Flexible and Intelligent Learning Architectures for SoS (FILA-SoS)

PI: Cihan H. Dagli

Nil Ergin, David Enke, Abhijit Gosavi, Dincer Konur, Ruwen Qin, Renzhong Wang, Louis Pape, Siddhartha Agarwal, Ram Deepak Gottapu

Research Task / Overview

FILA-SoS and the Wave Process address four of the most challenging aspects of system-of-system architecting:

1.) Dealing with the uncertainty and variability of the capabilities and availability of potential component systems.

2.) Providing for the evolution of the system-of-system needs, resources and environment over time.

3.) Accounting for the differing approaches and motivations of the autonomous component system managers.

4.) Optimizing system-of-systems characteristics in an uncertain and dynamic environment with fixed budget and resources

FILA-SoS does so using straightforward system definitions methodology and an efficient analysis framework that supports the exploration and understanding of the key trade-offs and requirements by a wide range system-of-system stakeholders and decision makers in a short time.

FILA-SoS

Initialize SoS

Enter Input values required to run the FILA-SoS which include the number of negotiation cycles, meta-architecture generation model selection type and individual system negotiation model types

Develop/ Evolve SOS

Send connectivity request to individual systems and start the negotiation between SoS and individual systems

Implement SoS Architecture

Evaluate the negotiated architecture quality and decide to renegotiate or move on to the next acquisition wave

Conduct_SoS_Analysis

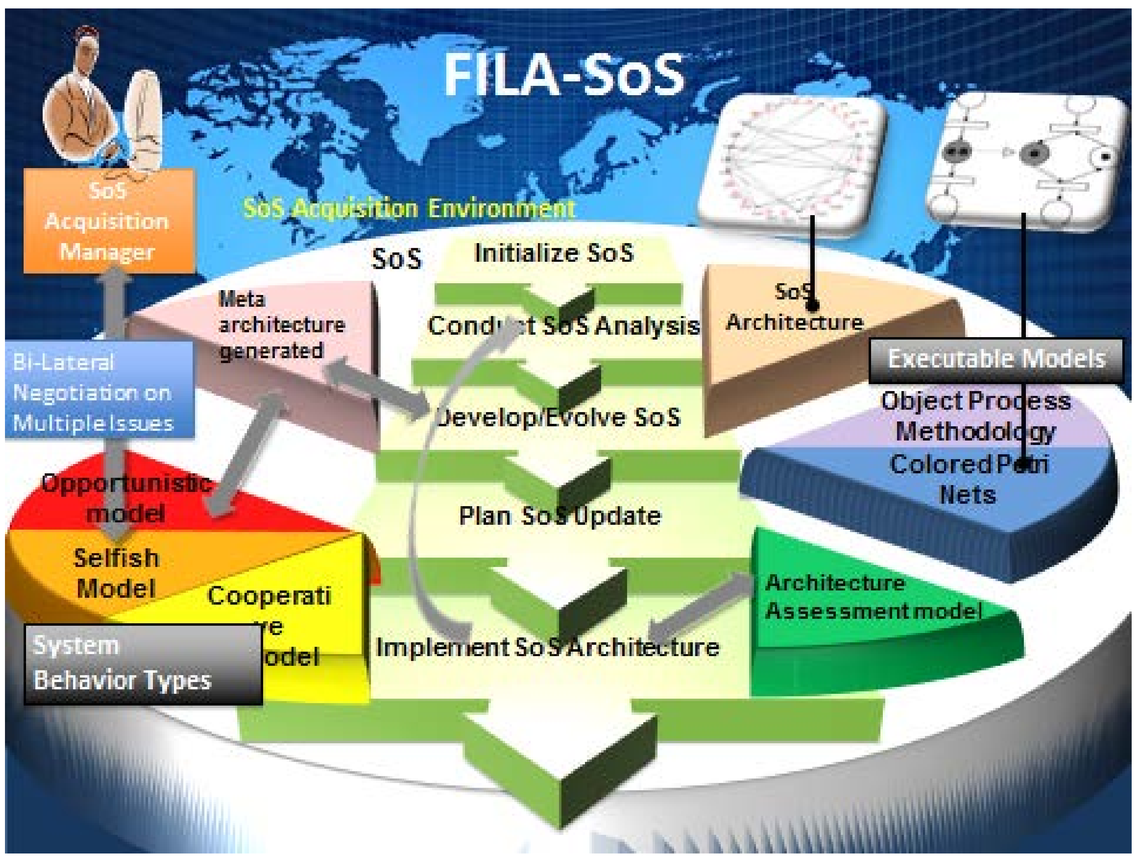
Execute the meta-architecture generation model which selects an initial SoS baseline architecture using the given input data

