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See the Forest for the Trees – How to Effectively Model and Randomize a DRT Structure

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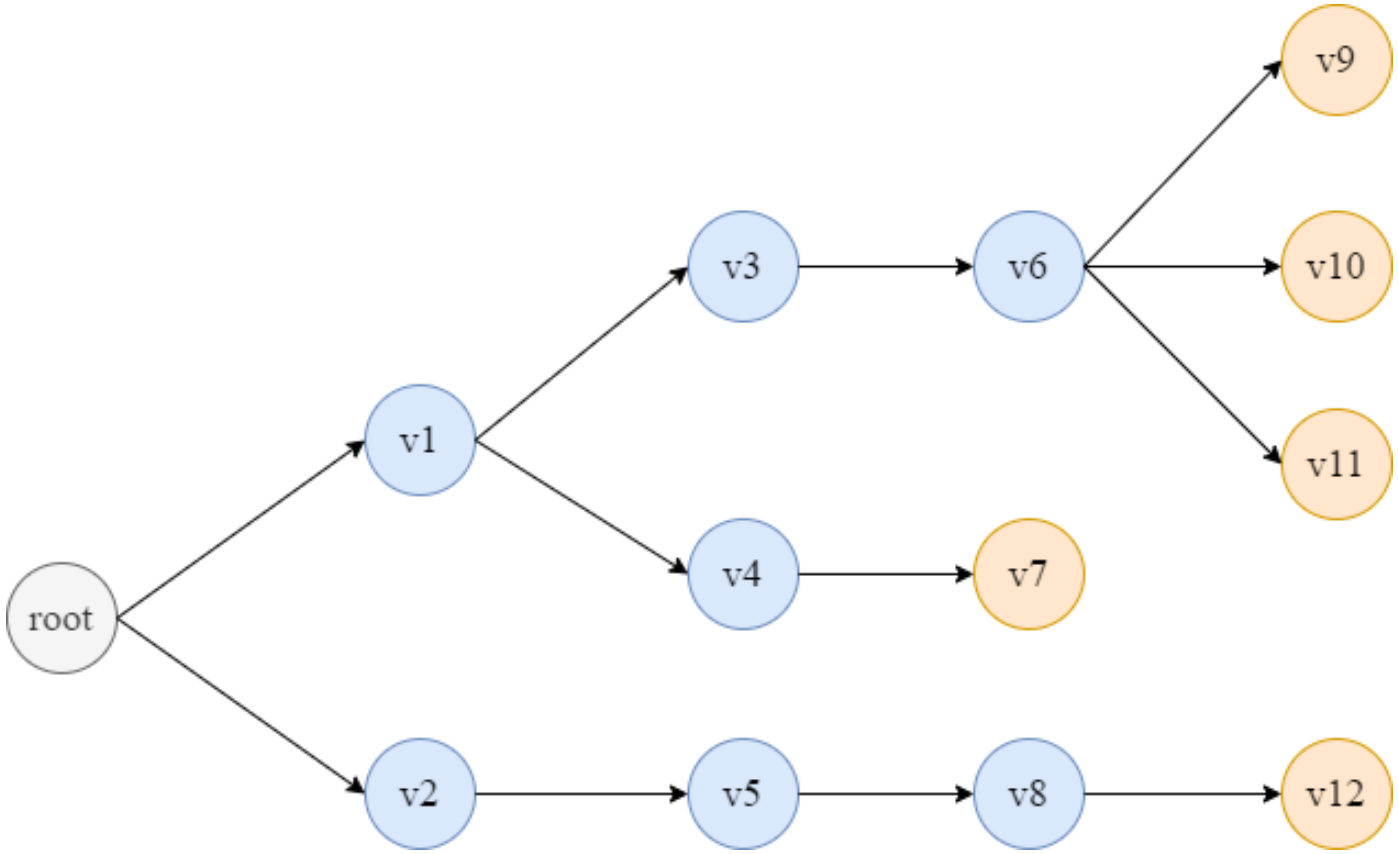
AXIS COMMUNICATIONS

