Complexity Metrics for Hierarchical State Machines

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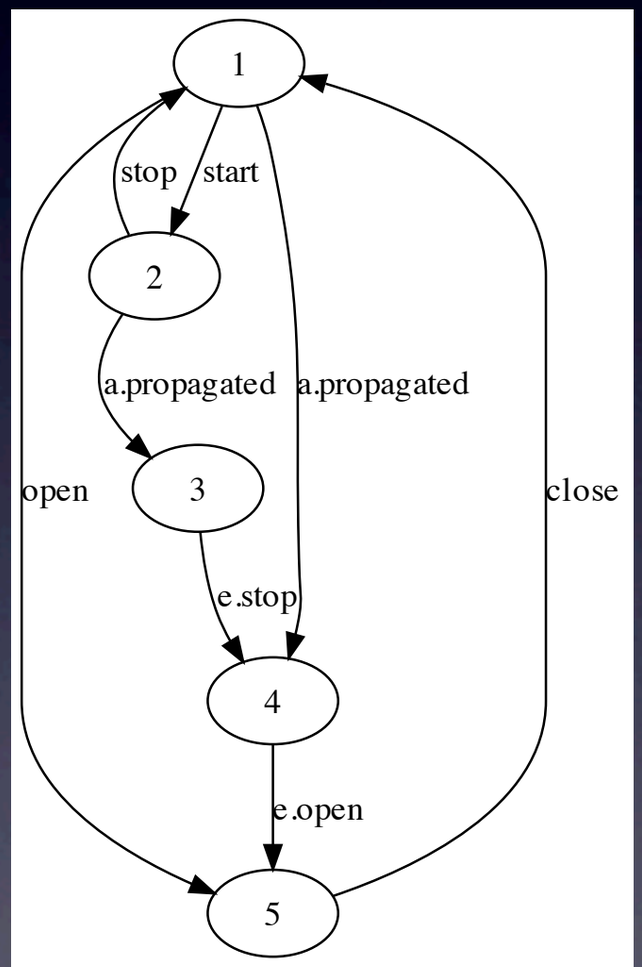
Overview

- PhD Topic
- Hierarchical State Machines
- Metrics
- PhD directions
- Further work

