NSF Simulation Optimization Workshop

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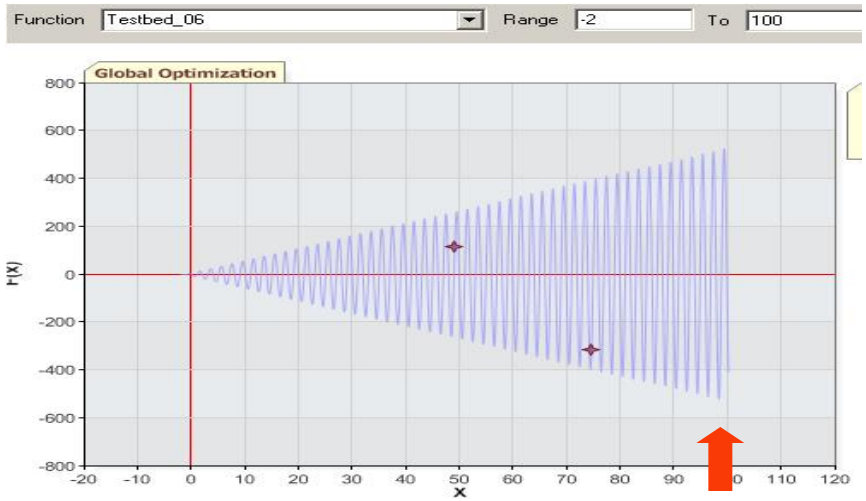
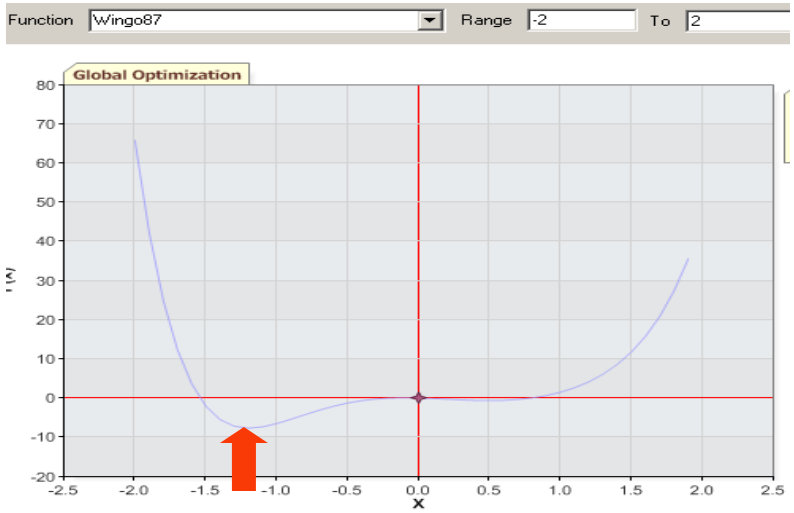
- Black boxes
  - A (possibly new) algorithm for *Attainable* global optimization
  - Retrospective Optimization & clones (SPO, SAA,…).
- Gray boxes
  - Frequency Domain Factor Screening
  - Experiment in the Model – simultaneous replication
  - Meta-model generation
  - Time Dilation (orders of magnitude improvement!)
- Clear boxes
  - Resource-driven, Activity Interaction, Dynamic Tagging, VRTs
  - DES ⟺ Linear Programs (opt and sensitivity)

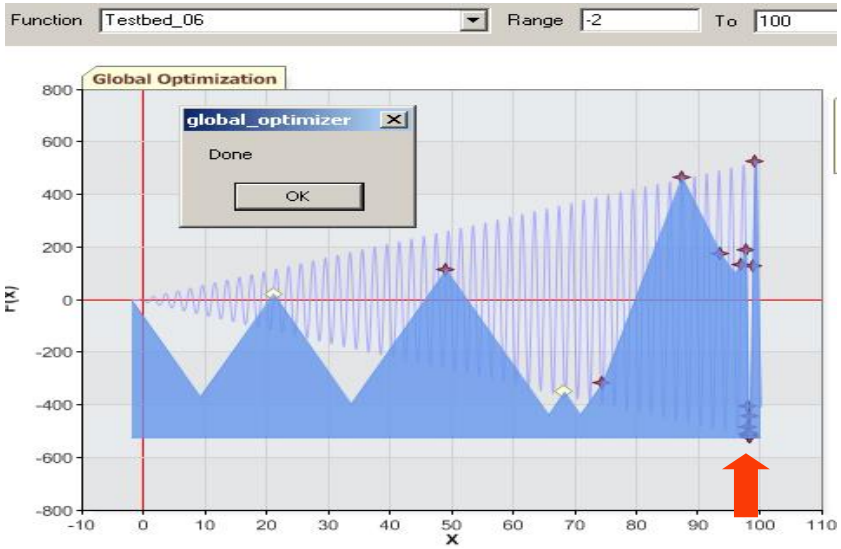
Current Research: Black Box Optimization

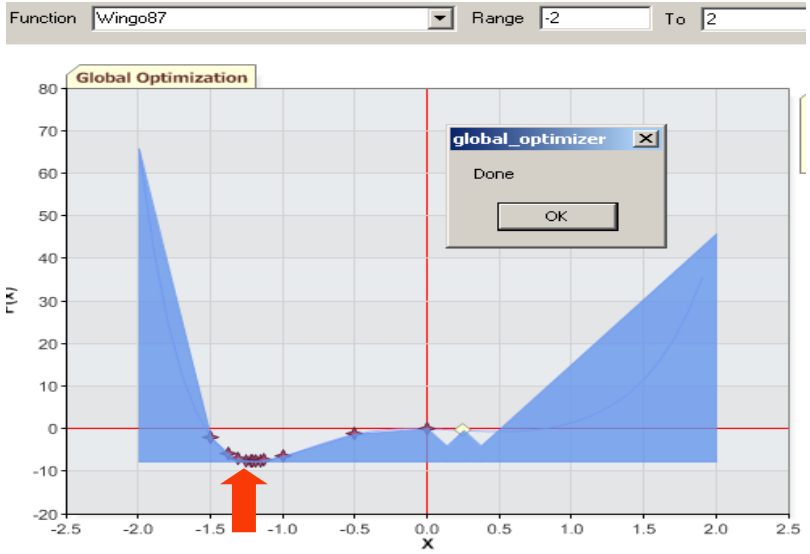
Algorithm: Select most likely *achievable* new minimum…(min *energy*)

