
# Controlled Evolution of Adaptive Programs

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# Debate Question

**What makes a program both easy and safe to evolve?**

# Our Answer: Structure-Shyness

**Minimize the coupling between the program's behavior* and structure. In other words, Schema Obliviousness.**

*** One or more collaborating methods.**

# Example (1)

- Structure sensitive behavior:

```
double volume(Cylinder c)
{ return PI * c.dimensions.radius^2
  * c.dimensions.height; }
```

  - Makes five structural assumptions: `Cylinder`, `dimensions`, `radius`, `height`, `PI`.
  - Three are relevant to the method's “function”: `PI`, `radius`, `height`.

# Example (2)

- Structure-shy behavior:

```
class VolumeCalculator
{ double volume = PI;
  double for_radius(double host)
   { volume *= host ^ 2; }
  double for_height(double host)
   { volume *= host; } }
```

  - Minimal structural assumptions.
  - Requires **specialization/binding** to specific execution contexts.
  - Implicit structural assumptions.
    - There is at most one `radius`, `height`.

# Evolving Structure-Shy Programs Is Easy

- Structure-shy behavior is generic:
  - The structure-shy volume behavior can execute, without changes, against any structure containing at most one `radius` and at most one `height`.
- Structure-shy behavior seamlessly adapts to structural evolution.
- Structure-shy behavior is reusable in more contexts.
  - Less reuse via copy-and-paste.

# Evolving Structure-Shy Programs Can Be Dangerous

- **Problem 1:** Evolving the structure might violate implicit assumptions made by the behavior.
  - "Express" and check these implicit assumptions.
  - Infer some implicit assumptions using static analysis.

# Evolving Structure-Shy Programs Can Be Dangerous

- **Problem 1:** Evolving the structure might violate implicit assumptions made by the behavior.
  - "Express" and check these implicit assumptions.
  - Infer some implicit assumptions using static analysis.
- **Problem 2:** A small change to the program might have a "drastic" effect on its meaning.
  - Increase the "syntactic distance" between legal programs by adopting a stricter notion of legality.

# Contribution

- “Solve” these two problems in the context of one concrete paradigm for writing structure-shy programs: *Adaptive Programming*.

# Adaptive Programs: Overview

- Adaptive programs are organized as advised depth first traversals over semi-structured data objects.

# Adaptive Programs: Example

- An adaptive program comprises:
  - An input object: to be traversed - The context.

```
Cylinder input = new Cylinder(new Dimensions(3.0, 1.0));
```

  - A set of advices: fired along the traversal – The Behavior.

```
class VolumeCalculator extends Visitor{
 double volume = PI;
 void before_radius (double host) { volume *= host ^ 2; }
 void before_height (double host) { volume *= host; }}
```

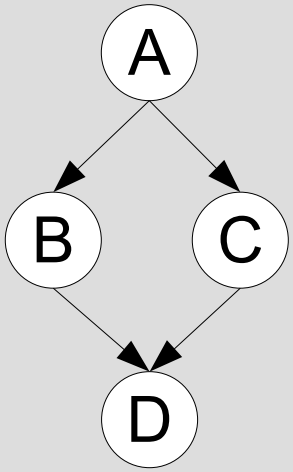
  - A traversal strategy: picks a set of paths to be traversed - Specializes methods to a context.

```
Visitor v = new VolumeCalculator();
ExecuteAdaptiveProgram(input, v, "from * to double");
```