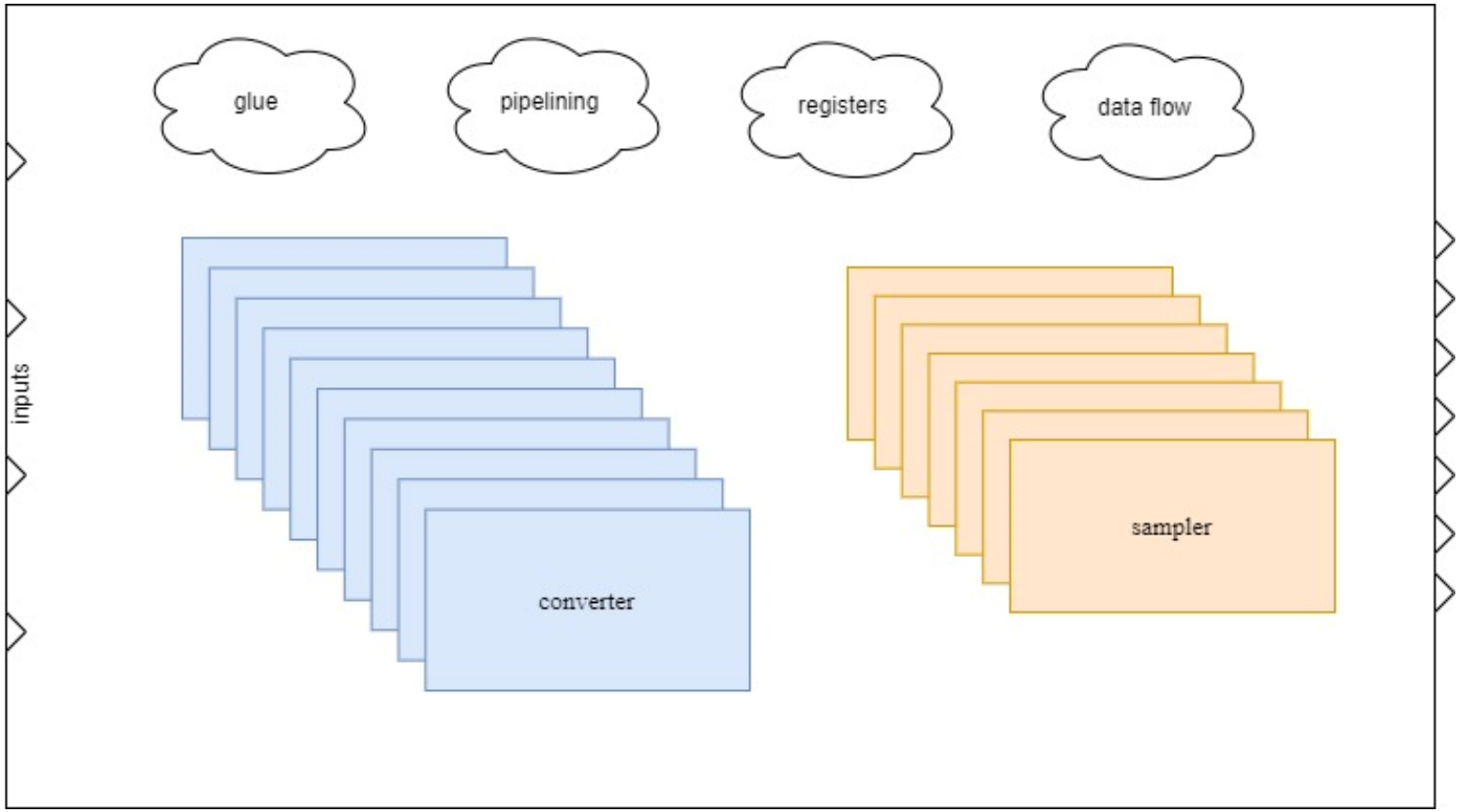
accellera SYSTEMS INITIATIVE

Graphs and Trees

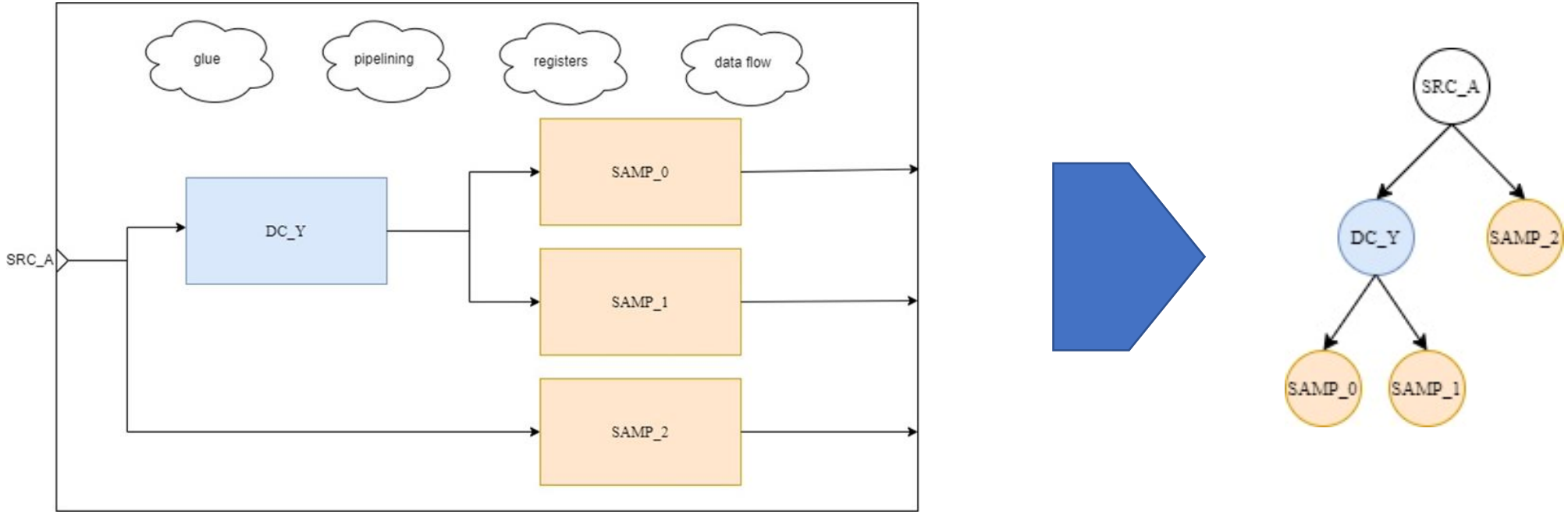
- Directed Rooted Tree (DRT)
  - Connected
  - Oriented
  - Acyclic
  - Each vertex has a single parent
  - Single start point, a root
  - All edges point away from root



Highly Configurable Datapath Unit



Modelling of Connectivity

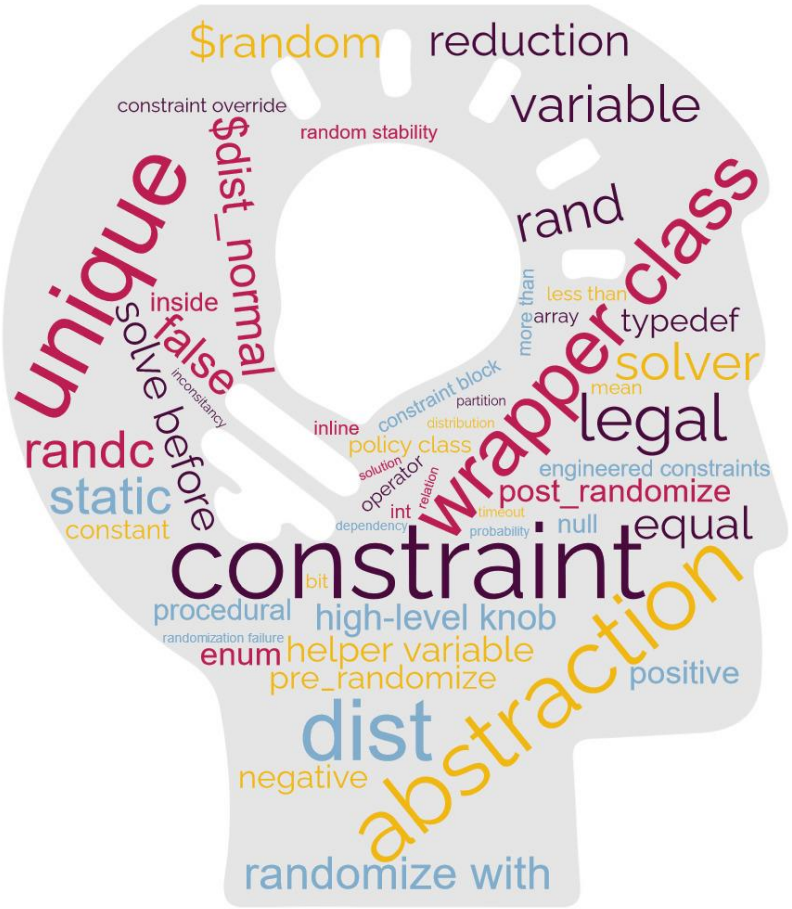


Challenges

Validity	Controllability	Performance	Scalability
• Rules • Constraints	• Steer • Direct	• Solver	• Vertices • Entry

How hard can it be?

