ASEC 2025 Conference
The 6th International Electronic Conference on Applied Sciences
09–11 December 2025 | Online

Construction Simulation Optimization Using VRTs

Mohammed Mawlana[1], Amin Hammad[2]
1 Department of Construction Management, Thomas Jefferson University, Philadelphia, USA
2 Concordia Institute for Information Systems Engineering, Concordia University, Montréal, Canada

INTRODUCTION & AIM

Simulation is often coupled with an optimization algorithm to optimize the construction operations. However, the major drawback of the current stochastic simulation optimization methods is that they require a long computational time and may present inferior solutions in the final Pareto front.

Objective

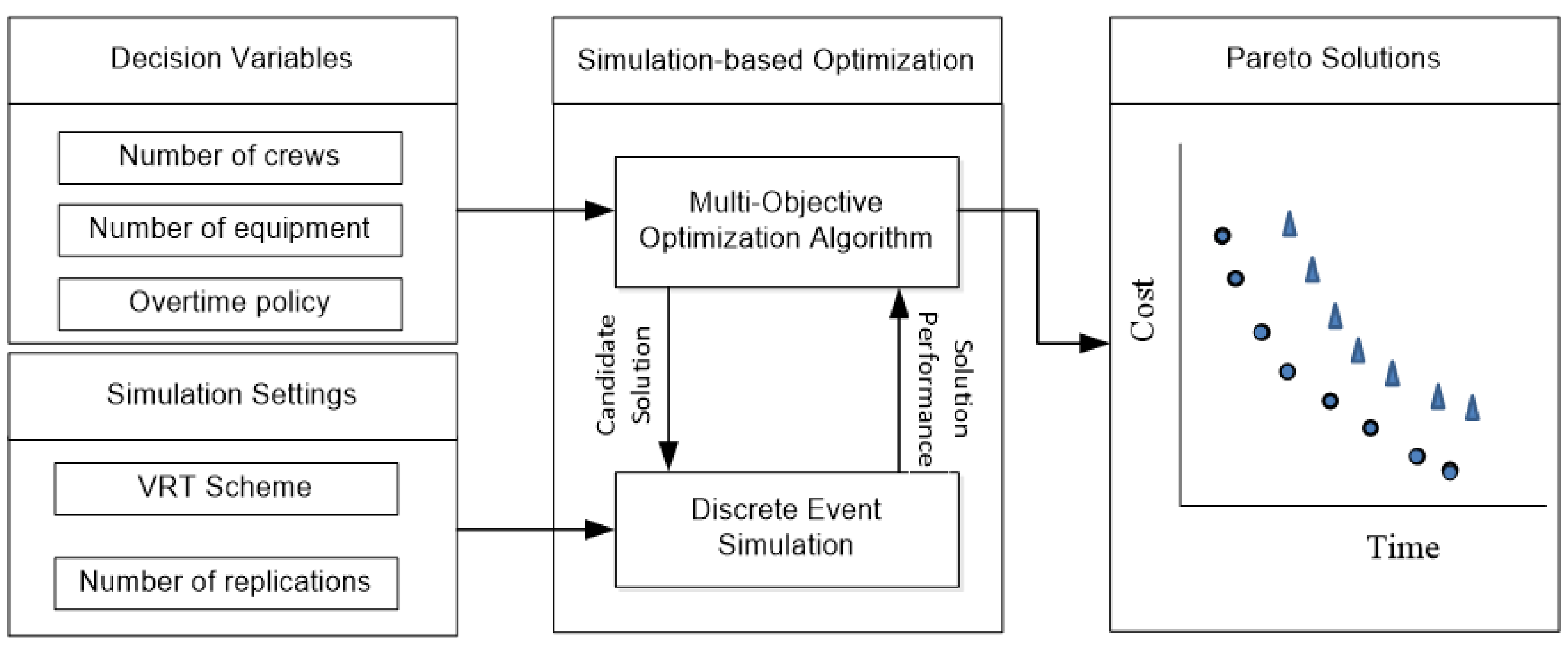
To investigate the benefits of incorporating Variance Reduction Techniques (VRTs) in discrete event simulation optimization problems with a large and discrete set of decision variables.
Three VRTs are used: Common Random Numbers (CRN), Antithetic Variance (AV), and combined CRN+AV

Anticipated Benefits

Reduce the computation time.
Improve the quality of the optimal solutions.
Increase the confidence in the optimality of the solutions.

METHOD

Proposed Framework



Integration Algorithms

DES Optimization Algorithm Under CRN

```
Generate and store seed number
Initialize population
FOR each population until termination DO
  FOR each solution in a population
    Run simulation
      IF j = 1 Then generate streams using seed number
      ELSE continue from last random number
      END IF
    Calculate duration and cost
  Sort population and apply genetic operators
RETURN Pareto solutions
```

DES Optimization Algorithm Under AV & CM

```
Generate and store seed number if CM is used
Initialize population
FOR each population until termination DO
  FOR each solution in a population
    Run simulation
      FOR each standard replication
        IF p = 1 Then generate streams using seed number
        ELSE continue from last random number
        END IF
      FOR each antithetic replication
        Use complimentary random numbers
    Calculate duration and cost
  Sort population and apply genetic operators
RETURN Pareto solutions
```

