



29th Annual **INCOSE**
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SET-BASED DESIGN OF VERIFICATION STRATEGIES



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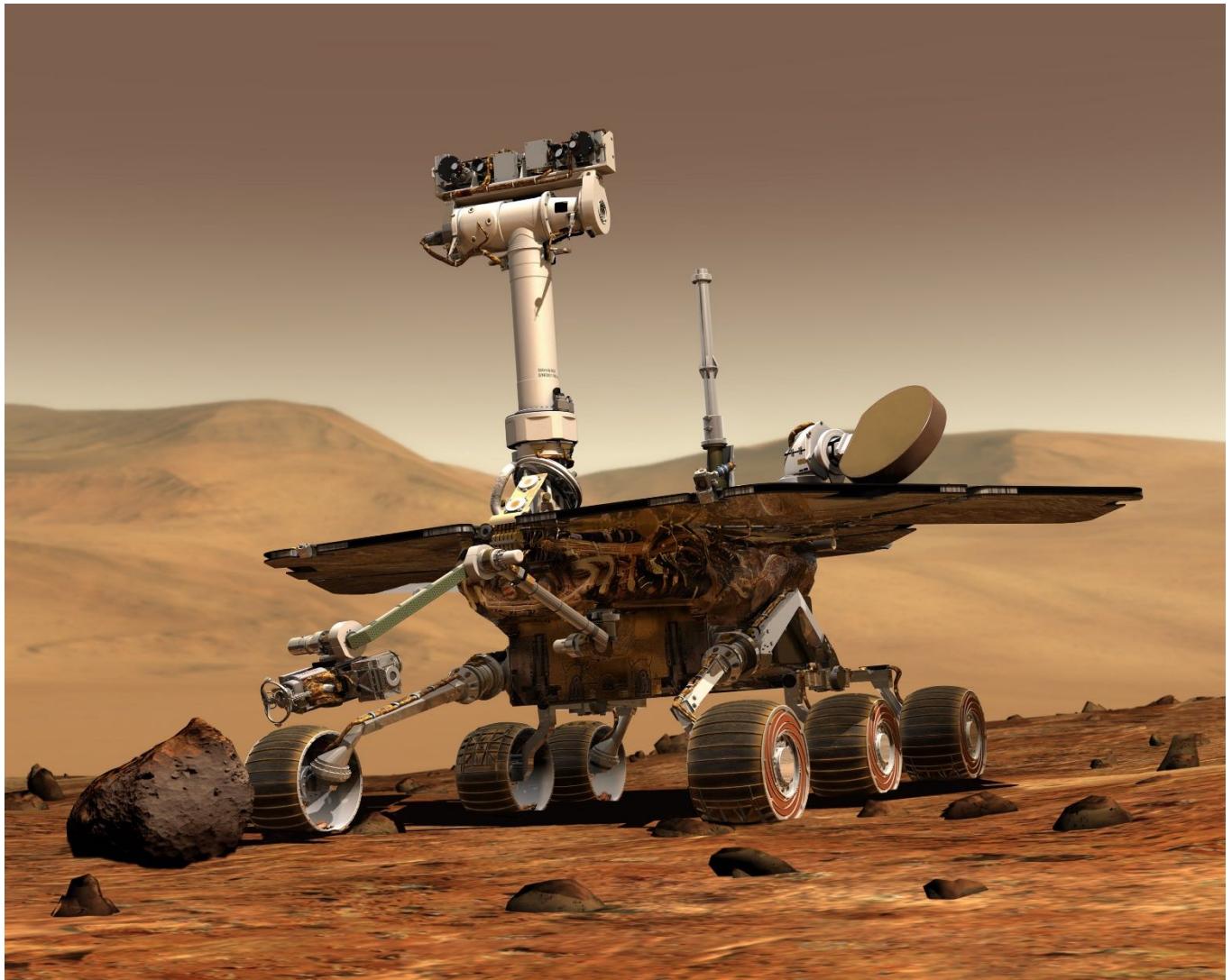
systems