- We have excellent support from SV language
- We can make use of complexity reduction techniques
- Number of re-use mechanisms available

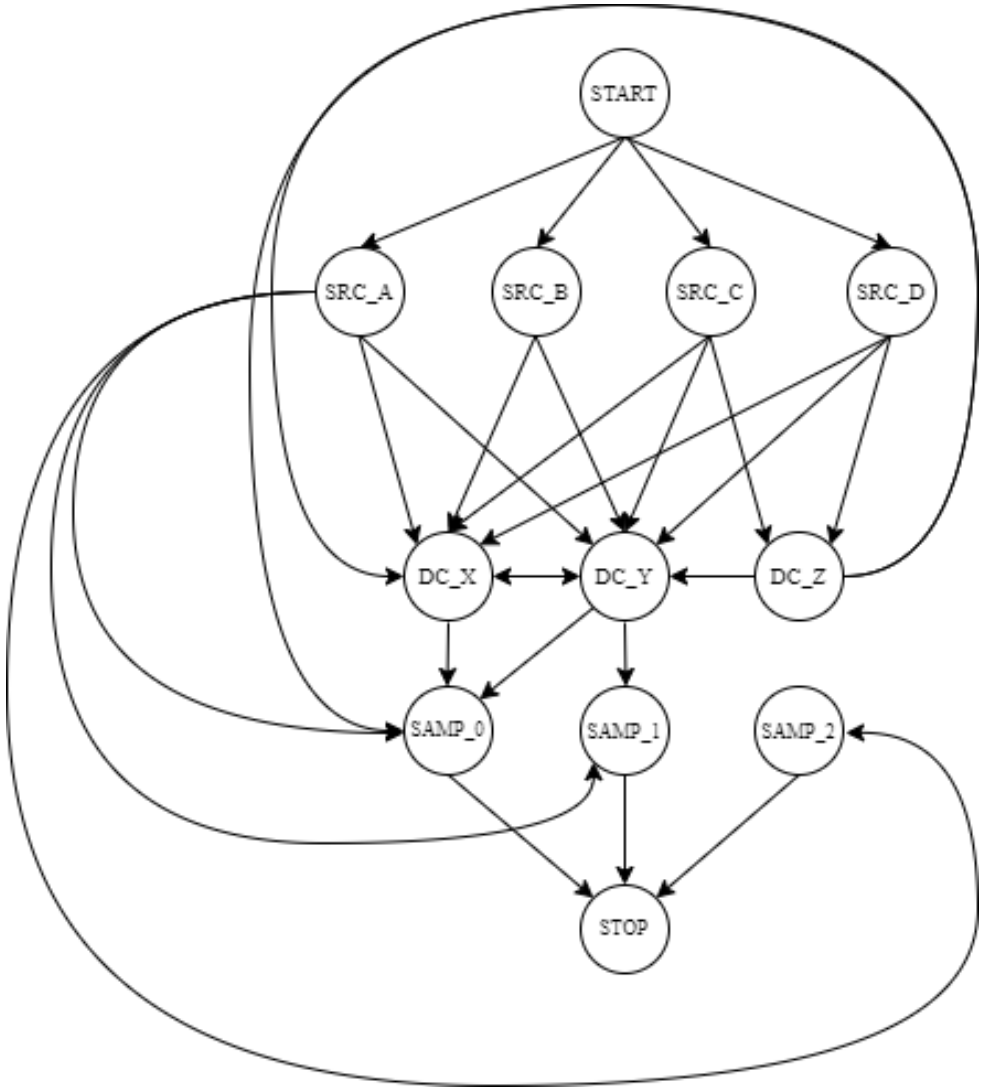


See the Forest from the Trees

- Tree has a recursive, self-similar shape
- Recursion
- Search problem
- Backtracking