Plan SoS Update /

Determine which systems to include based on the negotiation outcomes and form a new SoS architecture

SoS Behavior Object Process Model

Run SoS behavior model (Colored Petri Nets) for overall functionality and capability of the meta-architecture



Acknowledgement: This material is based upon work supported, in whole or in part, by the U.S. Department of Defense through the Systems Engineering Research Center (SERC) under Contract H98230-08-D-0171. SERC is a federally funded University Affiliated Research Center managed by Stevens Institute of Technology.

FILA-SoS Capabilities

Integrated model for modeling and simulating SoS systems with evolution for multiple waves.

Models can be run independently and in conjunction with each other

Model both SoS behavior and various individual system behavior

Study negotiation dynamics between SoS and individual systems

Methodology

SoS Architecture Assessment Model

Capture multiple stakeholder's understanding of key performance attributes accounting for their non-linearity. Determine the value of the attributes and evaluate the quality of a given architecture.

Fuzzy-Genetic Optimization Model

Multi-objective optimization of architecture consisting of systems and their interfaces with dynamic assessment of domain inputs

Multi-Level Optimization Model

Generic mathematical model for SoS architecting with efficient evolutionary algorithm for solutions

SoS Negotiation Models

Game theoretic negotiation model for maximizing the welfare for parties involved in the negotiation and Incentive contract design to persuade uncooperative systems to join the SoS development

Individual System Behavior Models:

Non-Cooperative model (Selfish behavior): A negotiation protocol that defines how negotiations are initiated, continued, and terminated. A decision framework of contract negotiation.

Semi-Cooperative (opportunistic behavior): Markov-chain based model designed for handling uncertainty in negotiation with ability to model very selfish to very selfless behavior

Cooperative: Negotiate multiple issues simultaneously with negotiation protocol. Illustrates the cognitive and financial aspects of human negotiations. Bilateral negotiation mechanism

Execute the negotiated Architecture through Object Process Methodology and Colored Petri Nets

Model the interactions between components. Access various behavior related performance of a SoS through simulation. Access different constitutions or configurations of the SoS

Future Research

What is the impact of different constituent system perspectives regarding participating in the SoS on the overall mission effectiveness of the SoS?

How do differing levels of cooperativeness in participating in the SoS impact the ability and timeliness of a group to agree on a SoS or system architecture? Or impact the ability to effectively use the architecture already in place?

How should decision-makers incentivize systems to participate in SoS, and better understand the impact of these incentives during SoS development and effectiveness?

Research Team & Contact Information

Principal Investigator: Dr. Cihan Dagli, Missouri S&T
Dr. Nil Ergin, Assistant Professor, Penn State University
Dr. David Enke, Professor, Missouri S&T
Dr. Abhijit Gosavi, Associate Professor, Missouri S&T
Dr. Dincer Konur, Assistant Professor, Missouri S&T
Dr. Ruwen Qin Assistant Professor, Missouri S&T
Dr. Renzhong Wang, Former Postdoctoral Fellow, Missouri S&T (Currently with Sprint Research Lab)
Louis Pape, Siddhartha Agarwal, Ram Deepak Gottapu, System Engineering PhD Students, Missouri S&T
Contact: Dr. Cihan H. Dagli, Founder and Director of Systems Engineering Graduate Program, Missouri S&T, dagli@mst.edu