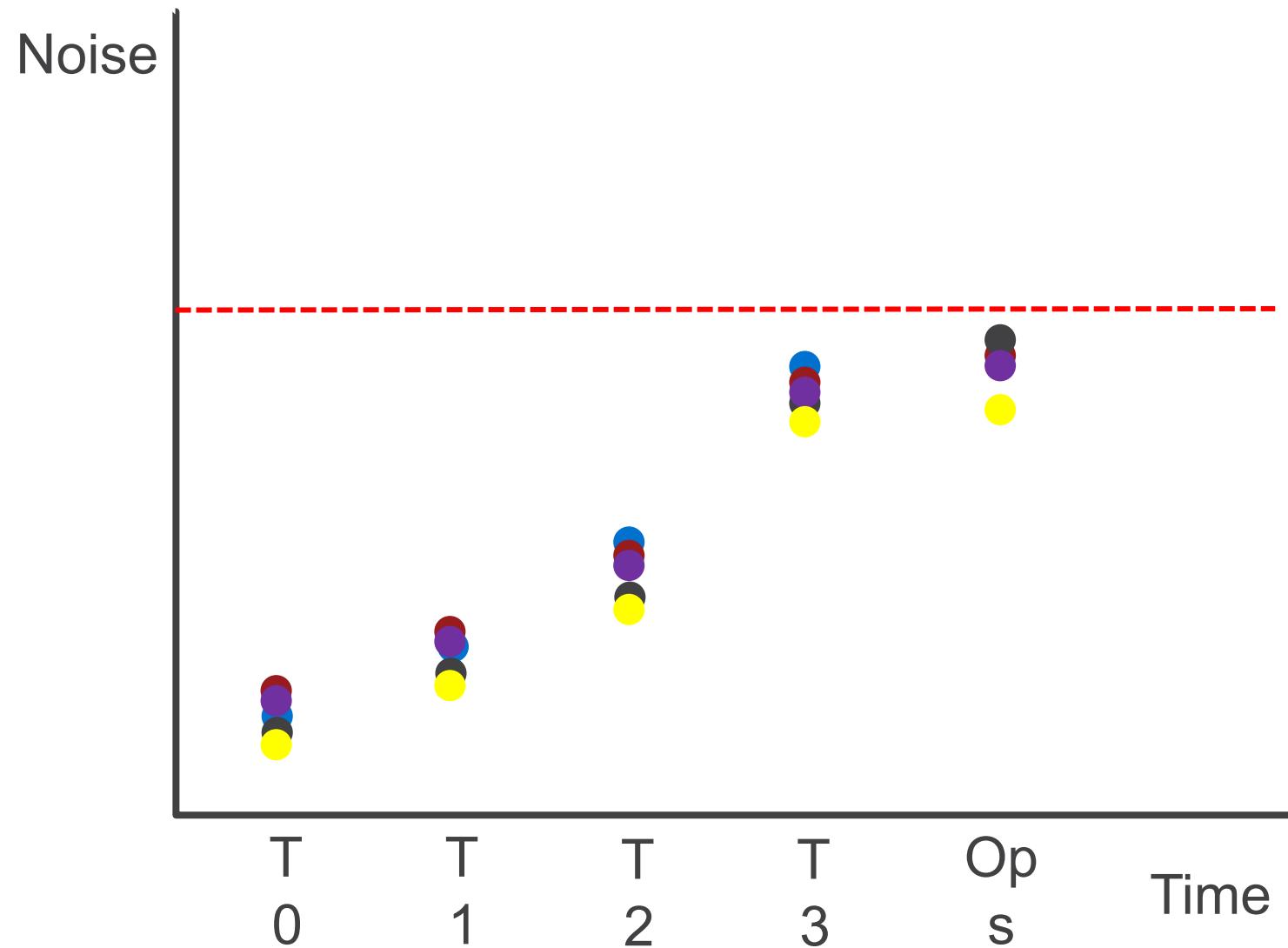
What is the HARDEST thing **engineers** do?



