Causal Models for Software Cost Prediction & Control (SCOPE) at the SEI 2019

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Why Causal Learning?

Estimating and controlling program costs would benefit from **causal** knowledge of program dynamics.

Regression does not **distinguish** between correlation and causation.

Causal knowledge is **actionable** knowledge.

Causal discovery is now **practical** and supported with **innovative** tools and algorithms.

Establishing causation with observational data remains a vital need and a key technical challenge but is becoming more feasible and practical.

Contrary and Surprising Results

Many different types of **complexity** are thought to affect program **success**.

- But the only consistent driver of success or failure we've found is **cognitive fog**.

The number of Information Assurance Vulnerability Alerts (IAVAs) addressed per month was thought to drive IAVA-release **effort**.

- But the most persistent drivers of such effort are **funding factors**.
- When controlling for super domain (SD), the relationship between IAVAs and effort **disappears**.

On the basis of earlier work, it was found that architecture pattern violations did not introduce **security vulnerabilities**.

- But a causal analysis discovered the contrary: **architecture pattern violations** do drive **security vulnerabilities**.

What Types of Complexity Drive/Impede Project Success?

In 2012, Sheard found that 3 of 40 measures of complexity correlated highly with 7 measures of success:

1) difficult requirements
2) stakeholder relationships
3) cognitive fog

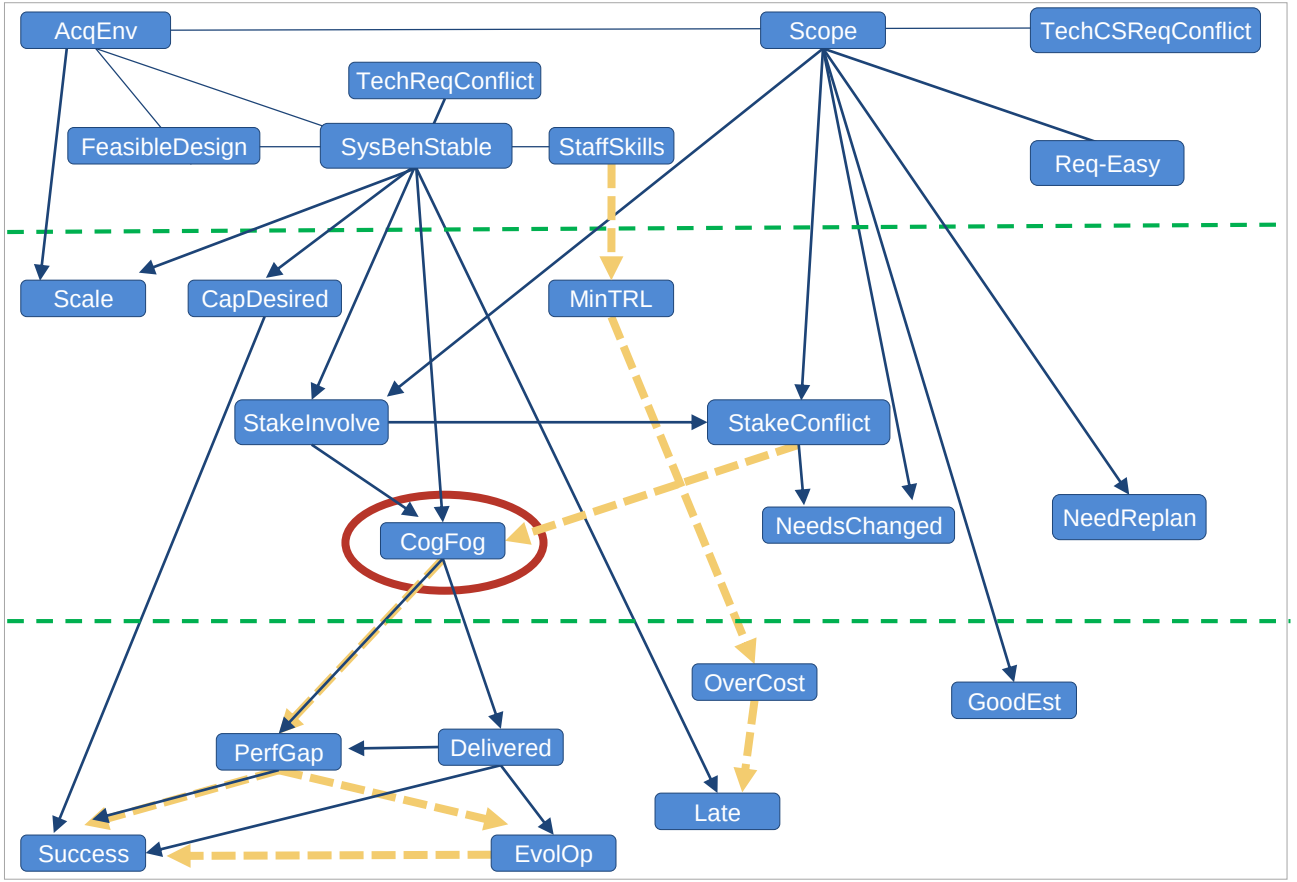
But **causal learning** found

- no evidence for 1)
- consistent evidence of 2) but only mediated through 3)
- consistent evidence for 3)
- weak evidence for other paths to success

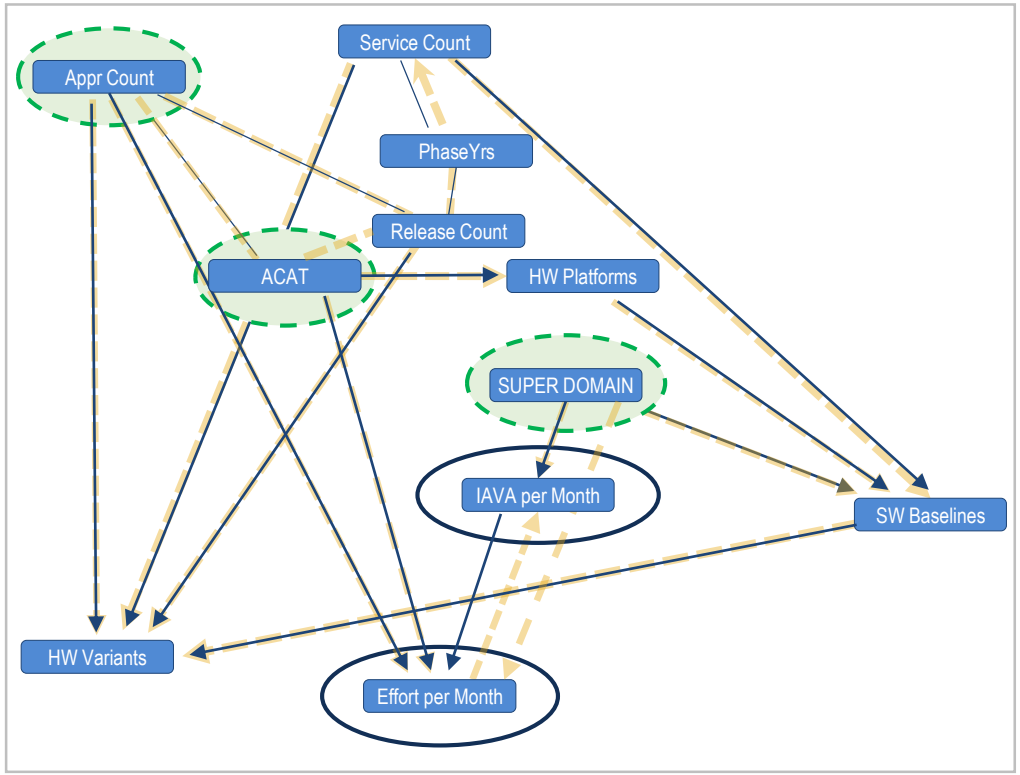
Legend

A → B	A **directly causes** B (all other factors held constant; a change in A results in a change to B)
A—B	Either A → B or A ← B, but which one was not determined

Gold edges represent results from a second search algorithm.