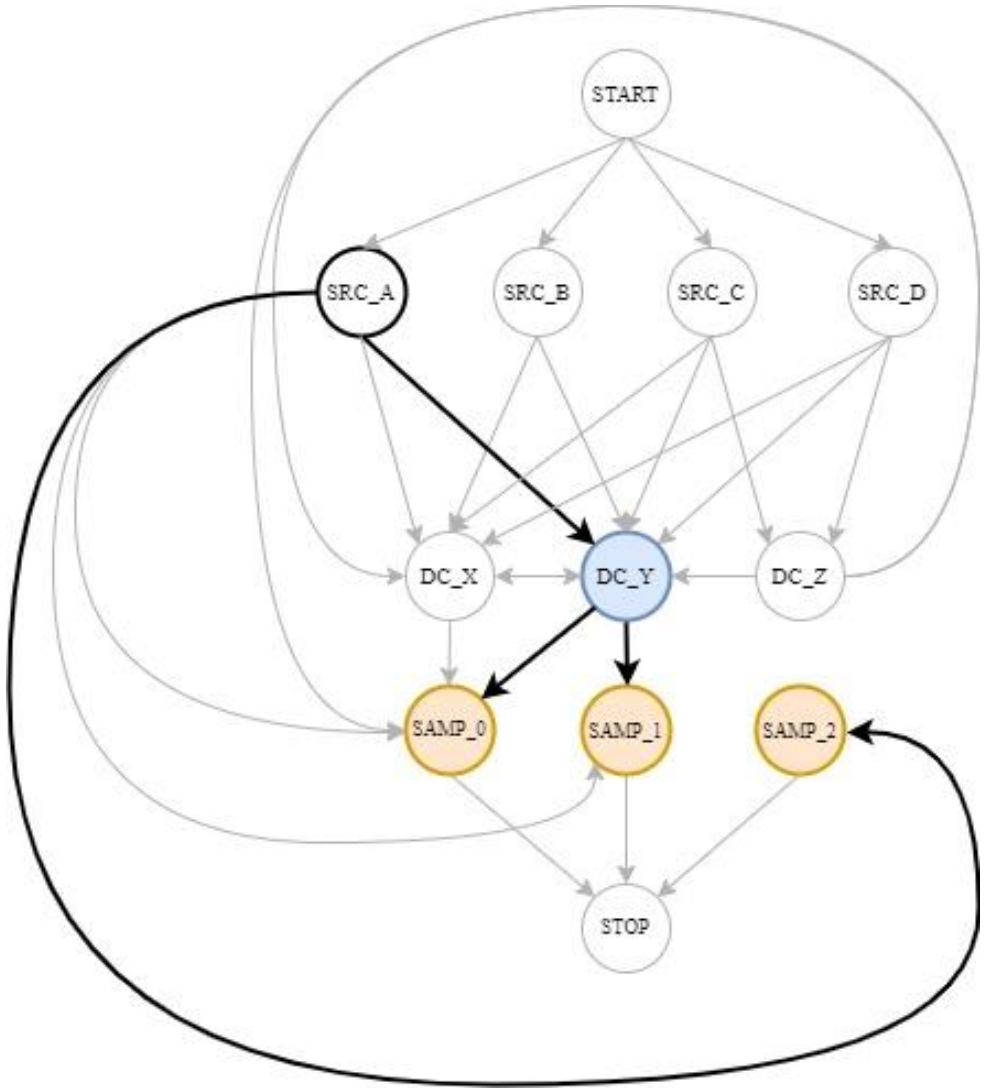
Model of Solution Space

- SRC_<*>: A primary input
- DC_<*>: A converter sub-unit
- SAMP_<*>: A sampler sub-unit
- Helper START and STOP vertices



A possible solution

- `SRC_<*>`: A primary input
- `DC_<*>`: A converter sub-unit
- `SAMP_<*>`: A sampler sub-unit
- Helper START and STOP vertices



Model of Solution Space in Constraints

```
class vertex extends vertex_base#(id_t, config_t);
  constraint c_connectivity {
    this.id inside {START}        -> this.child_id inside {SRC_A, SRC_B, SRC_C, SRC_D};
    this.id inside {SRC_A}        -> this.child_id inside {DC_X, DC_Y, SAMP_0, SAMP_1, SAMP_2};
    this.id inside {SRC_B}        -> this.child_id inside {DC_X, DC_Y};
    this.id inside {SRC_C, SRC_D} -> this.child_id inside {DC_X, DC_Y, DC_Z};
    this.id inside {DC_X}         -> this.child_id inside {DC_Y, SAMP_0};
    this.id inside {DC_Y}         -> this.child_id inside {DC_X, SAMP_0, SAMP_1};
    this.id inside {DC_Z}         -> this.child_id inside {DC_X, DC_Y, SAMP_0};
    this.id inside {SAMP_0,
                    SAMP_1,
                    SAMP_2}       -> this.child_id inside {STOP};
}
```

Backtracking

- Incrementally builds solution candidates
- Abandons potential candidates when not meeting criteria
- Guaranteed to produce a valid solution

```
function find(vertex v);
  if abandon(v) prune(v)
  if leaf(v) output(v)
  foreach children(v)[i]
    find(i)
endfunction : find
```

Building the Tree

- Separate `allocator` class
- Implements the different described functions for backtracking
- For implementation refer to the paper.

```
function find(vertex v);
  if abandon(v) prune(v)
  if leaf(v) output(v)
  foreach children(v)[i]
    find(i)
endfunction : find
```

```
if (!current.randomize() with {!(this.child_id inside {local::withdrawn});}) begin
  this.withdrawn.push_front(current.id);
  return 0;
end
```

abandon(v)

prune(v)

```
if (current.child_id == stop) begin
  this.withdrawn.push_front(current.id);
  return 1;
end
```

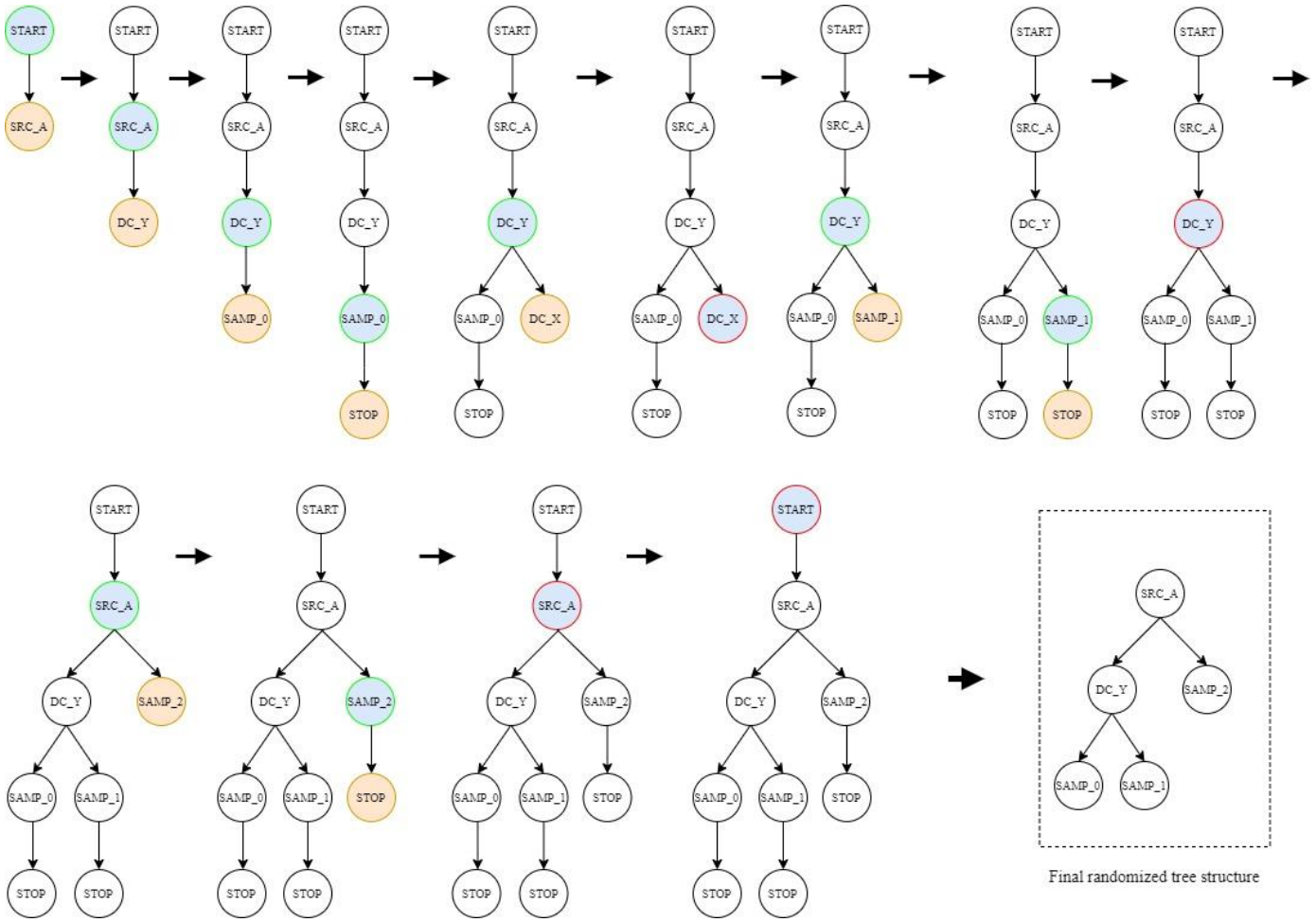
leaf(v)