Mill A. Agnew
Fernold C. Manock
Daniel Kottke
~~Barry Cash~~ ~~James D. Cawley~~
Gordon J. Wyman
~~Mark Hall~~ Bill Atkinson
Vick Millidge
Bruce Horn George Caw
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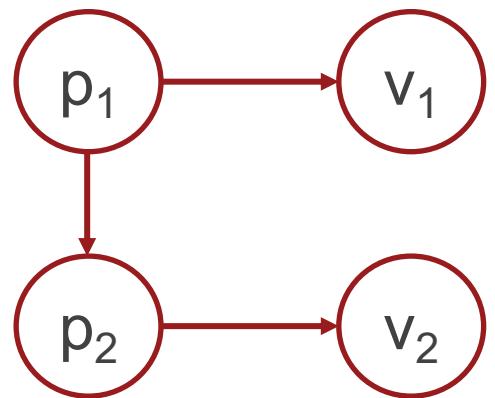






A verification activity is objective.
The confidence we gain is not.

Verification is not objective.
Verification is an **agreement**.

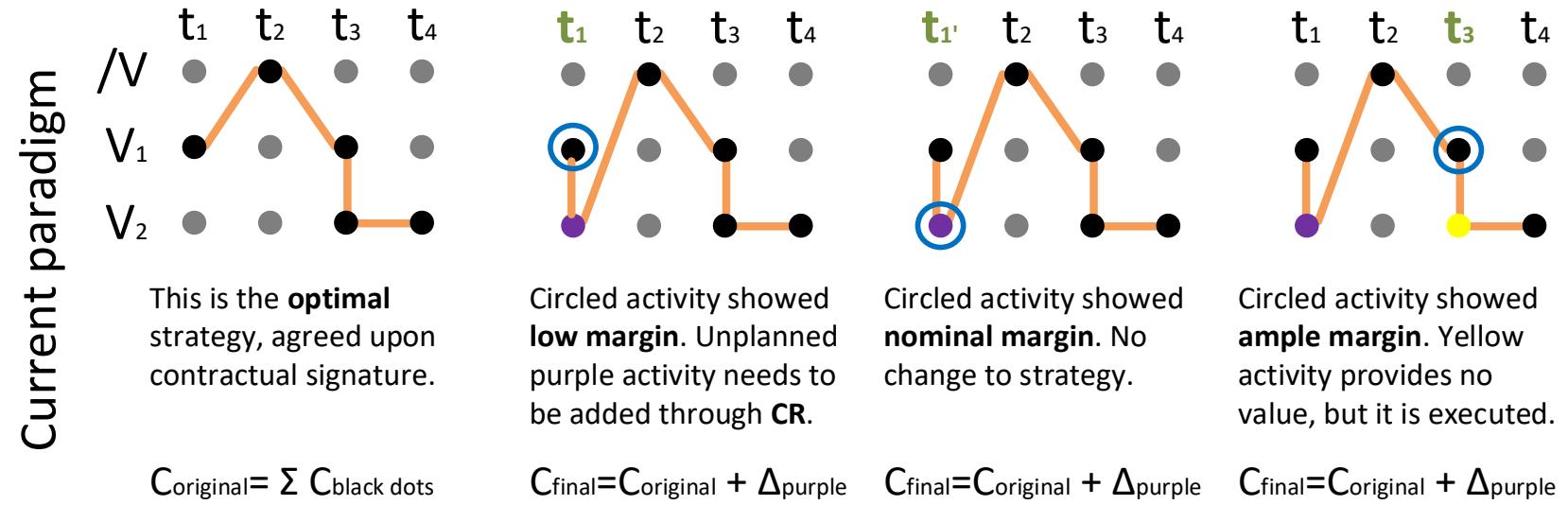


p_1 : physical properties of model

p_2 : mass of final product

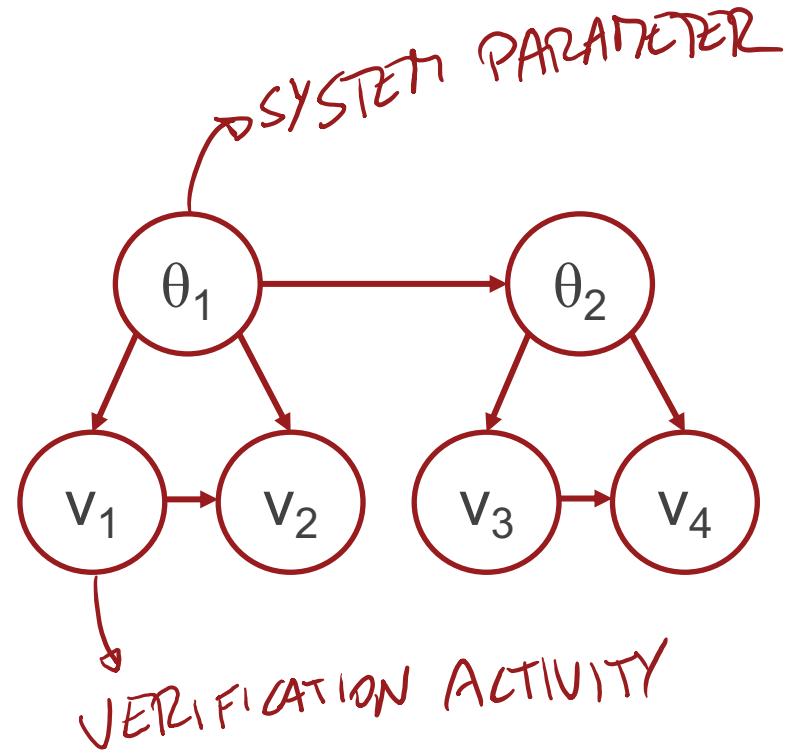
v_1 : estimated mass with model

v_2 : measured mass of final product

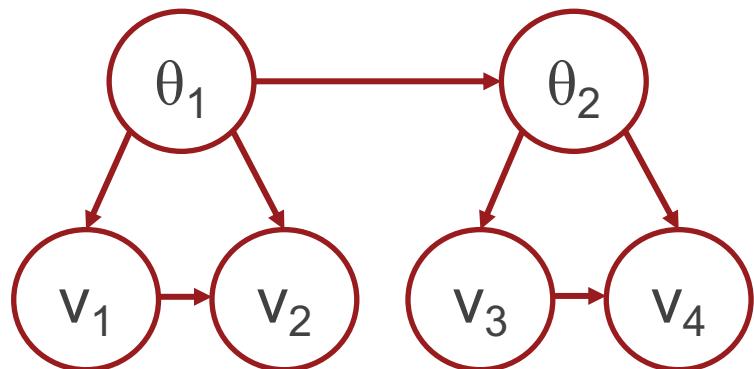




Case Study



Watts \longrightarrow Kelvin



$$E[C_T(S)] = \sum_{V \in \mathbf{V}} C_V(V) + \sum_{k=1}^o \sum_{j=1}^n \sum_{v \in L(T_j)} P(v) P(\theta_{jk} | v) \delta(\theta_{jk} | v) C_R(\theta_{jk}) + \sum_{k=1}^o \sum_{v \in \mathbf{V}^*} P(v) P(\theta_k = e | v) C_I(\theta_k = e)$$

EXECUTION *REWORK* *ERROR*



Optimization Algorithm

STEP 1 Determine optimal verification strategy at Time 1.

STEP 2 Choose first (timewise) verification activity (or subset of verification activities).

STEP 3 Execute activity and update Bayesian network.

STEP 4 Determine optimal remaining verification strategy and return to Step 2.

Dynamic Contracting Strategy (N, ACT, C)