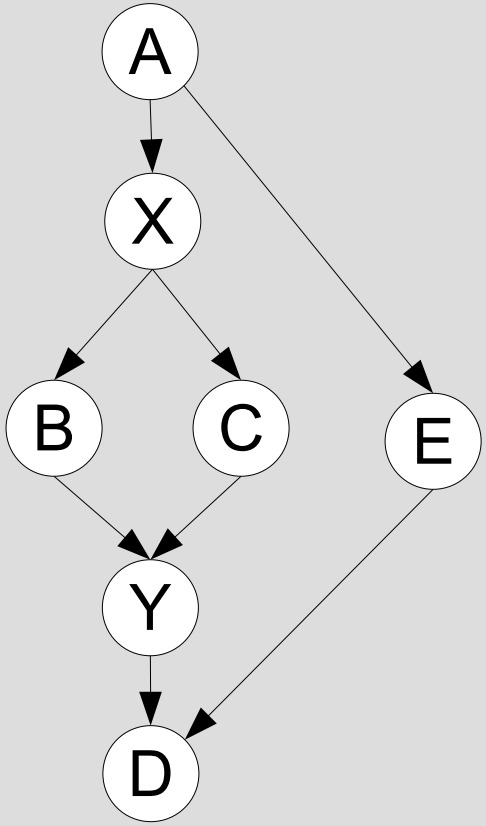
# Adaptive Programs: Execution

- Construct an automaton from the input schema and the strategy.
  - Traversal graph.
- Traverse the input object guided by the automaton.
  - Before traversing a child, make sure that it won't drive the automaton to a state with no tokens.
- Fire advices as the traversal proceeds.

# Constructing Traversal Graphs




Strategy

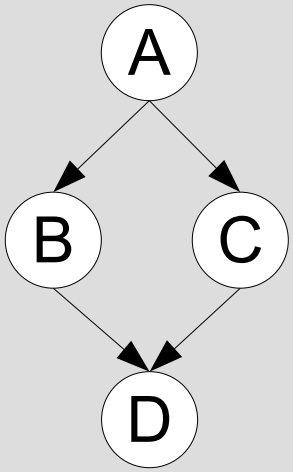



Input Schema

?

Traversal Graph

# Constructing Traversal Graphs

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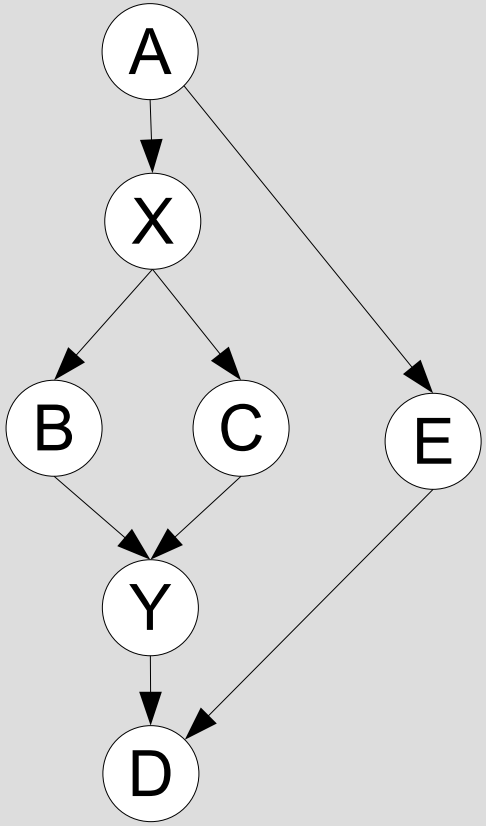


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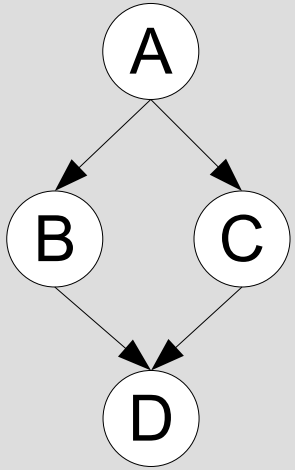


Traversal Graph

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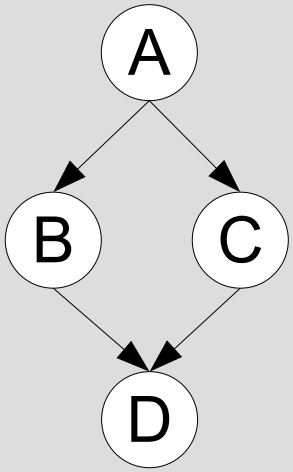


