14
11280122	E09497M	Maintenance - CM	PWRT.MDRV	Operational - Degraded	2	06 B-Urgent	M11700	06-SEP-19	10-MAR-14
11280122	E09497M	Maintenance - CM	PWRT.MDRV	Operational - Degraded	2	06 B-Urgent	M11700	06-SEP-19	10-MAR-14

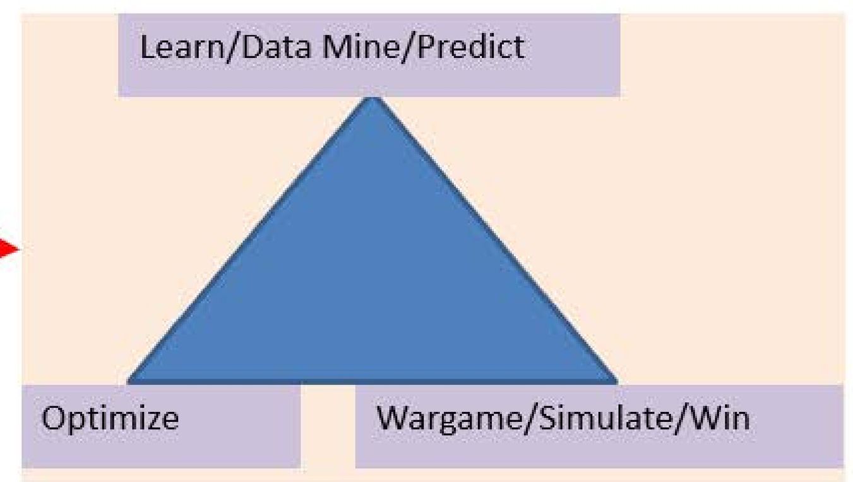
- Maintenance history: unique number of service request types, unique number of defect codes, unique number of operational status, unique number of echelon of maintenance, unique number of master priority code, count of job status dates, count of service cross-references, unique number of service parts, count of service activities, count of task numbers.
- Requisition data: maximum of part charge, count of document numbers, count of parts update dates, count of requirement numbers, count of unit issue, count of item types, count of supply route locations.
- Equipment usage data: owner unit address code, equipment operation time code, and meter reading.

- ~489 independent variables
- Dependent variable = measure of performance (MOP) = the days between opened and closed date more than 65 days (65 days is the mean of the days between the open and close dates
- 2065 service numbers/tickets and 599 (29%) of 2065 have for MOP = 1