output(v)

```
child = vertex_base#(id_t, config_t)::type_id::create();
child.init(current.child_id, current.id, this);
this.withdrawn.push_back(current.id);
ok = find_path(child, stop);
this.withdrawn.pop_back(current.id);
if (ok) begin
  this.withdrawn.push_front(current.id);
  current.add_child(child);
  return 1;
end
```

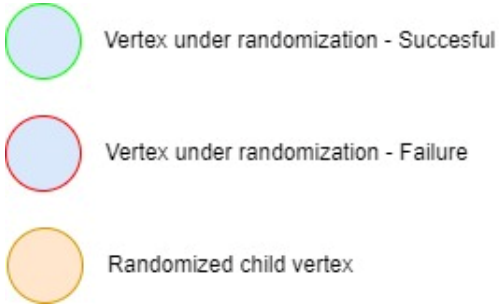
recursion

An Example



Final randomized tree structure

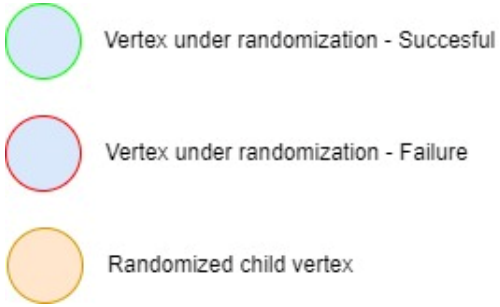
An Example

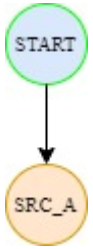



```
withdrawn = {}
```

```
this.id inside {START}        -> this.child_id inside {SRC_A, SRC_B, SRC_C, SRC_D};
```

An Example

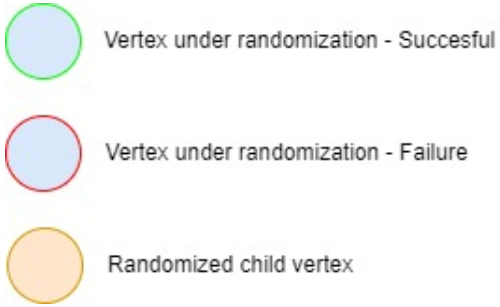


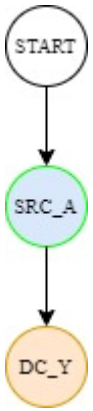



```
withdrawn = {}
```

```
this.id inside {START}        -> this.child_id inside {SRC_A, SRC_B, SRC_C, SRC_D};
```

An Example

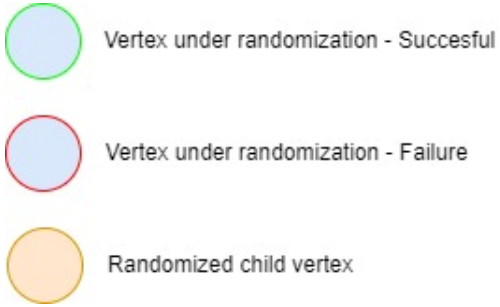


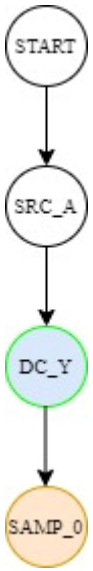



```
withdrawn = {SRC_A}
```

```
this.id inside {SRC_A}        -> this.child_id inside {DC_X, DC_Y, SAMP_0, SAMP_1, SAMP_2};
```

An Example

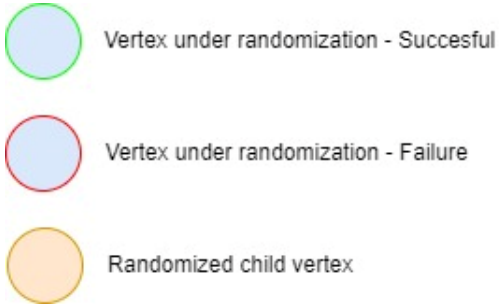


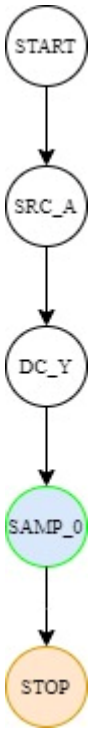



```
withdrawn = {SRC_A, DC_Y}
```

```
this.id inside {DC_Y}          -> this.child_id inside {DC_X, SAMP_0, SAMP_1};
```