Some 1-D examples



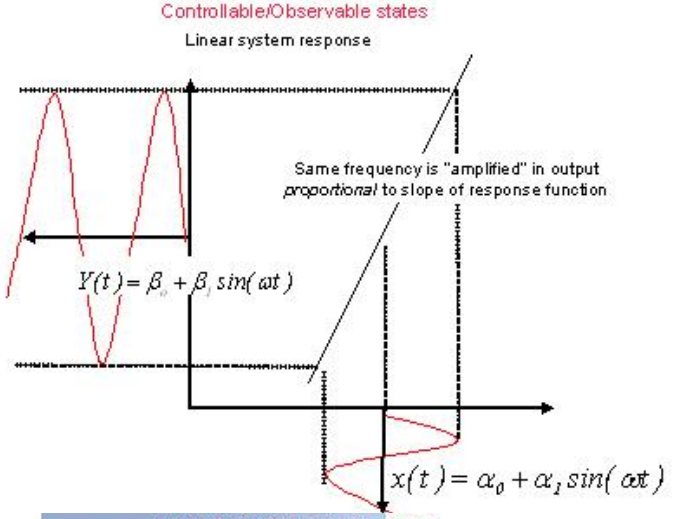






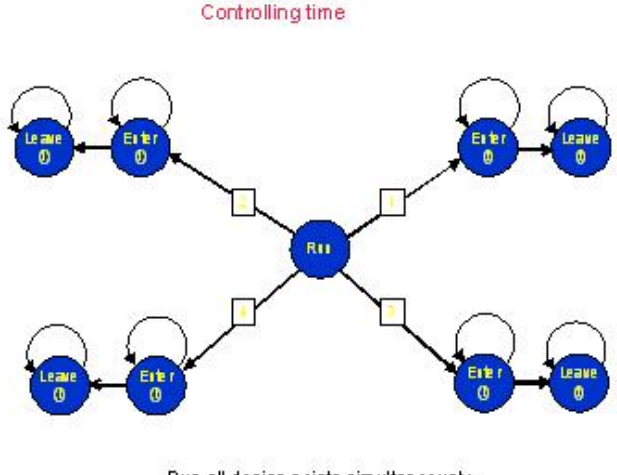
Gray Boxes (Most simulations?)

FDE



Factor	Range of Values	Type	Frequency
Mean Storm Time	3 to 5	continuous	0.00197
Distn of Storm Times	Uniform/Exponential	qualitative	0.00787
Mean Arrival Rate	8 to 14	continuous	0.01969
Distn of Arrivals	Uniform/Exponential	qualitative	0.03346
Number of Tugs	1 to 3	discrete	0.05709
Number of Berths	3 to 6	discrete	0.10236
Mean Ship Loading Times	Mean(ship type) ± 8	continuous	0.13189
Distn of Ship Loading Times	Uniform/Exponential	qualitative	0.1732
Distn of Ship Types	Multinomial CDF 1,2	qualitative	0.23984
Mean Inter-StormTime	24 to 72	continuous	0.32283
Distn of Inter-Storm Times	Uniform/Exponential	qualitative	0.40254

Meta Model Output



Meta-model Generation

Since

$$\hat{\beta}^{(p)} \doteq \sum_{j=1}^{k} \alpha^{(p)} \bar{Y}_j = \frac{1}{n} \sum_{j=1}^{k} \alpha^{(p)} \sum_{i=1}^{n} Y_{i,j} = \frac{1}{n} \sum_{i=1}^{n} \hat{\beta}_i^{(p)}$$

- Replicate full experiment in single run.

$$\{Y_{i,j}\}$$

- Generate meta-model parameters as output.

$$\{\, \hat{\beta}_i^{(p)} : \hat{\beta}^{(p)} = \sum_{j=1}^{k} \alpha_j^{(p)} Y_{i,j} \,\}$$

The meta-model is the output,
not computed from the output.

Gray Boxes- time dilation

Controlling time

Time Dilation

Run simultaneous replications at various design points

Change the time scale to spend less time simulating poor factor settings

Spawn new factor settings when it makes sense

Focus the run on the winners

Controlling time

Comparisons*

	Parts required	Ratio of parts required comp. to time dilation	Total cost to decision
Arena	325,00	10	$130,000
ProModel	2,600,000	80	$1,040,000
Witness	330,000	10	$132,000
ProModel, new version	760,000	23	$304,000

Time Dilation experiment cost $ 8,790.

*Law, A. M. and M. G. McComas. 2000. Simulation-based optimization. *Proceedings of the 2000 Winter Simulation Conference*, 46–49.

Black Box "*Simulation*" Research: are we missing something?

In a simulated environment one can control

- Speed – (adaptive entity tagging)
- State Observability/Control (FDE, MM output)
- Uncertainty (Corr. Ind., Bayesian bootstrap)
- Time scale (Time dilation)
- Future (Retrospective optimization & clones)
- Resolution (Implicit tagging, M^4s)
- Causality (LP models of DEDS, Virtual resources, queueing duality)

How can Simulation Research further exploit the advantages of simulation?