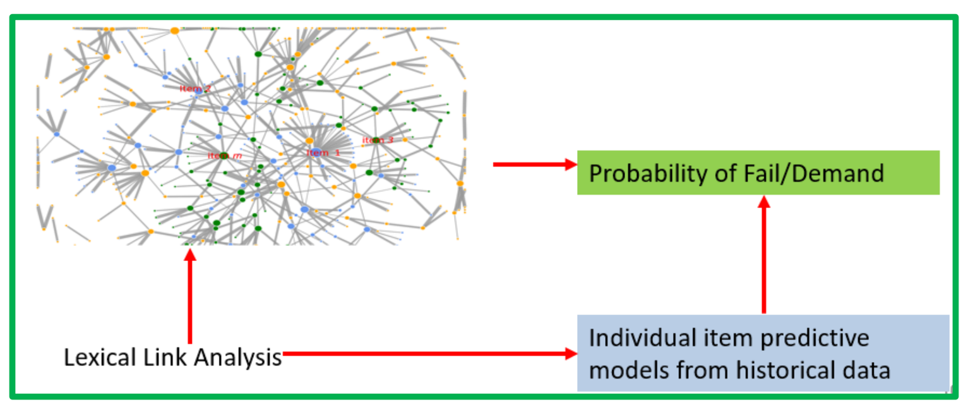
Conclusions and Recommendations

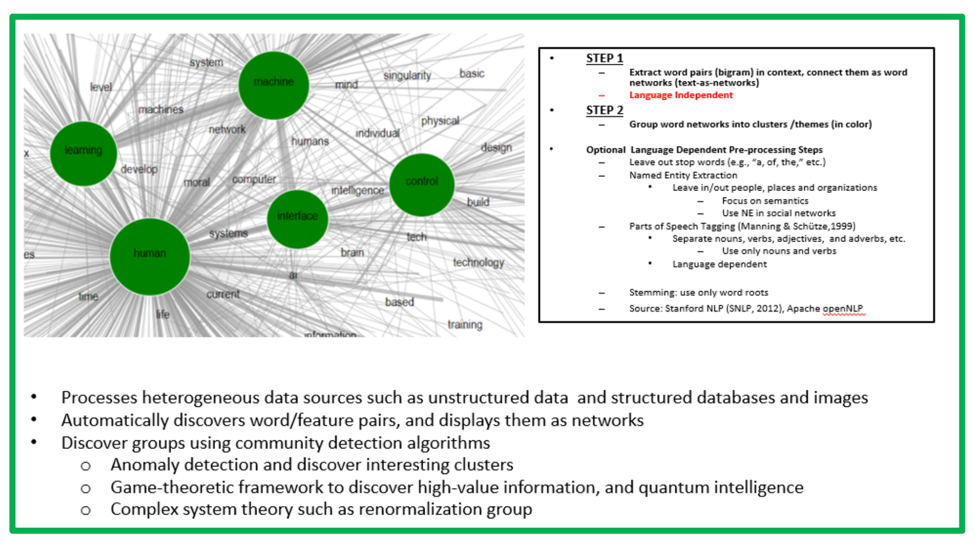
- ❑ We found Soar-RL results comparable in predictive accuracy for predicting the MOP. Since Soar-RL is also rule-based and explainable, it was selected and used in a simulation phase integrated with the coevolutionary algorithms. The simulation shows that in terms of the MOP value, the logistics solutions, on average, worsens in evolution, while the opponent, representing logistics tests, on average, improves in evolution. The algorithms systematically simulate and discover possible new tests or "vulnerability", and evolved solutions or "resiliency" are also discovered. Therefore, the LAILOW framework provides a holistic predictive and simulation platform to improve total readiness of a resilient and agile USMC logistics enterprise.
- ❑ Recommendations: It is imperative for United States Marine Corps (USMC) to adopt more advanced data sciences, including: machine learning/artificial intelligence (ML/AI) techniques to focus on the entire spectrum or end-to-end (E2E) logistic planning for the complex enterprise of maintenance, supply, transportation, health services, general engineering, manpower, lesson learned, and finance. Continuous work in this area jointly with the development of Global Combat Support System-Marine Corps (GCSS-MC) is necessary.