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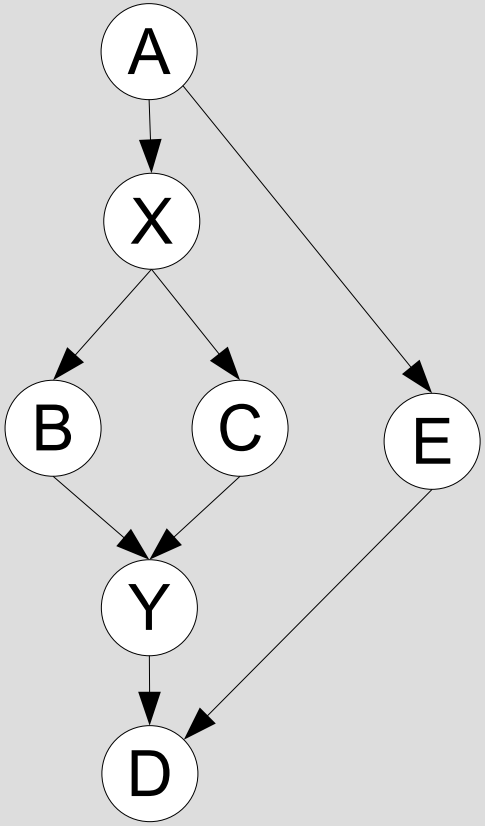


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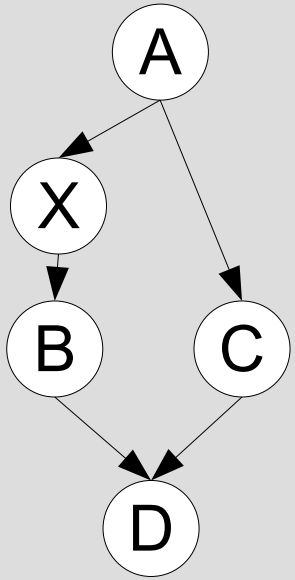


Traversal Graph

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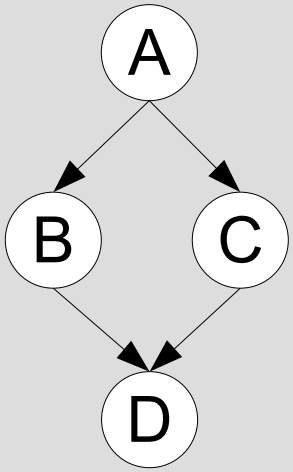


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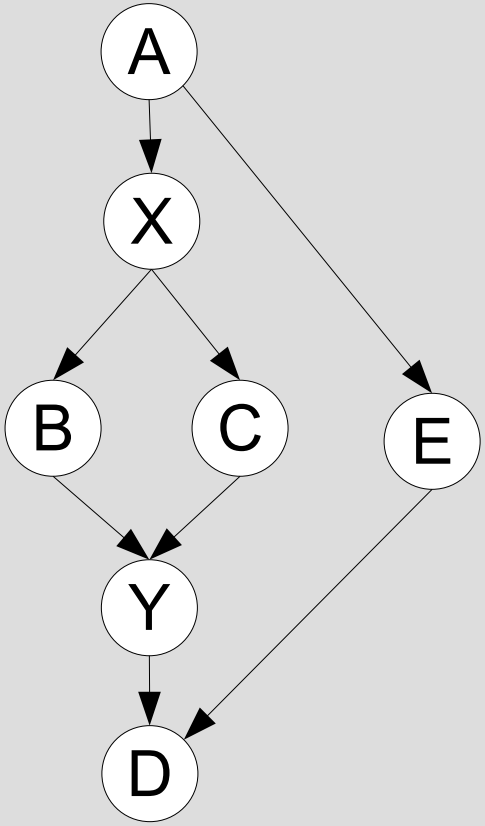


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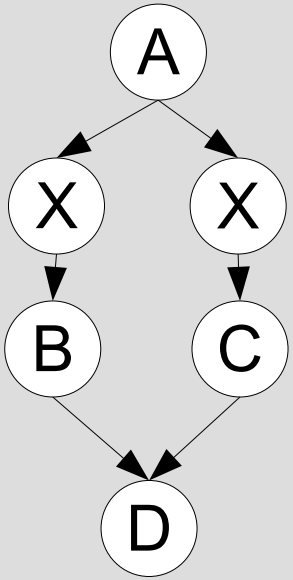


