Projects in the Systems Engineering, Architecture, and Knowledge Lab

Two interdisciplinary projects are available for Systems, MAE, ECE, and CS students in the Systems Engineering, Architecture, and Knowledge Lab. Both projects involve new software development, based on existing code. All software development will be done in Java, Jess (Jave Expert System Shell), and/or Python. Research group website: http://www.selva-research.com

Application Instructions

E-mail Prof. Selva (ds925@cornell.edu) with the following materials:

- Updated CV
- Unofficial transcript
- Short paragraph indicating your motivation and preference for a specific project or projects
- Level of effort (number of credits desired)

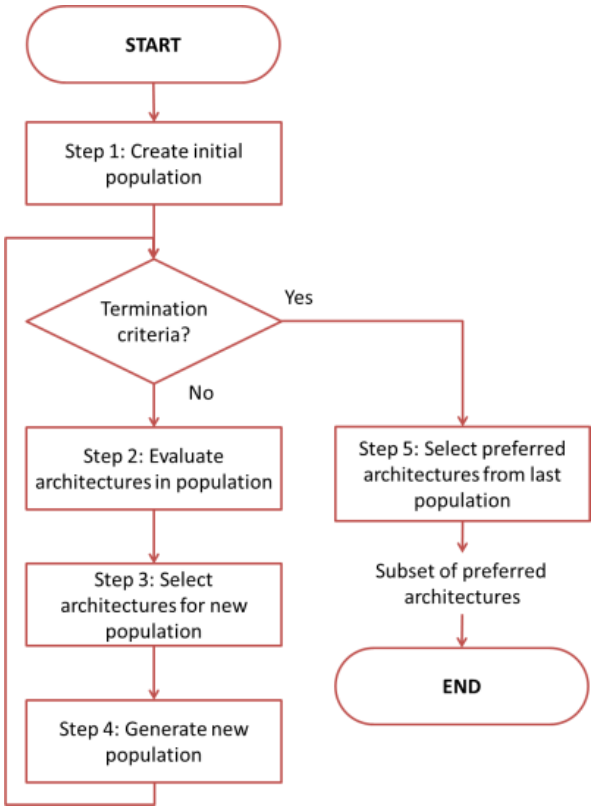
Projects

Agent-based simulation of federated satellite systems

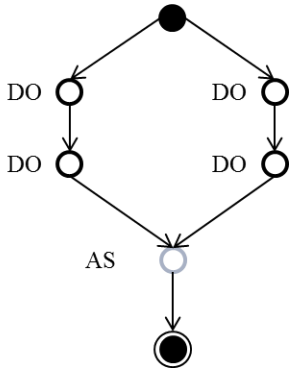
The idea behind federated satellite systems is to create in-space markets of resources between autonomous satellites. These resources could initially be downlink bandwidth or data processing capability, and as technologies become available, more innovative options such as power beaming could be considered. Satellites in a federation only offer resources on an opportunistic basis. For example, satellites that don't fully use their downlink bandwidth during certain periods of time (e.g. when satellites go over the sea/land) could sell that resource to other satellites that need it. Simulation-based analysis is necessary to understand the complex dynamics of the problem (e.g. changing network topology due to celestial mechanics), as well as the behavior of different market-based or other mechanisms for resource allocation (e.g. first-come first-served vs fixed price vs different types of auctions). Of particular interest is the question of whether as a result of these markets, "supplier" satellites that are mostly or exclusively dedicated to support other satellites "emerge" as a good solution, or whether more distributed networks without clear customers or suppliers are possible or even preferable. These simulations will be done using the Madkit multi-agent paradigm. Multi-agent systems are computational models in which the actions of and interactions between a set of autonomous agents (in our case, the satellites) are modeled with the goal of simulating and understanding higher-level emergent behavior. The ideal candidate for this project has expertise in simulation and a strong interest in space applications. Knowledge of basic economics concepts is a plus.

Generation of enumerable architectural models from architecture decision graphs

Heuristic optimization algorithms such as genetic algorithms are often used to solve systems design and architecture problems thanks to their empirically proven performance on a wide range of problems. Despite being relatively easy to use compared to other techniques, heuristic optimization algorithms still require to define an appropriate data structure to encode an architecture in a given problem, as well as appropriate operators, i.e. functions that stochastically and progressively transform architectures with the goal of improving them. An important limitation of this approach is that it is hard to choose the right set of heuristics to solve a given problem, because the performance of a heuristic strongly depends on the problem at hand in ways that are hard to predict. Furthermore, the operators must be tailored to the mathematical structure of the problem. The long-term goal to which this project contributes is to foster code reuse in systems architecture by developing an intelligent tool that automatically selects the right data structure for an architecture, as well as the different operators, based exclusively on the number and mathematical structure of decisions and the relationships between them.



The goal for this particular project is two-fold:



1) Define a set of data structures that represent an architecture space by means of a directed graph. The nodes of this graph represent the architectural decisions, that can be of six canonical types (subset, bipartite matching, surjective bipartite mapping, partition, permutation, adjacency matrix). The edges represent the dependencies between the decisions (e.g. pre-conditions). Data structures must be created for the main entities, namely Architecture, Decision, ArchitectureDecisionGraph, as well as each of the six canonical classes of architectural decisions.

2) Design an intelligent agent that automatically generates an enumerable architecture model (i.e. an enumerable data structure that encodes a system architecture) based on its architectural decision graph and some additional information about the decisions (e.g. allowed options).

The ideal candidate for this project has experience in object-oriented programming and an interest to learn more about systems design and architecture. Notions on good software architecture is a plus.