Which Factors Drive the Number of IAVAs and Effort per Month?



Causal learning found that

1. Super Domain (SD) drives IAVAs and effort (per month).
   - IAVAs and effort are causally related, but their relationship vanishes if data is segmented by SD.
2. The number of appropriations and ACAT also drives effort.
   - This could be interpreted to mean we're missing some controllable measures.
3. Could other measures provide insight?
   - accounting type
   - number of IAVAs opened and closed
   - technical stack

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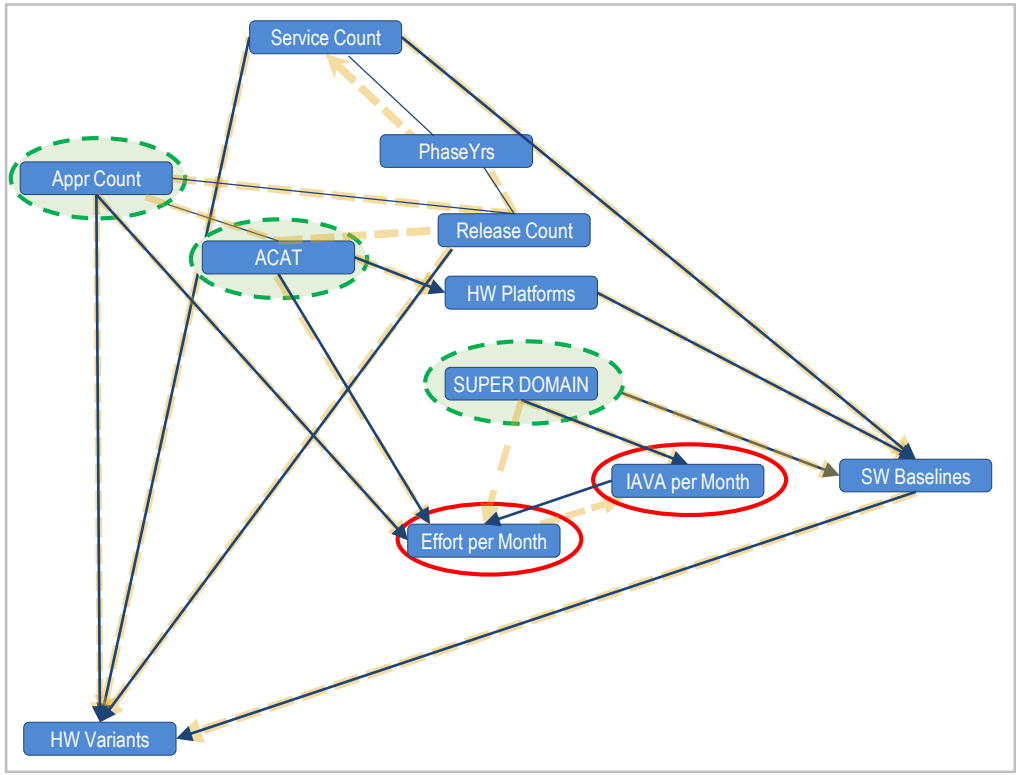