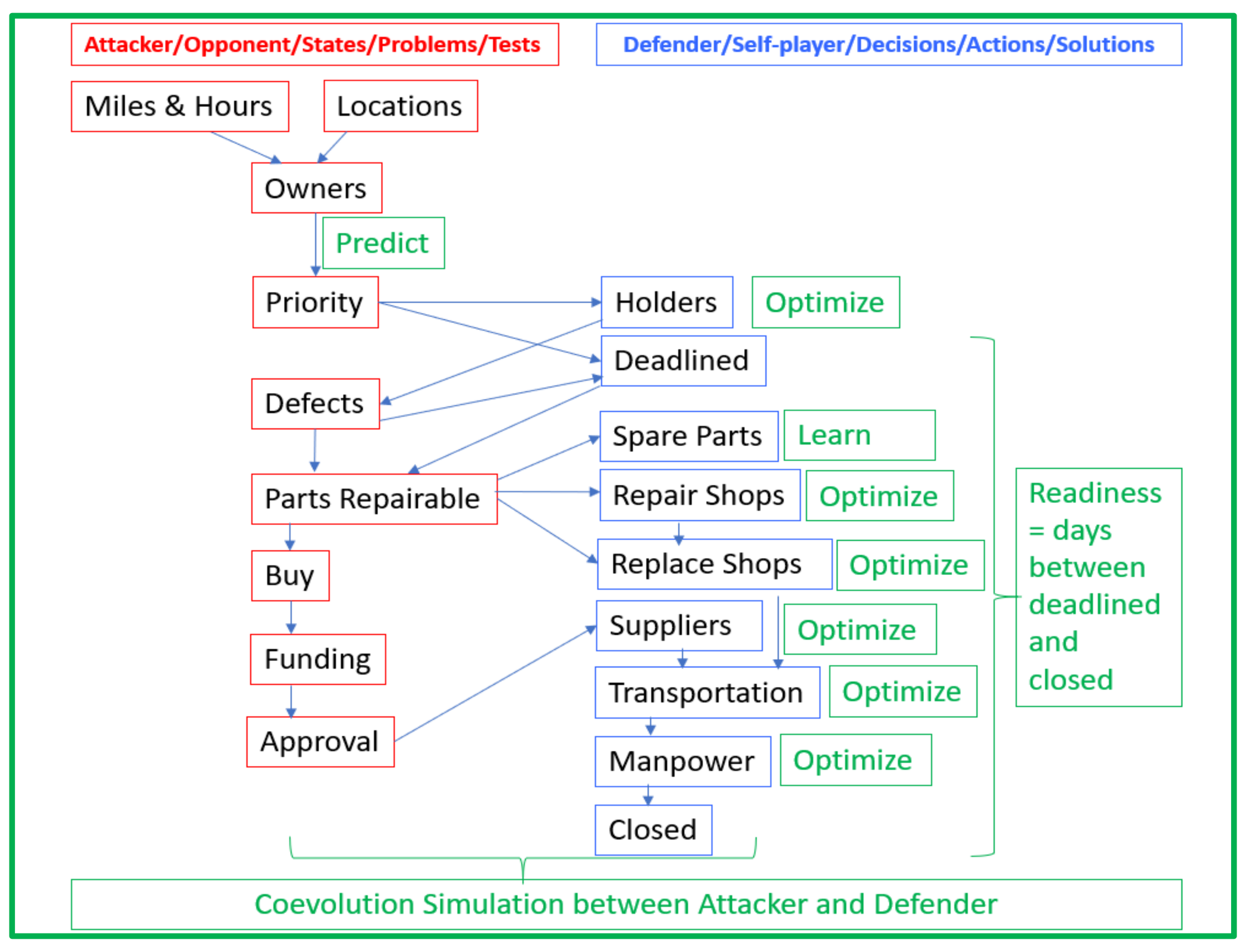
Research Methods



- Databases and data fusion
- Orange: learn/data mine/predict
- Lexical link analysis
  - Learn associations among parts, identify cascade effect part fail/demand and improve prediction
  - Learn process relations
- Soar-RL: rule-based reinforcement learning algorithm used to predict readiness
- Coevolutionary algorithms for simulation and optimization

