Task Value Calculus:
Multi-objective Trade off Analysis using Multiple-Valued Decision Diagrams

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Abstract

Traditional multiple-objective optimization algorithms focus on continuous input variables. Given that many decision variables in government and industry settings such as the number of employees to hire or the number of computers to purchase are discrete rather than continuous, we develop a multiple-objective optimization framework known as Task Value Calculus (TVC). TVC allows for fast multiple-objective optimization in discrete systems by the use of the Multiple-Valued Decision Diagram (MDD) data structure. TVC has no requirements for mathematical models of objective functions and interfaces with a simple Graphical User Interface, making it suitable for use by both laypersons and domain experts.

Multiple-Objective Optimization

Problem Statement:
- Conduct optimization across multiple objective functions simultaneously

Current Approaches:
- *A priori* methods force the user to rank-order the objective functions by importance
- *A posteriori* methods present the user with pareto-optimal trade-offs between objective functions

Shortcomings:
- Existing algorithms are complicated for a non-technical user
- Requires mathematical modeling of objective functions
- Lack of support for discrete variable systems
- Slow runtime for large problems

Multiple-Valued Decision Diagrams

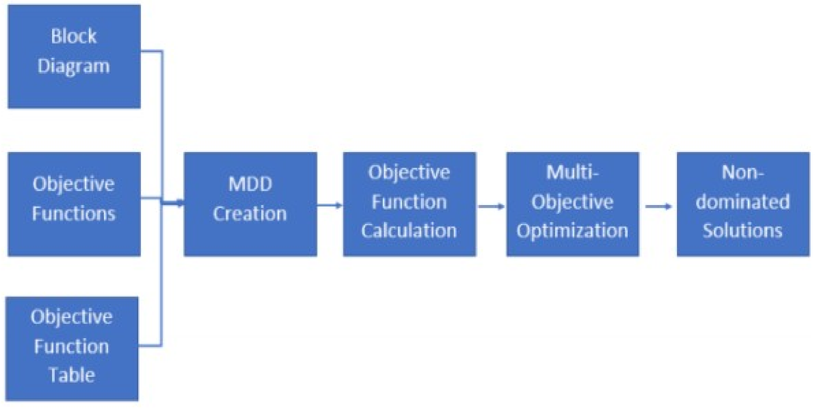
Characteristics:
- Represent discrete variable systems
- Efficient storage and traversal for large problems
- Naturally interface with simple block diagram GUI

MDDs for Optimization

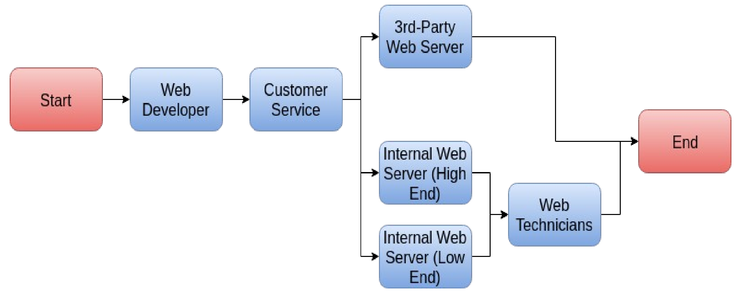
Requirements:
- Model objective functions with discrete variables
- Model system with block diagram representation
- Map system inputs to objective functions
- Traverse MDD to optimize objective functions
- Present set of pareto-optimal choices to the user

Features:
- Simple user interface
- Fast iteration of MDD for large problems
- Easy to model objective functions with discrete values
- Visualize trade-off between objective functions
- Flexible to different objective functions

Applications:
- Business hiring/purchasing decisions and cost benefit analysis
- Interplay between cost, time, and reliability



Block Diagram Example



Objective Functions Example

State	0	1	2
Web Developer	50	75	100
Web Technicians	20	40	60
Customer Service	25	50	75
Low-End Server	5	10	15
High-End Server	25	50	75
3rd-Party Server	50	100	150

Conclusions

- Efficient multiple-objective optimization for large problems and many objectives
- Simple user interface
- Simple modeling of objective functions as discrete variables and no mathematical modeling required
- Future work includes heuristics for faster MDD traversal and increased flexibility for different types of objective functions