An Example

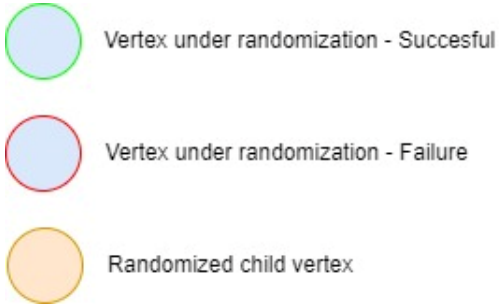


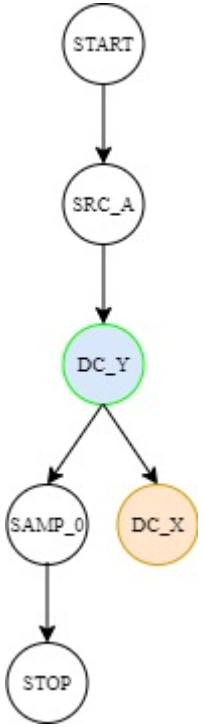



```
withdrawn = {SRC_A, DC_Y, SAMP_0}
```

```
this.id inside {SAMP_0, SAMP_1, SAMP_2} -> this.child_id inside {STOP};
```

An Example

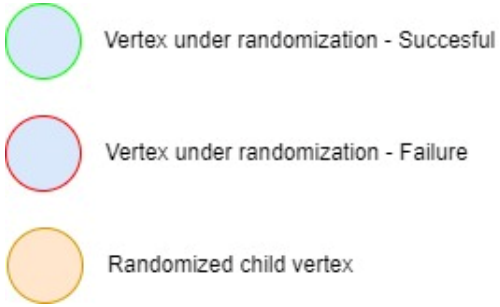


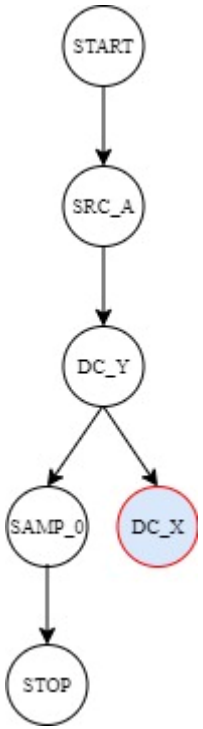



```
withdrawn = {SRC_A, DC_Y, SAMP_0}
```

```
this.id inside {DC_Y} -> this.child_id inside {DC_X, SAMP_0, SAMP_1};
```

An Example

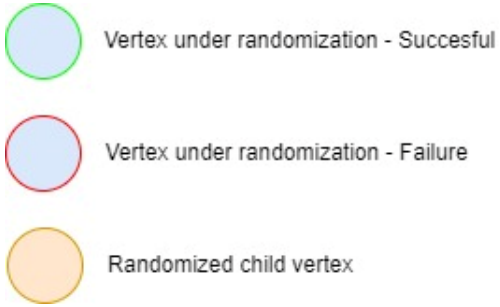


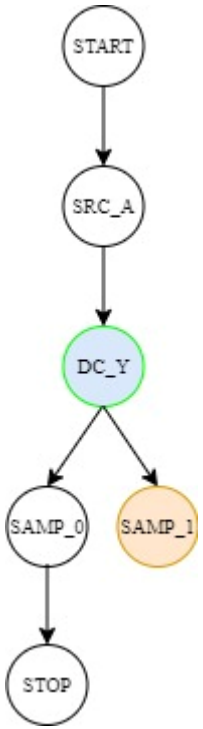



```
withdrawn = {SRC_A, DC_Y, SAMP_0, DC_X}
```

```
this.id inside {DC_X} -> this.child_id inside {DC_Y, SAMP_0};
```

An Example

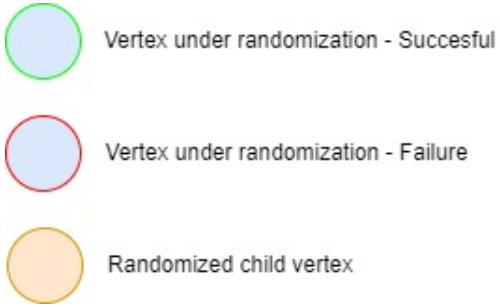


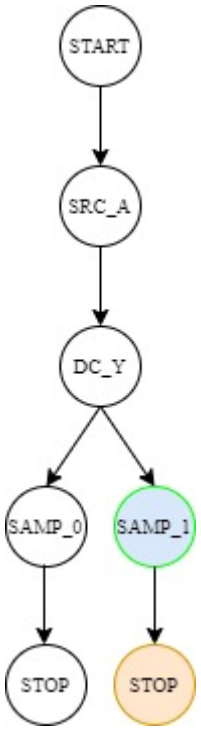



```
withdrawn = {SRC_A, DC_Y, SAMP_0, DC_X}
```

```
this.id inside {DC_Y} -> this.child_id inside {DC_X, SAMP_0, SAMP_1};
```

An Example

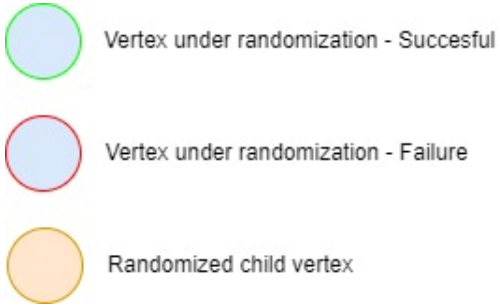


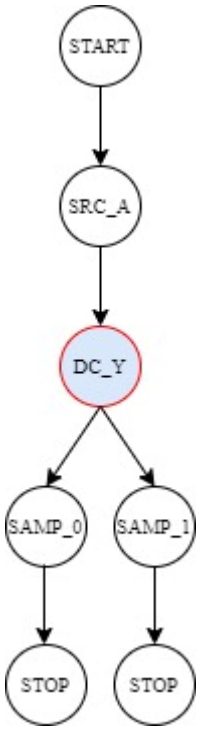



```
withdrawn = {SRC_A, DC_Y, SAMP_0, DC_X, SAMP_1}
```

```
this.id inside {SAMP_0, SAMP_1, SAMP_2} -> this.child_id inside {STOP};
```