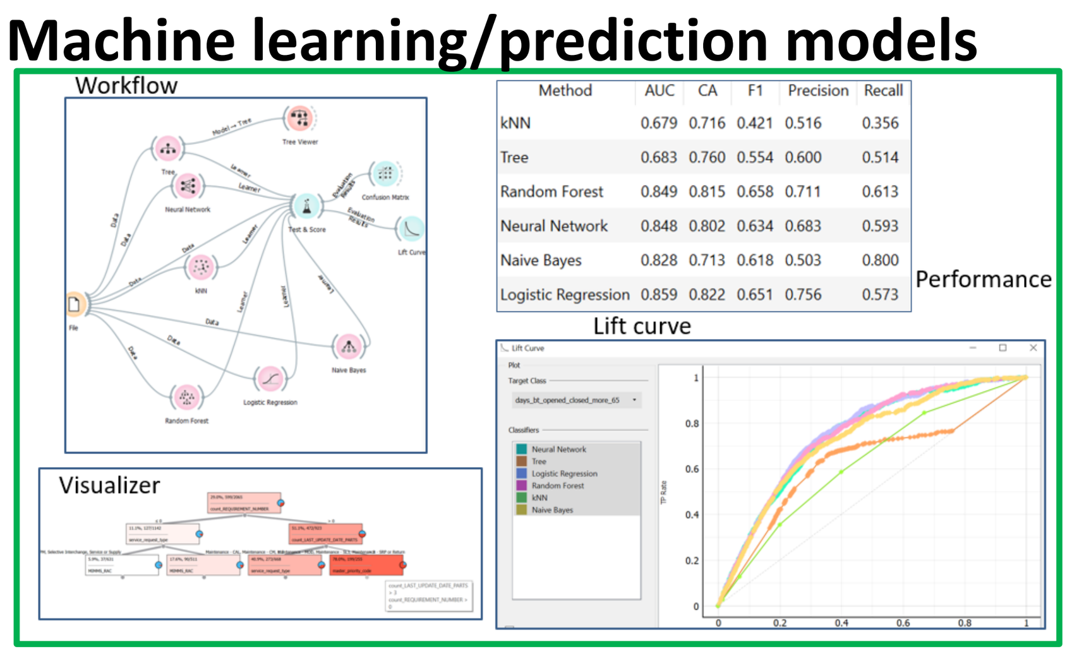




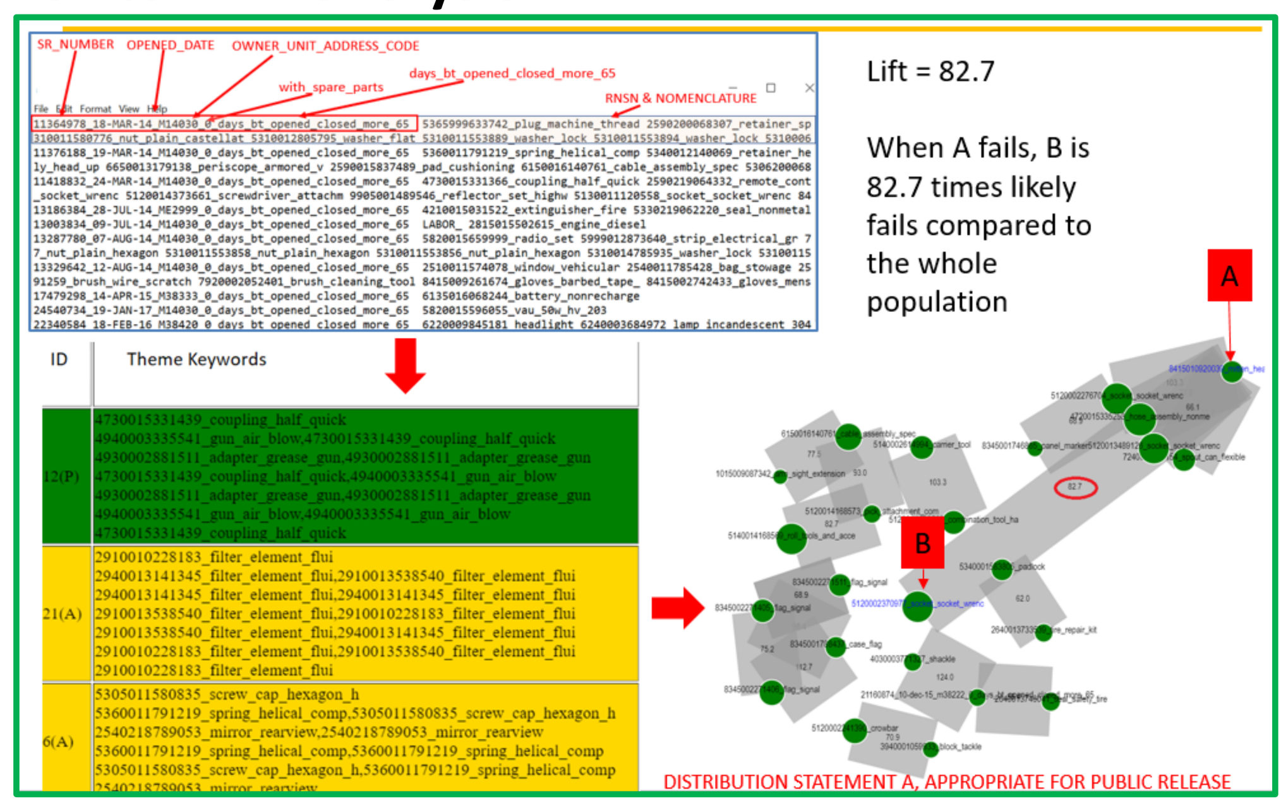


Research Results

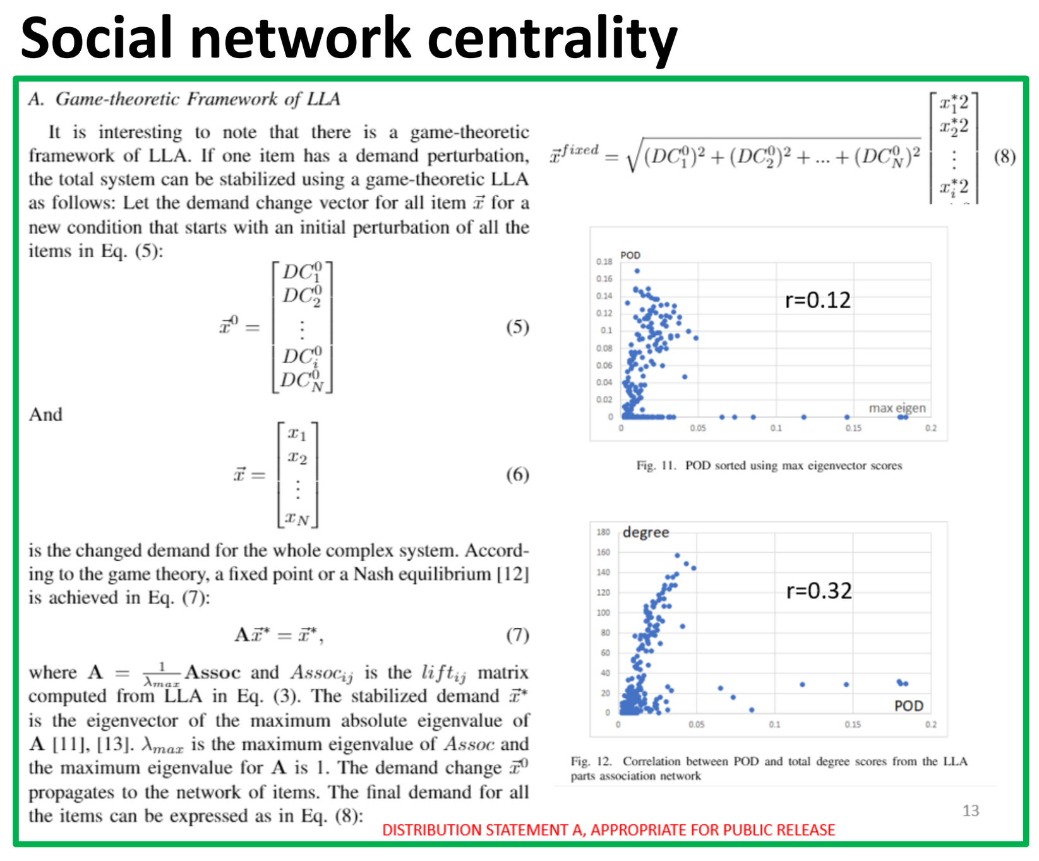
Machine learning/prediction models



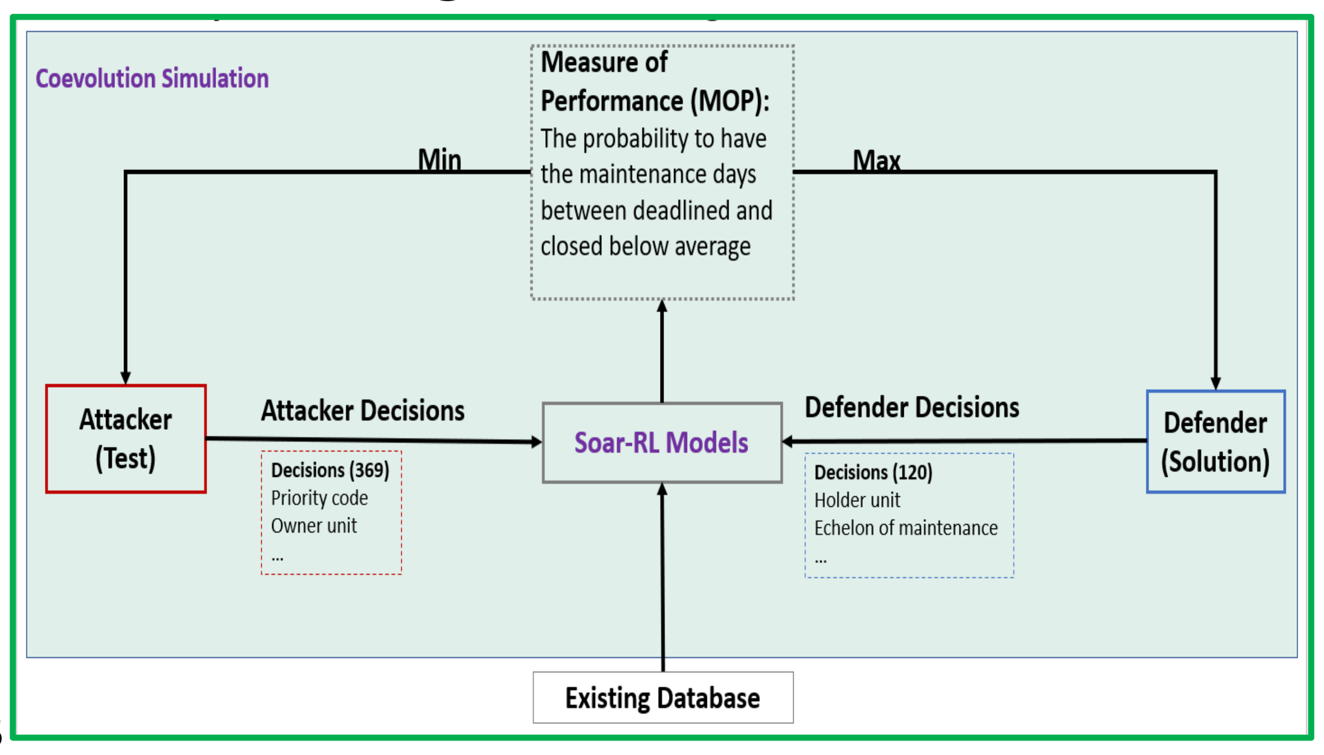
Lexical link analysis



