# A report: Understanding Simulation steps in research.

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CENX570: Simulation and Modelling

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This report summarizes how the following research paper accomplishes the steps in simulation study.

"Message Prioritization in Contested and Dynamic Tactical Networks using Regression Methods and Mission Context"

by Rohit Raj Gopalan, Md Hedayetul Islam Shovon, and Benjamin Campbell (Defence Science and Technology); Vanja Radenovic, Kym McLeod, and Leith Campbell (Consilium Technology); and Dustin Craggs and Claudia Szabo (University of Adelaide)

A simulation study has the following steps in general:

1. Defining the problem
2. Setting objectives for simulation and overall project plan
3. Model conceptualization/Model Sketch
4. Data collection
5. Create simulation
6. Verification
7. Validation
8. Experimental design
9. Production run and analysis
10. Completed/ More runs required?
11. Documentation and reporting
12. Implementation

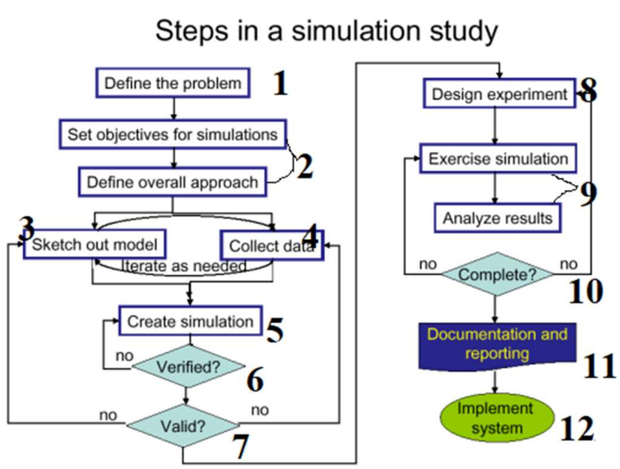


*Figure 1: Steps in a simulation study*

In the research paper in discussion the authors discussed a method for message prioritization for Contested and Dynamic Tactical Networks that may be used for defence communications.

1. **Defining the problem**: The research paper claims that Command and control (C2) information management between the commanders and assigned forces plays a vital role for a successful defence operation. Firstly, human decision makers can be overloaded by the vast range of messages which can come through digital media. Secondly, the network itself can be overloaded due to the restricted and intermittent performance of mobile networks operating in congested and contested radio frequency (RF) environments in complex terrain without fixed infrastructure.

2. **Setting objectives for simulation and overall project plan: A** system is required that can automatically prioritize the messages that have a high impact on the current mission and can reduce the potential cognitive burden. The objective of this experimentation is to investigate the effectiveness of both Linear Regression and Decision Tree models in understanding context for developing predictions that assist message prioritization.

3. **Model conceptualization/Model Sketch:** The researchers demonstrate that these regression-based techniques can effectively assist the message prioritization better than a non-ML approach that relies on a fixed ordering to sort messages.

4. **Data collection:** Robotics Collaborative Technology Alliance (RCTA) developed a module that facilitates the collection of information from the environment, mission and social context; encouraging joint decision making and collaborative operations between humans and AI powered robots. The AI approaches that have been applied include Speech/Gesture Recognition and Natural Language Processing (NLP).

5. **Create simulation:** For both training and experimentation, the authors have generated 20-minute scenarios with hierarchical network topologies consisting of 13 friendly nodes and 40 friendly nodes. These nodes will move through the environment, detect enemies (six enemies for 13-node networks and 20 enemies for 40-node networks) and periodically generate messages to be sent across a basic network simulation environment with network congestion being low, medium and high.

6. **Verification:** Two exemplar regression methods have been applied to generate models for distributed message prioritization. They are Multivariate Regression and Decision Trees. These two methods represent a basic linear regression method and a hybrid method, respectively. Both algorithms utilize the Scikit-Learn API, a Python-based ML library. They have developed individual models for all message and context modifier types using the generated CSV data from the 300, 13-node and 150, 40-node scenarios.

7. **Validation:** The research validates developed individual models for all message and context modifier types using the generated CSV data from the 300, 13-node and 150, 40-node scenarios.

8. **Experimental design:** The model is embedded within a SMARTNet module that will generate Friendly Node Positions every second and will sort messages (in descending order) based on their cost by message size ratio.

9. **Production run and analysis:** Across 300, 13-node scenarios (100 for each congestion level of low, medium and high) and 150, 40-node scenarios (50 for each congestion level), these models were compared against our baseline, a non-ML approach that generates and sends Friendly Node. SOS messages are prioritized first followed by Text, Tactical Graphics, Enemy Detection and Friendly Node Positions.

| # Nodes | Congestion | Linear Regression | Decision Tree |
|---|---|---|---|
| 13 | Low | -326.49% | -9.05% |
| 13 | Medium | 9.27% | 24.16% |
| 13 | High | 3.07% | 2.61% |
| 40 | Low | -67.17% | 26.70% |
| 40 | Medium | 9.50% | 18.58% |
| 40 | High | 11.58% | 7.10% |

*Figure 2: Results showing level of improvement by ML methods over the non-ML approach.*

10. **Completed/ More runs required?:** This depends on obtained results and expected results. Is the model satisfactory for the real implementations?

11. **Documentation and reporting:** The authors successfully demonstrated that linear regression and decision trees can improve message prioritization when compared to a fixed ordering-based prioritization approach. Critically, these methods have been shown to be particularly effective in medium and high congestion scenarios, where prioritization is expected to have the most value.

12. **Implementation:** The next step after this is implementation and integration with actual systems.

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