Input: N — Bayesian Net; ACT — Activity Constraint Table

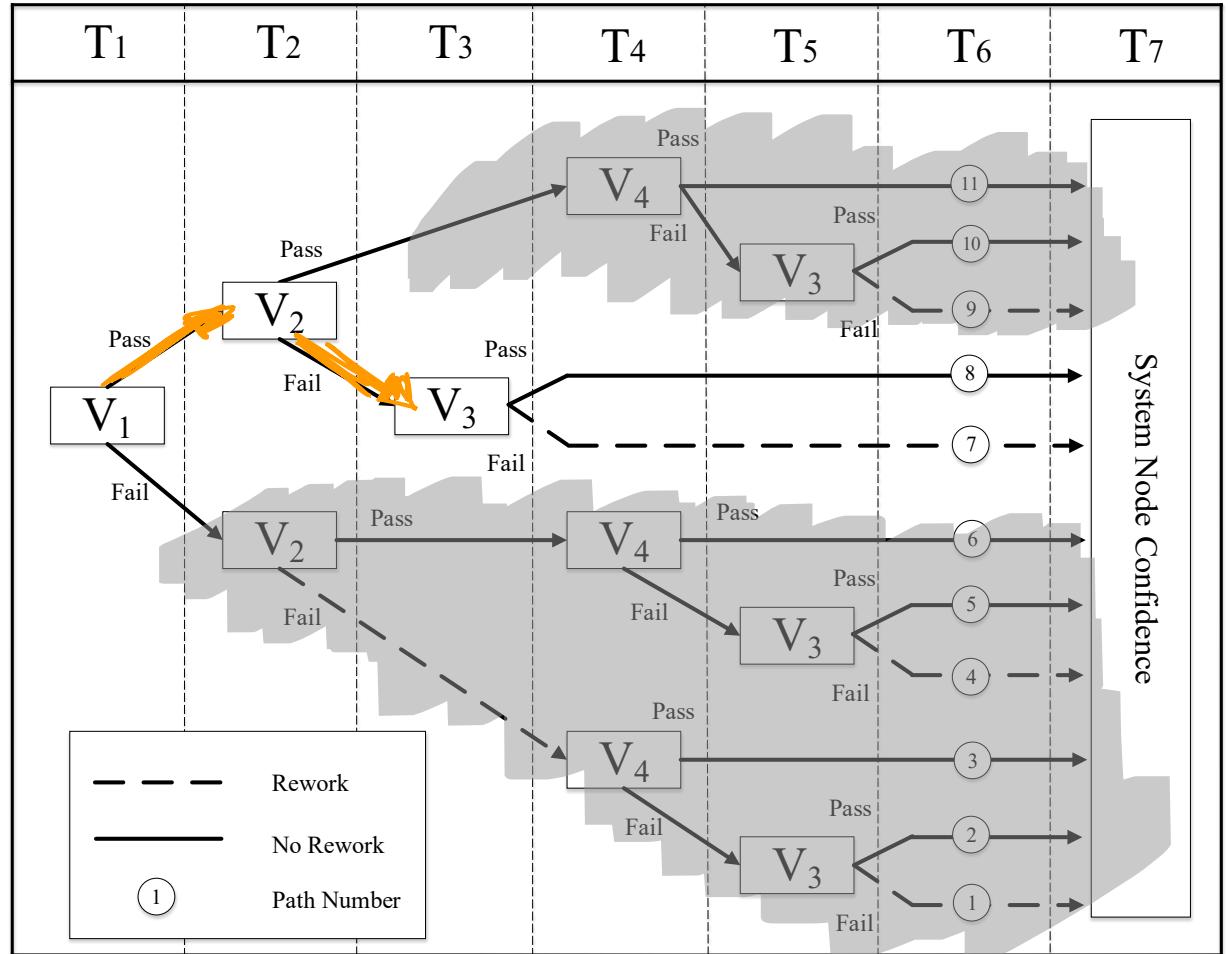
C — Cost Table

Output: $S_{opt} = \{V_{opt}(T_1), V_{opt}(T_2), \dots V_{opt}(T_n)\}$

- 1: **For** t in $T_1 : T_n$
- 2: Generate all feasible paths $VS_{ti} = \{S_1, S_2, \dots S_m\}$ at time point t ;
- 3: Evaluate the expected cost of all verification paths;
- 4: Select the minimum one $S = \{V_{opt}(T_1), V_{opt}(T_2), \dots V_{opt}(T_t), V(T_{t+1}) \dots V(T_n)\}$ and update the optimal path $S_{opt} = \{V_{opt}(T_1), V_{opt}(T_2), \dots V_{opt}(T_t)\}$;
- 5: Collect the results of $V(T_t)$ and set the evidence adaptively;
- 6: Update the Bayesian network and ACT
- 7: **End**
- 8: **Return** the optimal path $S_{opt} = \{V_{opt}(T_1), V_{opt}(T_2), \dots V_{opt}(T_n)\}$