Traversal Graph

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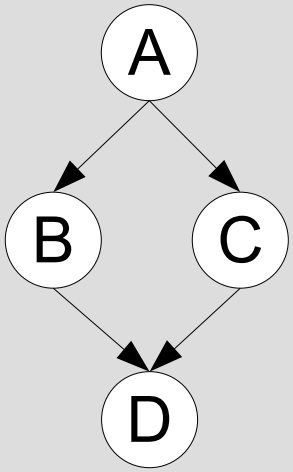


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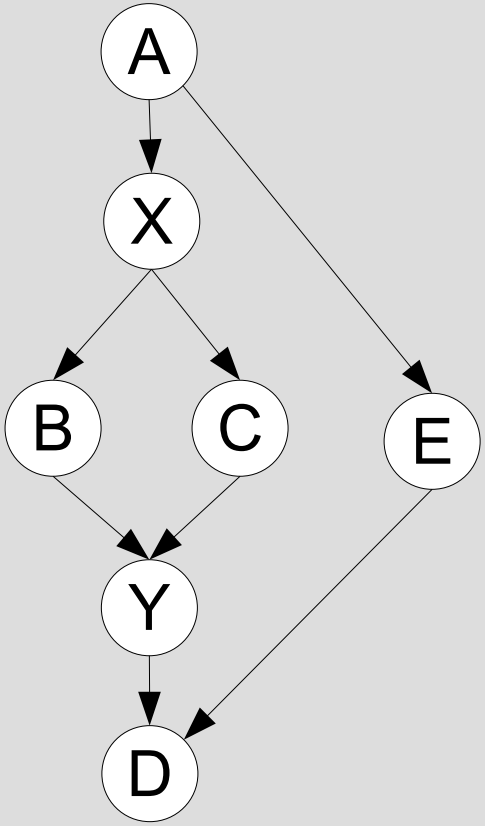


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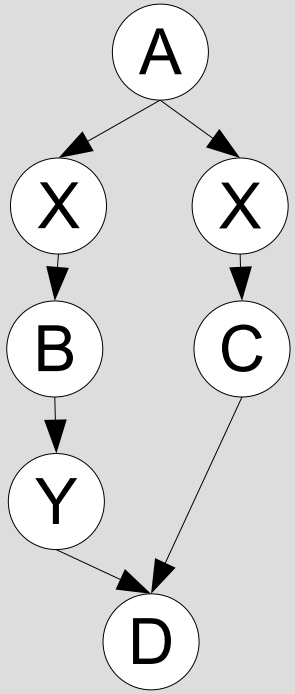


Traversal Graph

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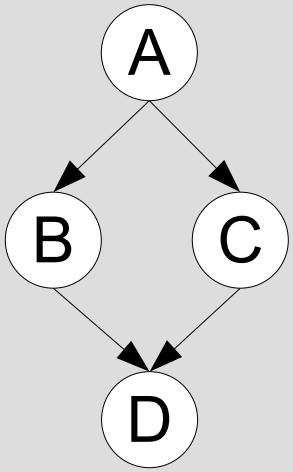


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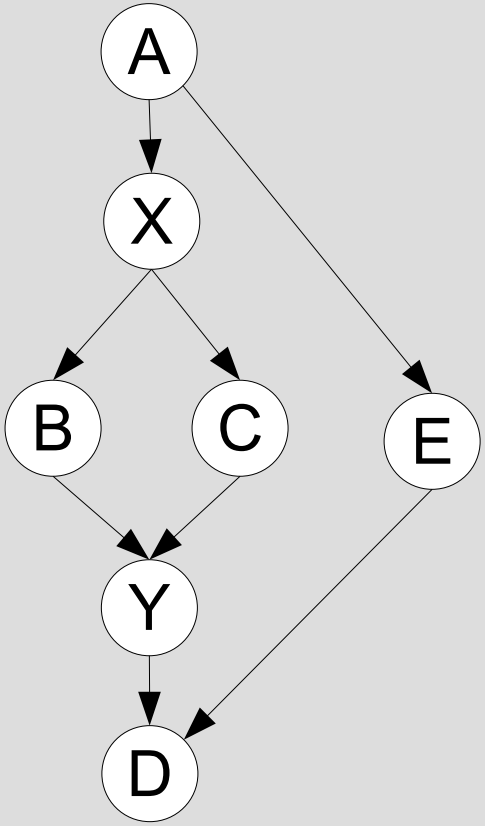