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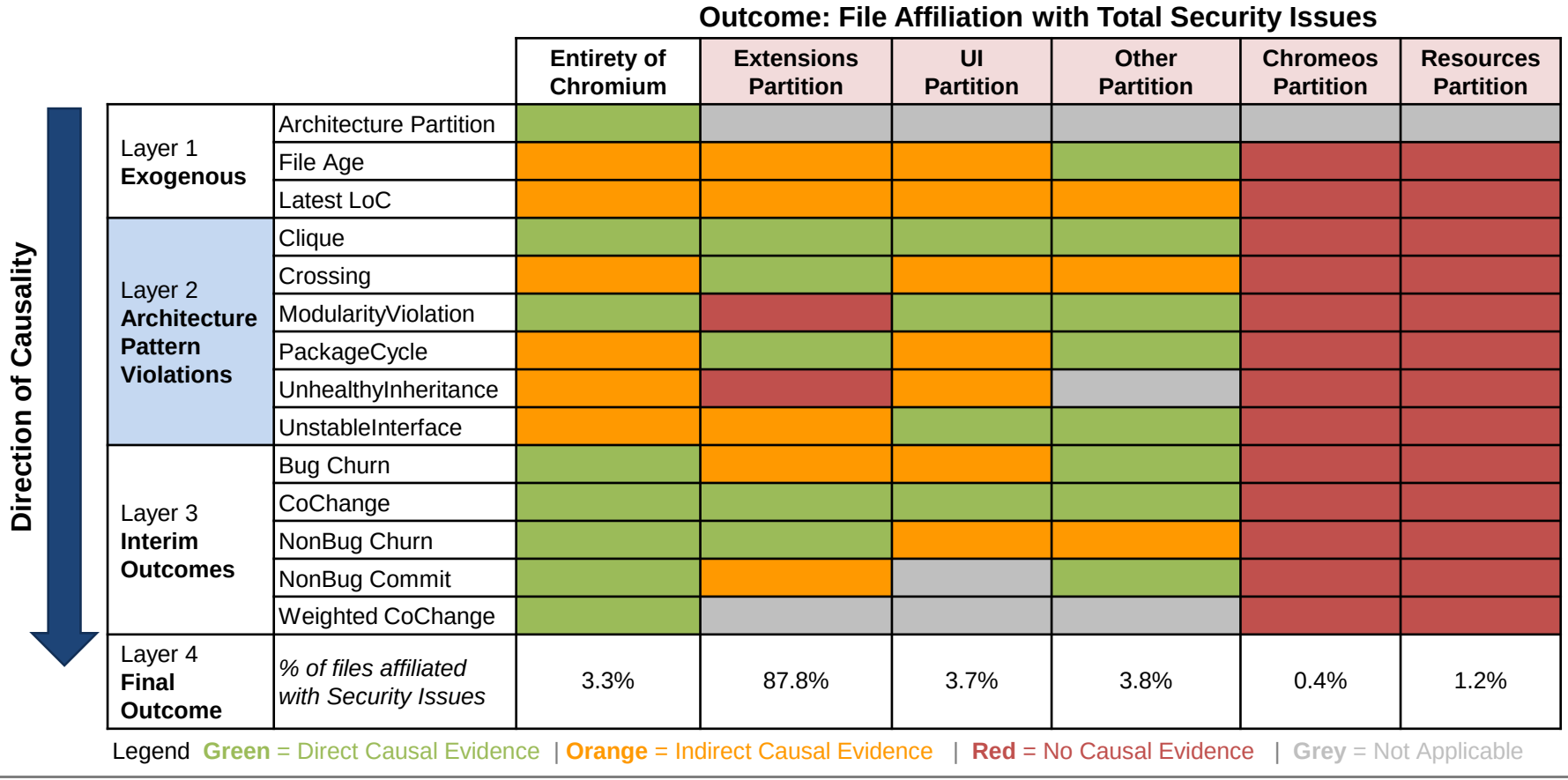
Do Architecture Pattern Violations Cause Vulnerabilities?



Conclusions and Future Work

Progress in **software engineering** can be accelerated by using **causal learning.**

- identifying deliberate courses of action
  - programmatic decisions and policy formulation
- focusing measurement on factors identified as causally related to outcomes of interest
  - **We may be measuring the wrong things and acting on the wrong signals.**

In the coming year, we will

- investigate determinants and dimensions of quality
- quantify the strength of causal relationships
- seek replication with other data sets and continue to refine our methodology
- integrate the results into a unified set of decision-making principles

If you have data or an interest in causal learning, see us about next steps.

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