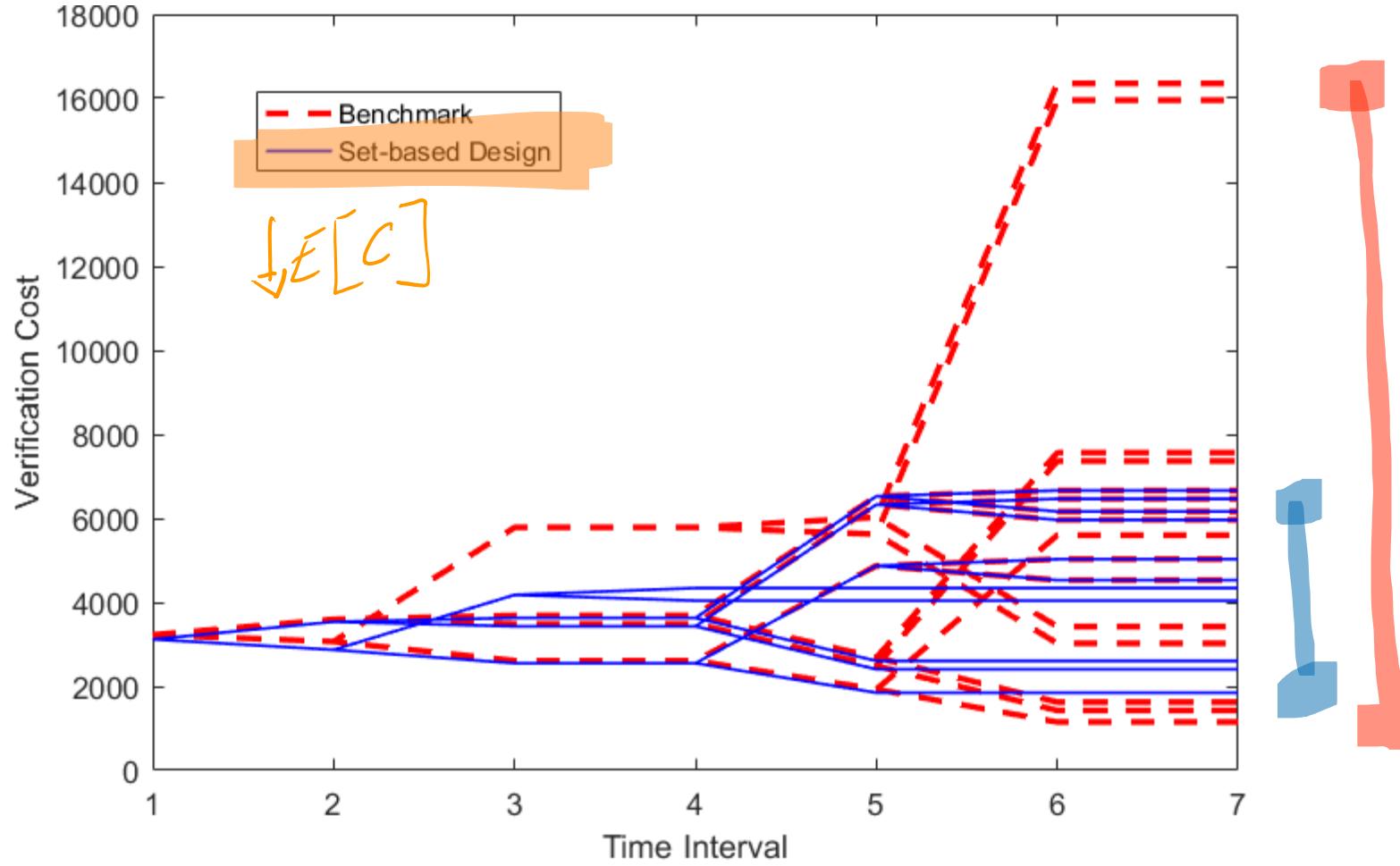


Visualization of Set-Based Strategy