RESULTS & DISCUSSION

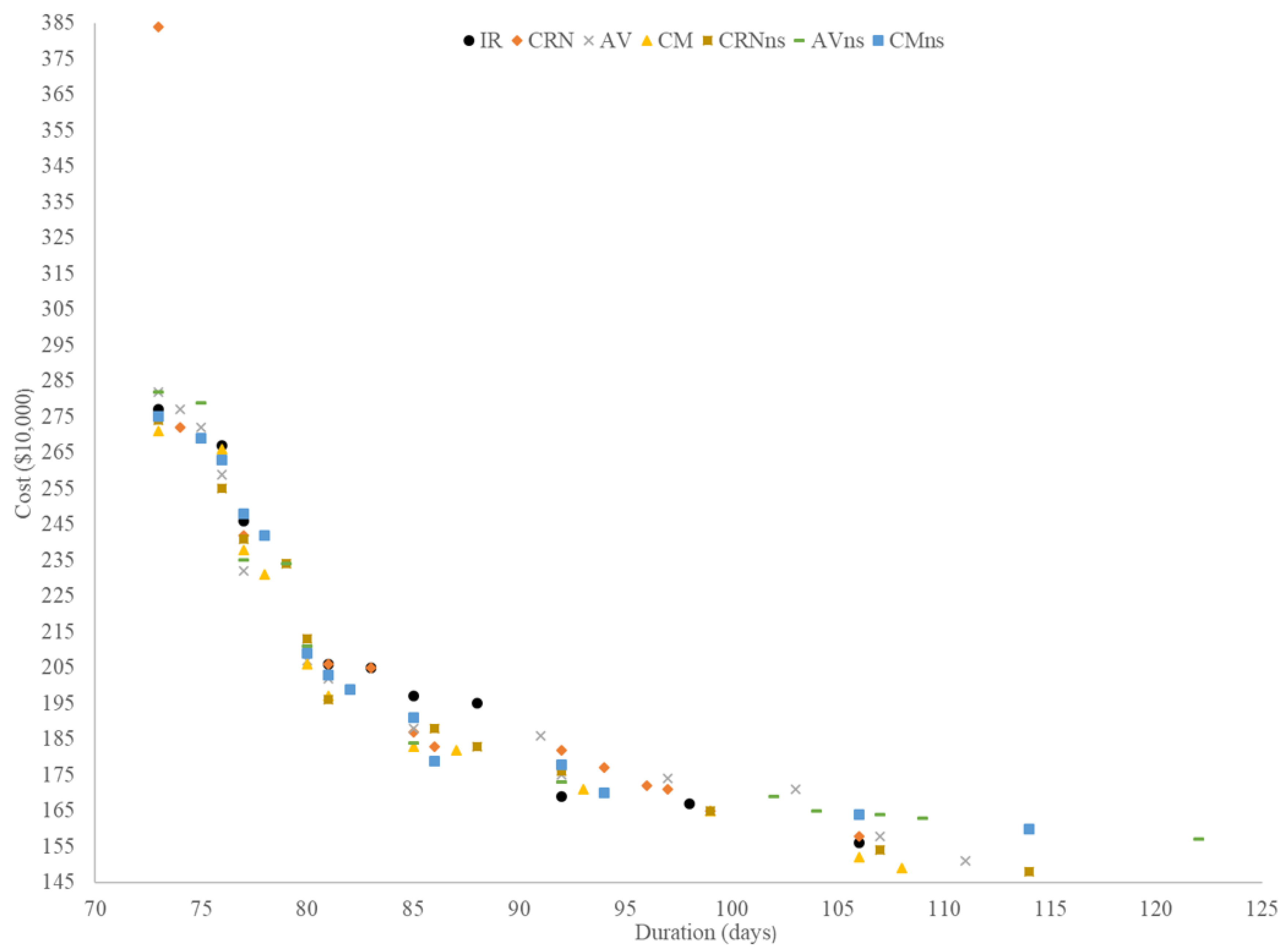
Performance Metrics

$$Time\ Savings\ (T_s) = \frac{T_{IR} - T_{VRT}}{T_{IR}} \times 100$$

$$\Delta \text{HyperVolume}(HV) = \frac{HV_{IR} - HV_{VRT}}{HV_{IR}} \times 100$$

$$Inferior\ Solutions\ (IS) = \frac{IS_{scheme}}{PS_{scheme}} \times 100$$

Obtained Pareto Fronts using Each Technique



Summary of the Performance Metrics Results

Technique	*N*	*P*	*T* (hours)	T_s (%)	*HV*	Δ*HV* (%)	*IS* (%)
IR	*100*	---	7.20	---	7,004	---	38
CRN	*10*	---	1.37	80.97	7,036	0.47	26
AV	---	*5*	1.33	81.53	7,160	2.24	13
CM	---	*5*	1.33	81.53	7,368	5.21	7
$CRNn_s$	10	---	1.27	82.36	7,265	3.74	20
AVn_s	---	*5*	1.28	82.22	7,038	0.50	18
CMn_s	---	*5*	1.28	82.22	7,162	2.27	0

N = Number of replications; *P* = Number of pair runs

CONCLUSION

Proposed method seems promising in improving overall performance of simulation optimization models.
Time reduced by 81.81%, quality improved by 2.4%, and the presence of inferior solutions reduced by 63.15%.

FUTURE WORK / REFERENCES

Further investigation of the proposed method.