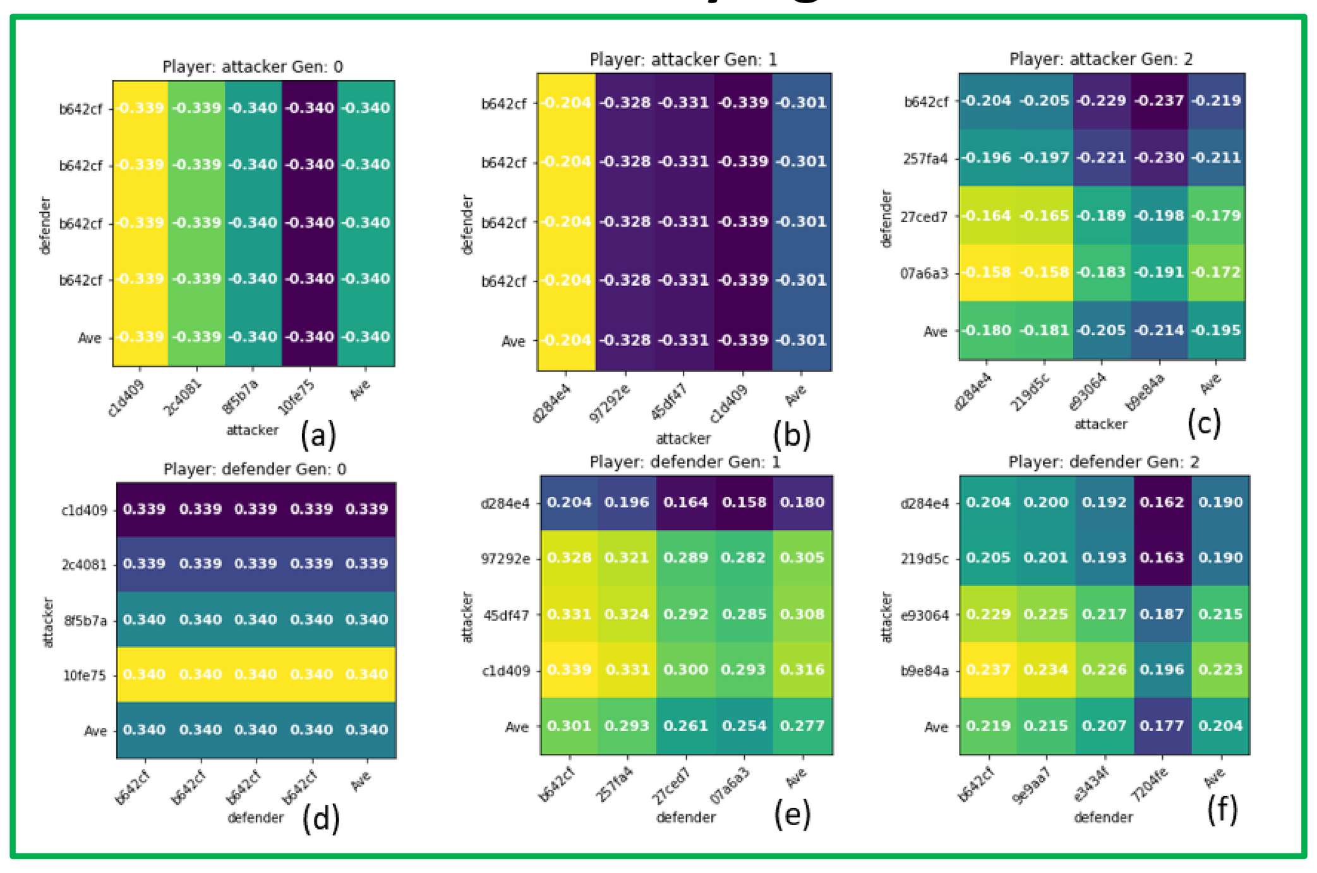
Social network centrality

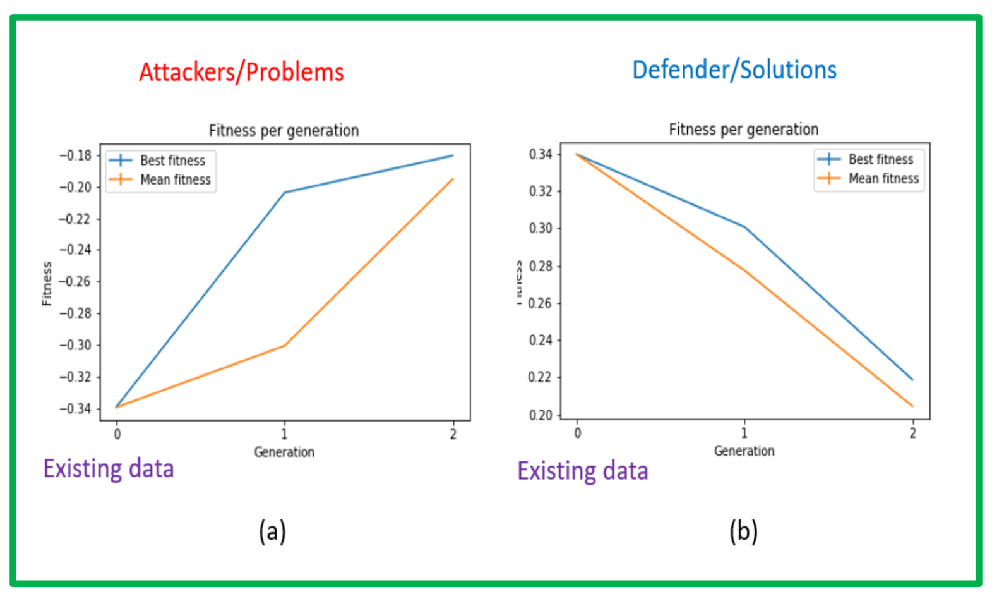


Simulation/Wargame Models



Soar-RL and coevolutionary algorithms





- ❑ Zhao, Y. & Mata, G. (7-10 December, 2020). *Leverage Artificial Intelligence to Learn, Optimize, and Win (LAILOW) for the Marine maintenance and supply complex system.* [Paper presentation]. The 2020 International Symposium on Foundations and Applications of Big Data Analytics (FAB 2020) in conjunction with the IEEE/ACM ASONAM.
- ❑ Zhao, Y., Hemberg, E., Derbinsky, N., Mata, G., & O'Reilly, U. (2021) *Modeling a complex enterprise using an asymmetrical war game leveraging Soar reinforcement learning and coevolutionary algorithms.* [Manuscript submitted for publication].

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