An Example

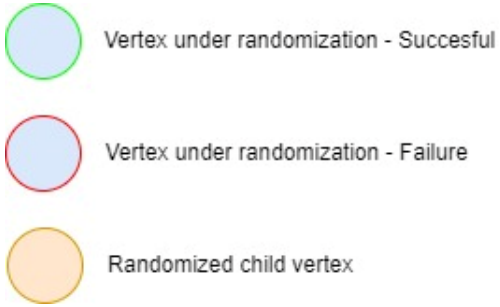


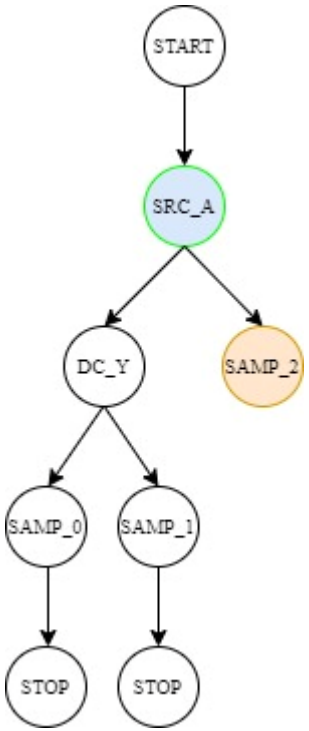



```
withdrawn = {SRC_A, DC_Y, SAMP_0, DC_X, SAMP_1}
```

```
this.id inside {DC_Y} -> this.child_id inside {DC_X, SAMP_0, SAMP_1};
```

An Example

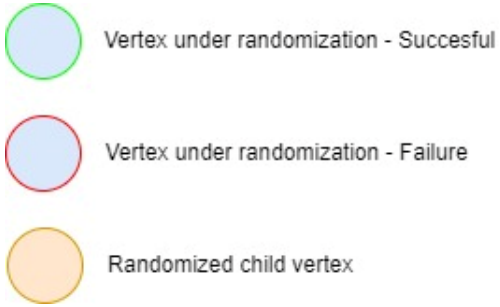


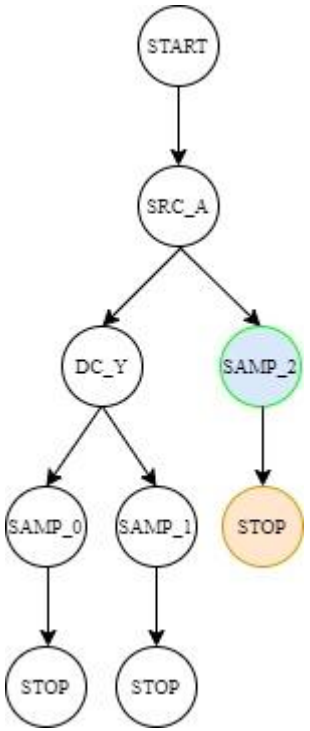



```
withdrawn = {SRC_A, DC_Y, SAMP_0, DC_X, SAMP_1}
```

```
this.id inside {SRC_A}        -> this.child_id inside {DC_X, DC_Y, SAMP_0, SAMP_1, SAMP_2};
```

An Example

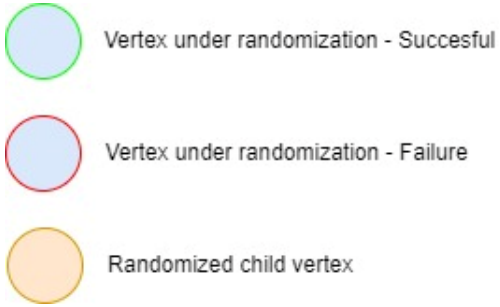


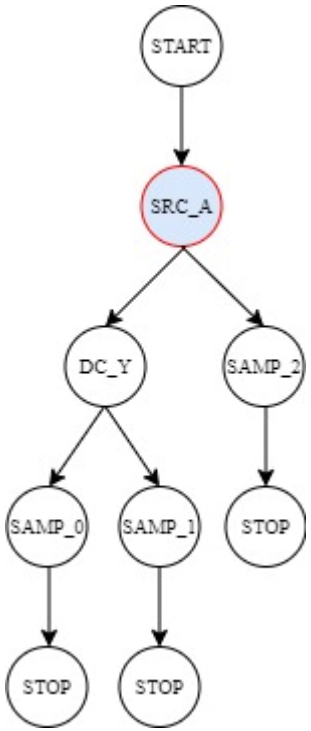



```
withdrawn = {SRC_A, DC_Y, SAMP_0, DC_X, SAMP_1, SAMP_2}
```

```
this.id inside {SAMP_0, SAMP_1, SAMP_2} -> this.child_id inside {STOP};
```

An Example

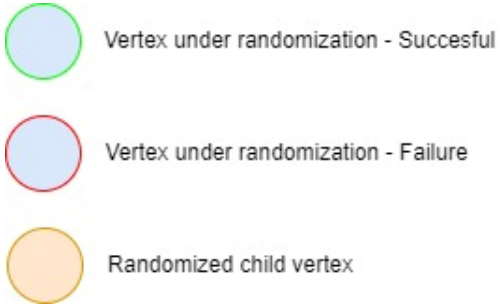


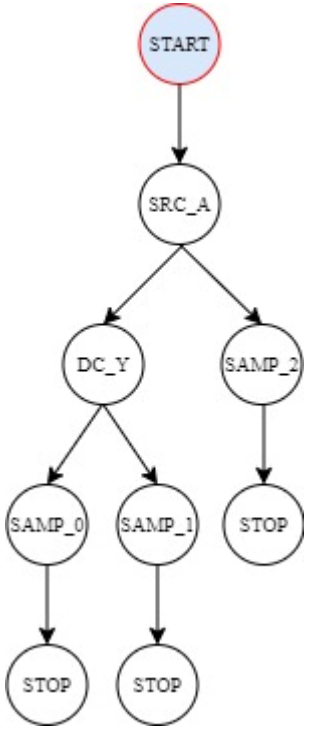



```
withdrawn = {SRC_A, DC_Y, SAMP_0, DC_X, SAMP_1, SAMP_2}
```

```
this.id inside {SRC_A}        -> this.child_id inside {DC_X, DC_Y, SAMP_0, SAMP_1, SAMP_2};
```

An Example

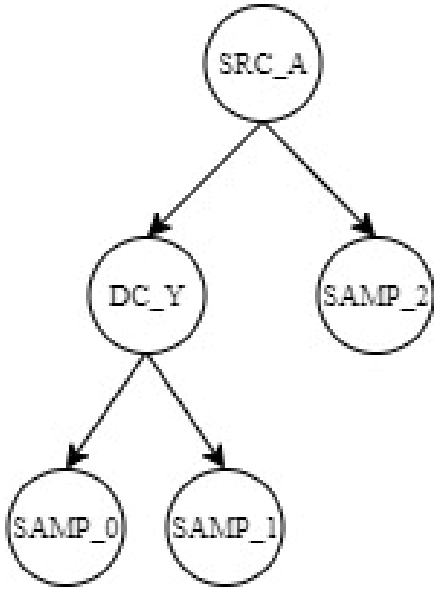





```
withdrawn = {SRC_A, DC_Y, SAMP_0, DC_X, SAMP_1, SAMP_2}
```