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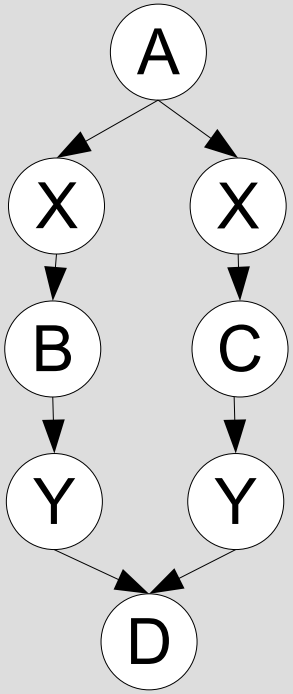
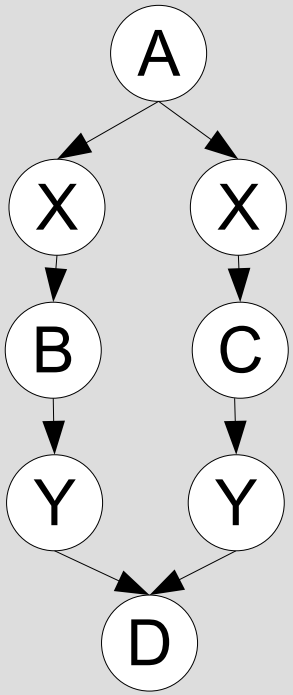



Traversal Graph

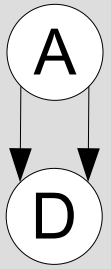
# Smoothing out Traversal Graphs

- Represents the set of all possible advice execution traces.




Traversal Graph

Only A,D are advised




Smoothed out Traversal Graph

# Evolving Adaptive Programs: Implicit Assumptions

- Evolving the input schema or the traversal strategy or the set of advices can result in:
  - No impact
    - Same smoothed out traversal graph.
    - Adding `Color` to `Cylinder`.
  - Minor impact
    - Change to the number of times an advice executes.
    - Adding an inner `radius`.
  - Drastic impact
    - Change to an advice execution context.
  - Other impacts:
    - The time between advice execution.

# Controlling Minor Impacts

- Annotate advices with a cardinality constraint.
  - The method `before_radius` is executed only once in the context of a `Cylinder`.
  - <= 1 in `Cylinder`.
  - There is exactly one path leading from a `Cylinder` to a `radius` in the smoothed out traversal graph.
  - > | < | == | <= | >= | != .

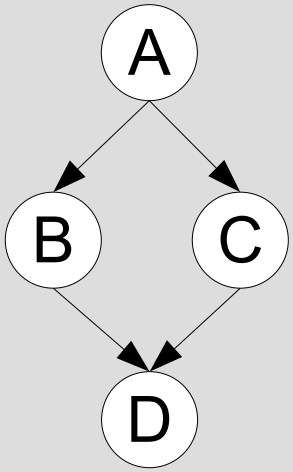
# Controlling Drastic Impacts

- Method A executes in the context of B and either C or D:
  - in B [C D].
- Method A never executes in the context of B:
  - not in B.
- Method A executes directly after method B.
  - directly in B.

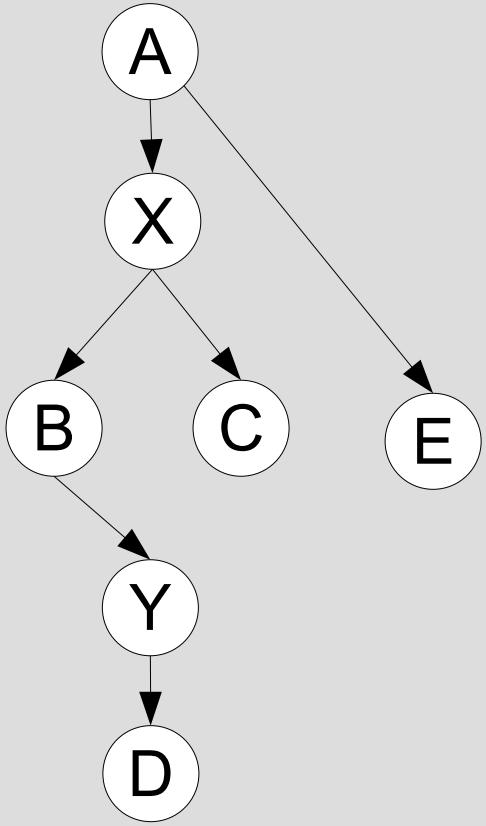
# Evolving Adaptive Programs: Stricter Notion of legality (1)