Results

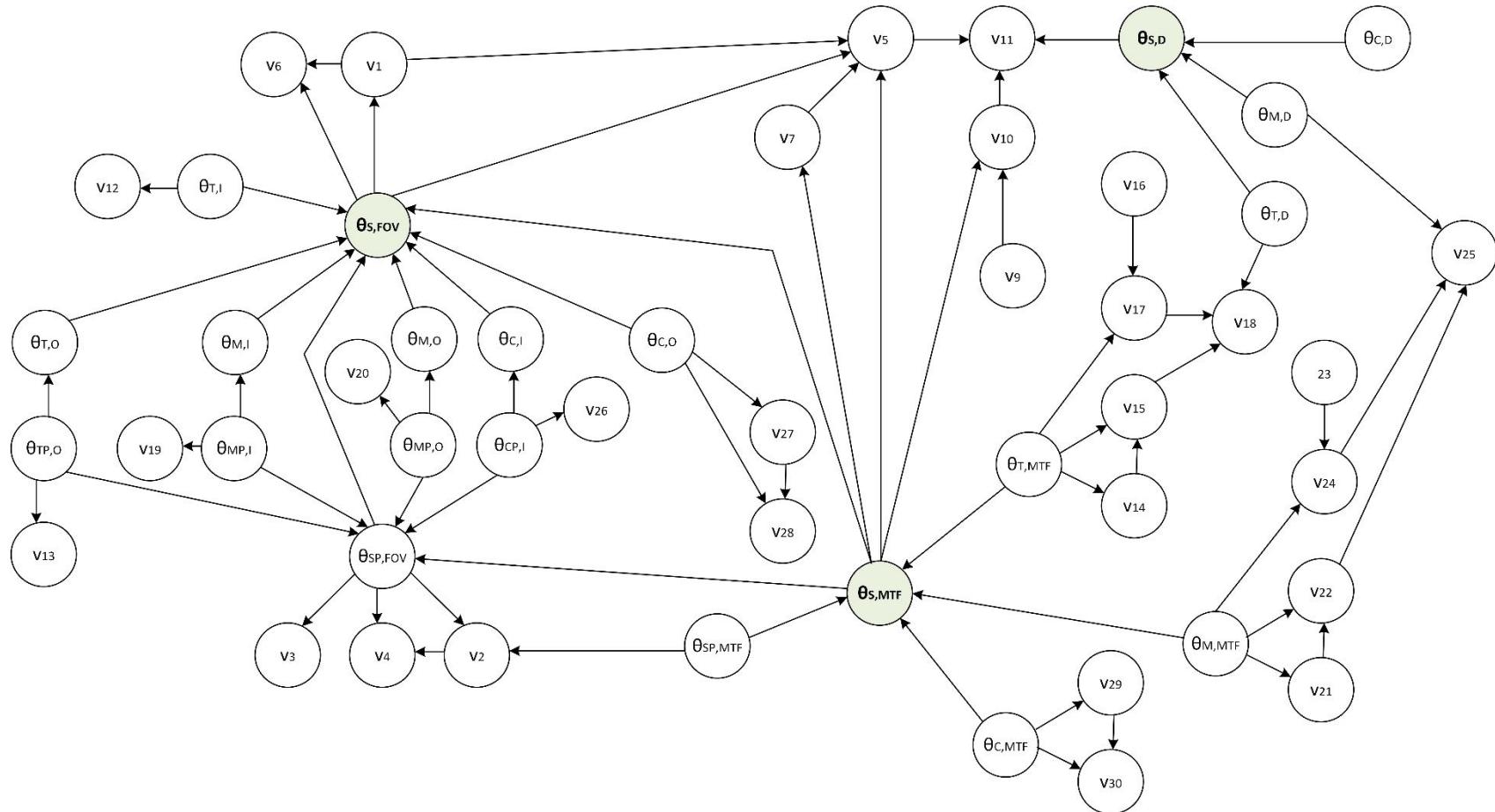


Expected Cost:

- Set-based Design: \$ 3,004k
- Benchmark: \$ 3,214k

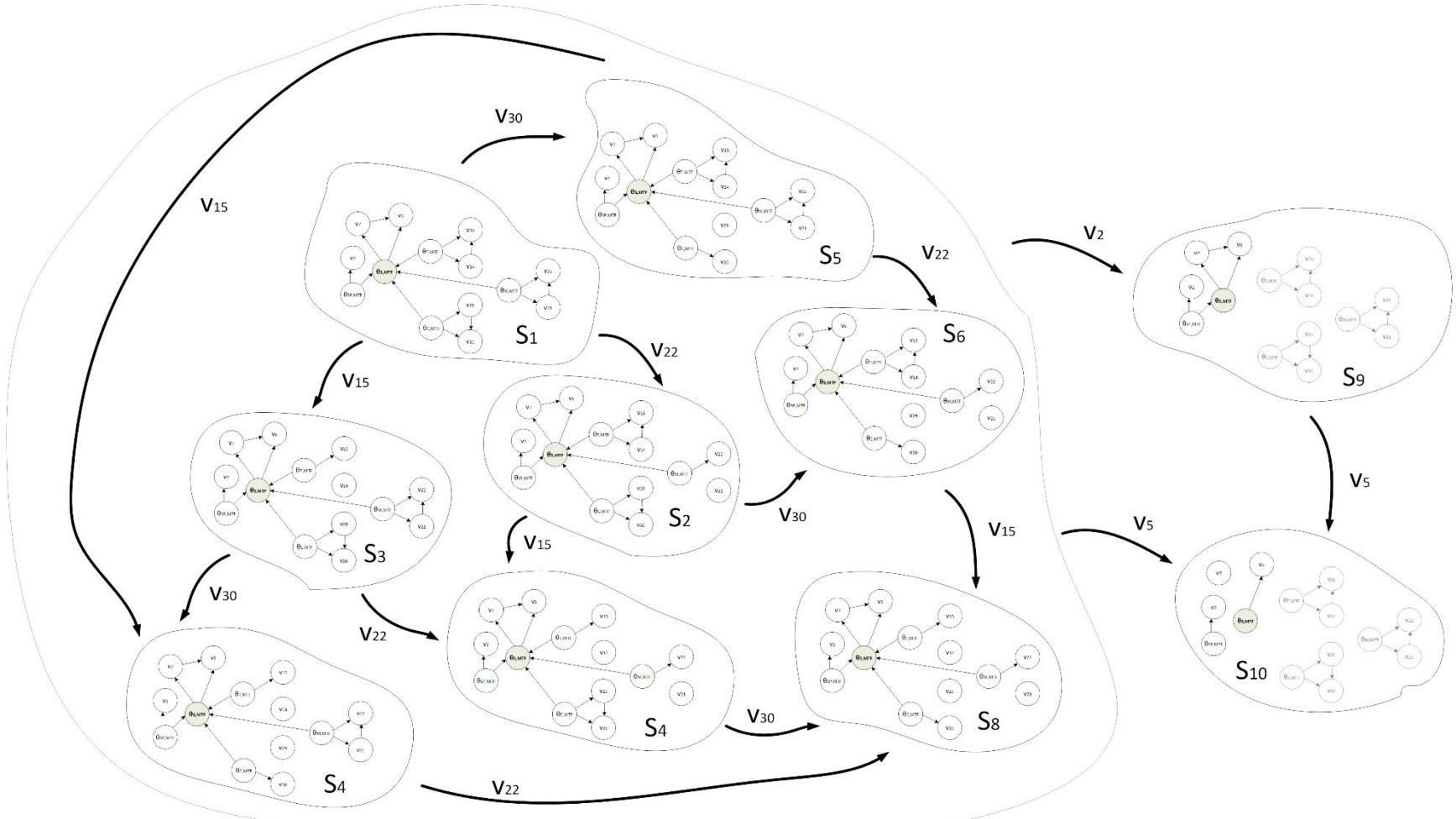


Currently working on this...





Planning to work on this...





Conclusion

CONTRACTING
verification activities must be

Dynamic
Adjusted after results



Thank you for your attention!



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