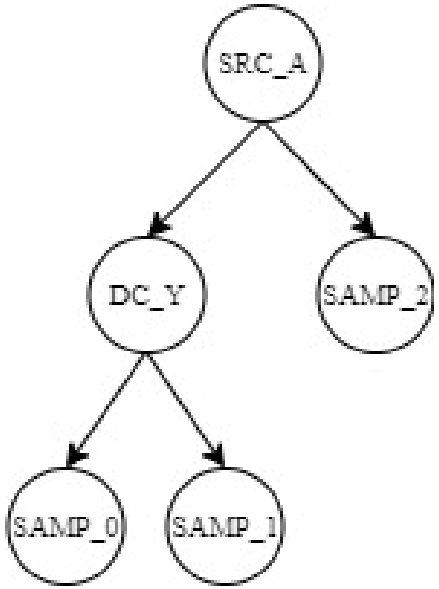
```
this.id inside {START}        -> this.child_id inside {SRC_A, SRC_B, SRC_C, SRC_D};
```

A Tree



Results

- Validity
- Controllability
- Performance
- Scalability



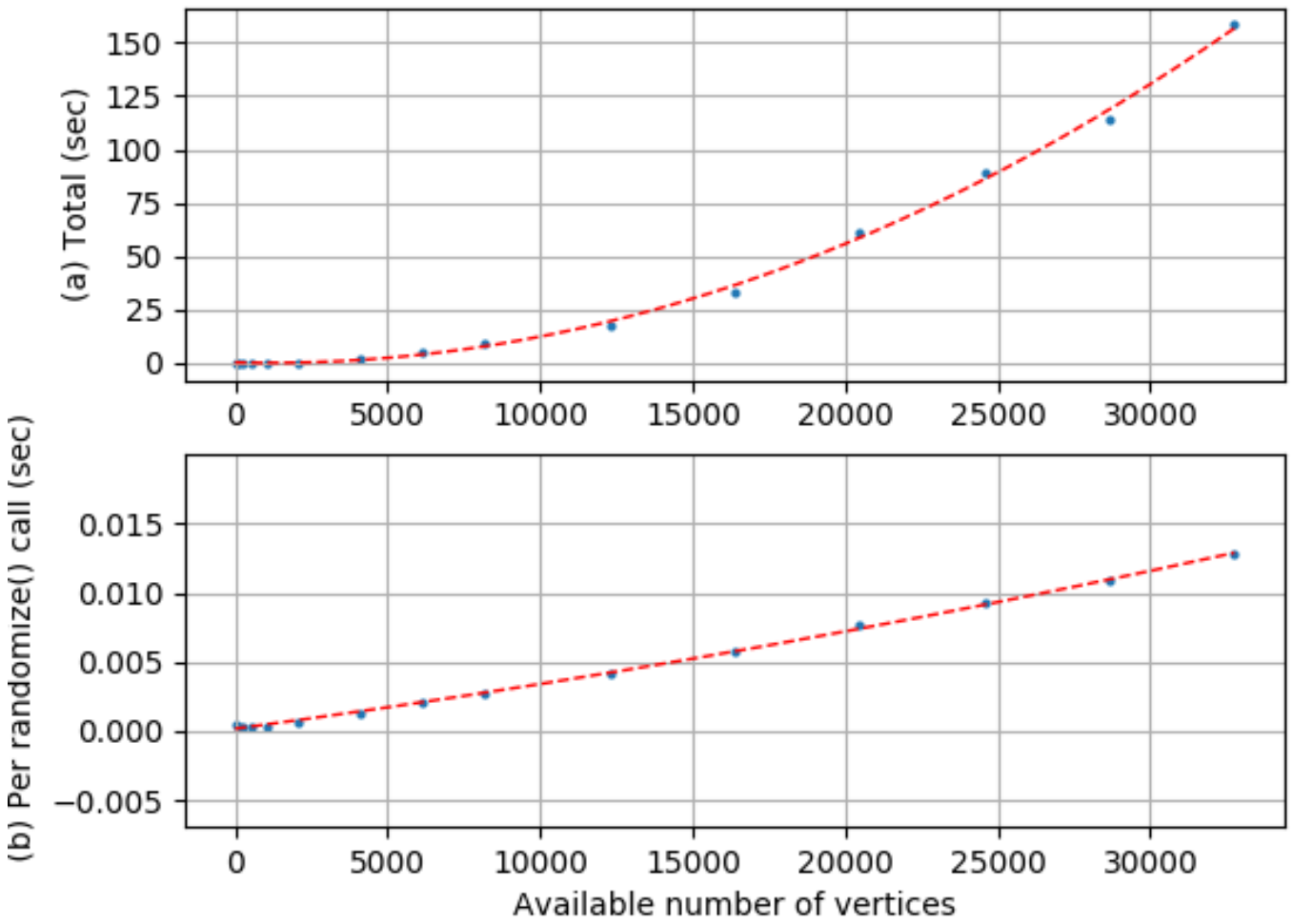
Results

- Validity
- <u>Controllability</u>
- Performance
- Scalability

```
class sampler0 extends vertex#(id_t, config_t);

  constraint c_samp_0 {
    this.id inside {SRC_A} -> this.child_id inside {DC_X,
                                                    DC_Y,
                                                    SAMP_0};

    this.id inside {DC_X}  -> this.child_id inside {SAMP_0};
    this.id inside {DC_Y}  -> this.child_id inside {SAMP_0};
    this.id inside {DC_Z}  -> this.child_id inside {SAMP_0};
  }

...
```

Results

- Validity
- Controllability
- <u>Performance</u>
- <u>Scalability</u>



Summary

- Modelling of connectivity
- Recursive, backtracking randomization
- Criteria
- Generic framework

Q&A


Megapixel
Quality
Ease of use
Network video
Reliability
open
Innovation
Easy installation
Protect
Service
all the way
support
integration
Thank you!
Image usability
Thermal
Convergence
HDTV
Access control
Partners
World Leader
Competence
Quality
Intelligent
Focus
Video encoder
Safe
Cameras
Outdoor
Secure
Global