- Behavior must be compatible with the traversal graph:
  - All Advised nodes must be mentioned in the strategy.
  - Every strategy graph node is either advised or can reach an advised node.
- Strategy must be compatible with the input schema:
  - Strategy must look-like the input schema.
  - Strategy must be identical to the input schema after smoothing out non-strategy nodes.

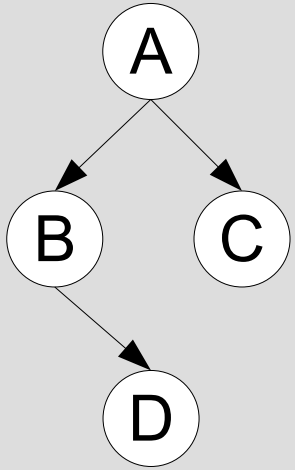
# Evolving Adaptive Programs: Stricter Notion of legality (2)




Strategy

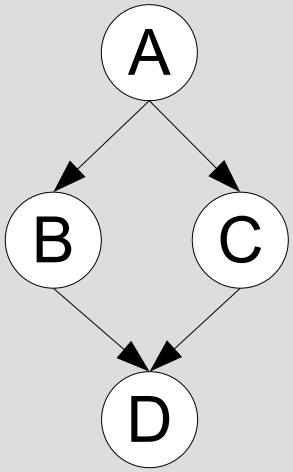



Input Schema

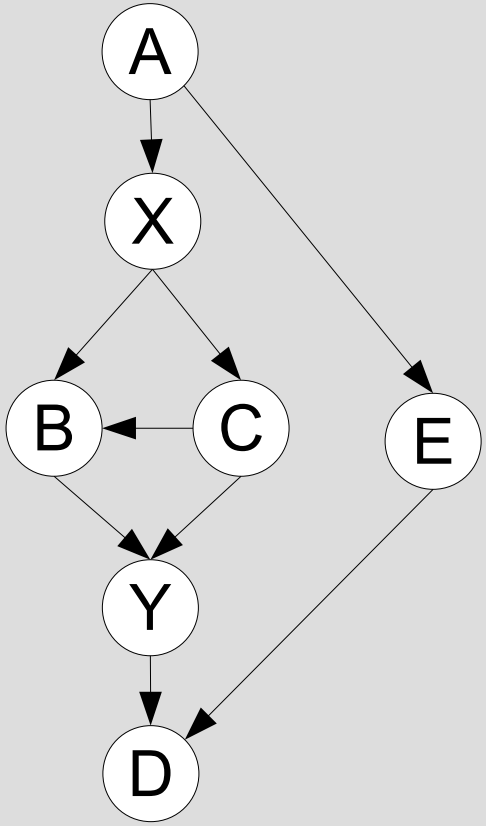



Smoothed Input Schema

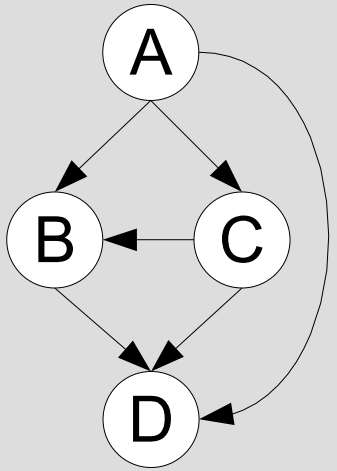
# Evolving Adaptive Programs: Stricter Notion of legality (3)




Strategy




Input Schema




Smoothed Input Schema

- How would the traversal graph look like?

# Conclusion

- Structure-Shy programs are easy, but dangerous to evolve.
- Structure-Shy programs can be made safer by checking implicit assumptions and enforcing strict notion of compatibility.
- Adaptive programming is a traversal based paradigm for writing structure-shy programs.

# Questions, Comments?