PhD Topic

Reverse engineered state machines

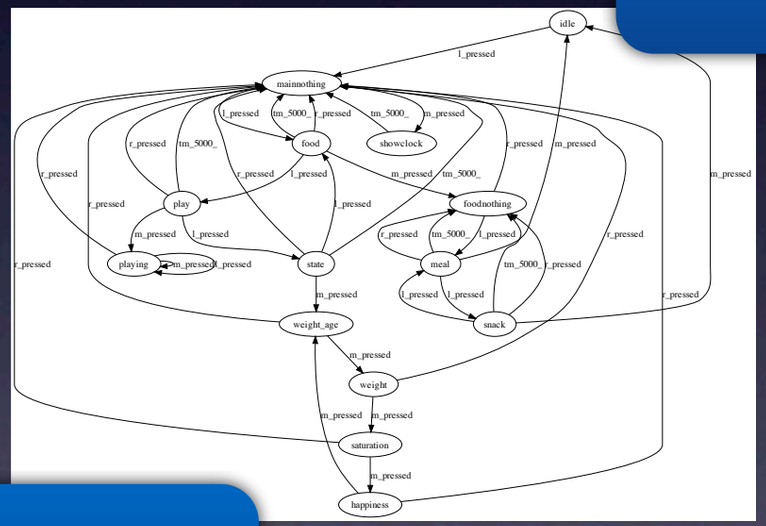
State Machines



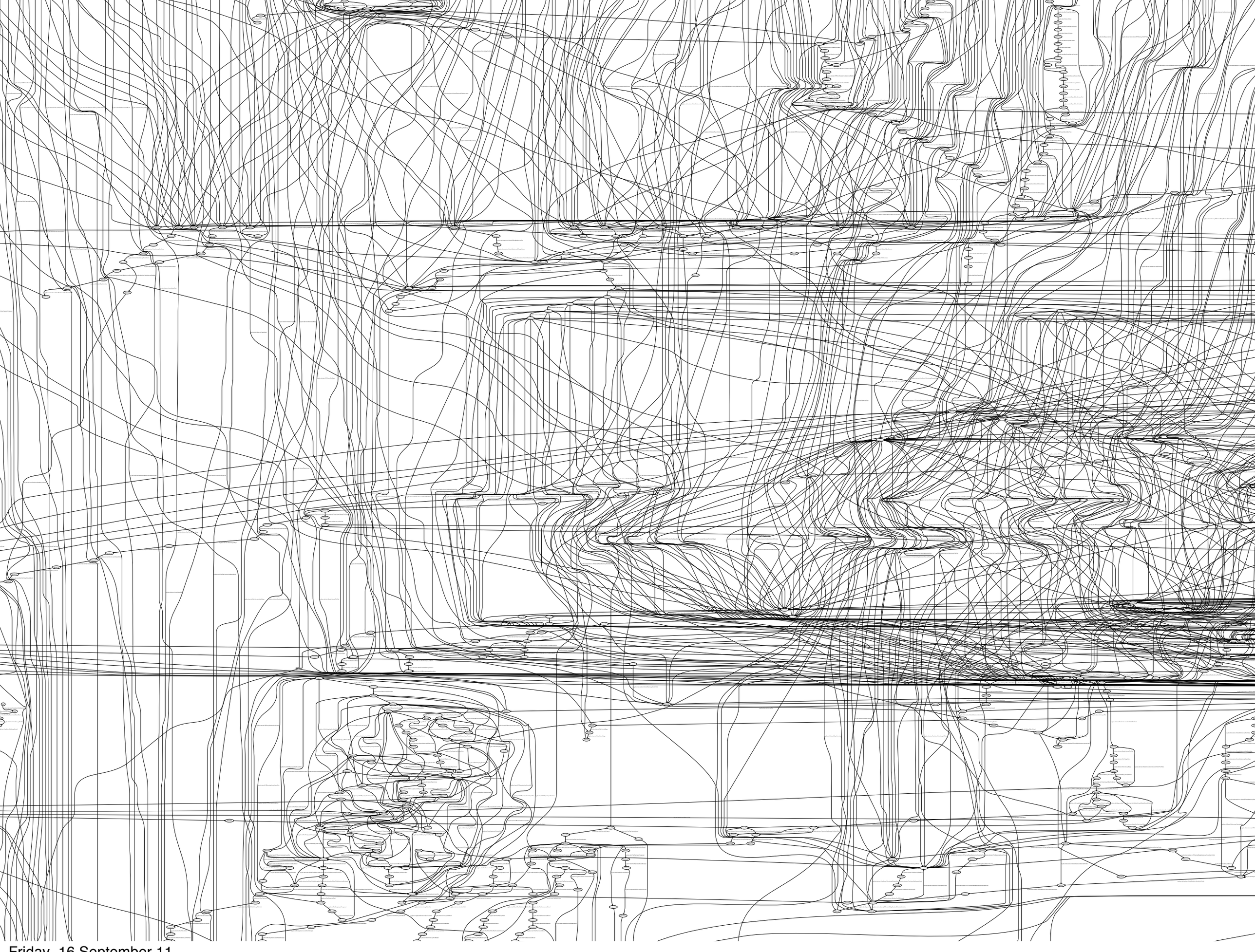
State Machines

Convey Behaviour

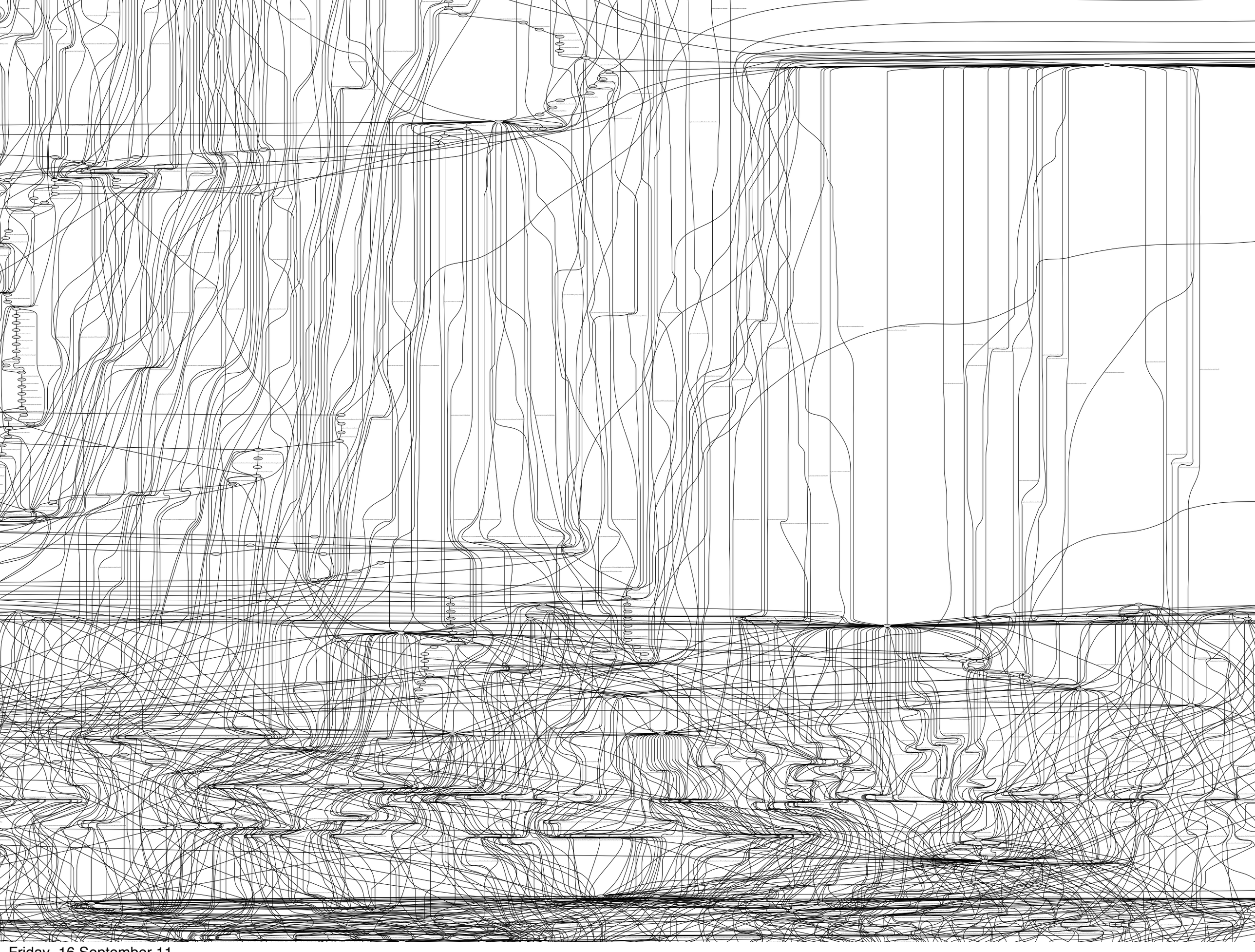
Implementation Independent



Can be Reverse Engineered



Friday, 16 September 11



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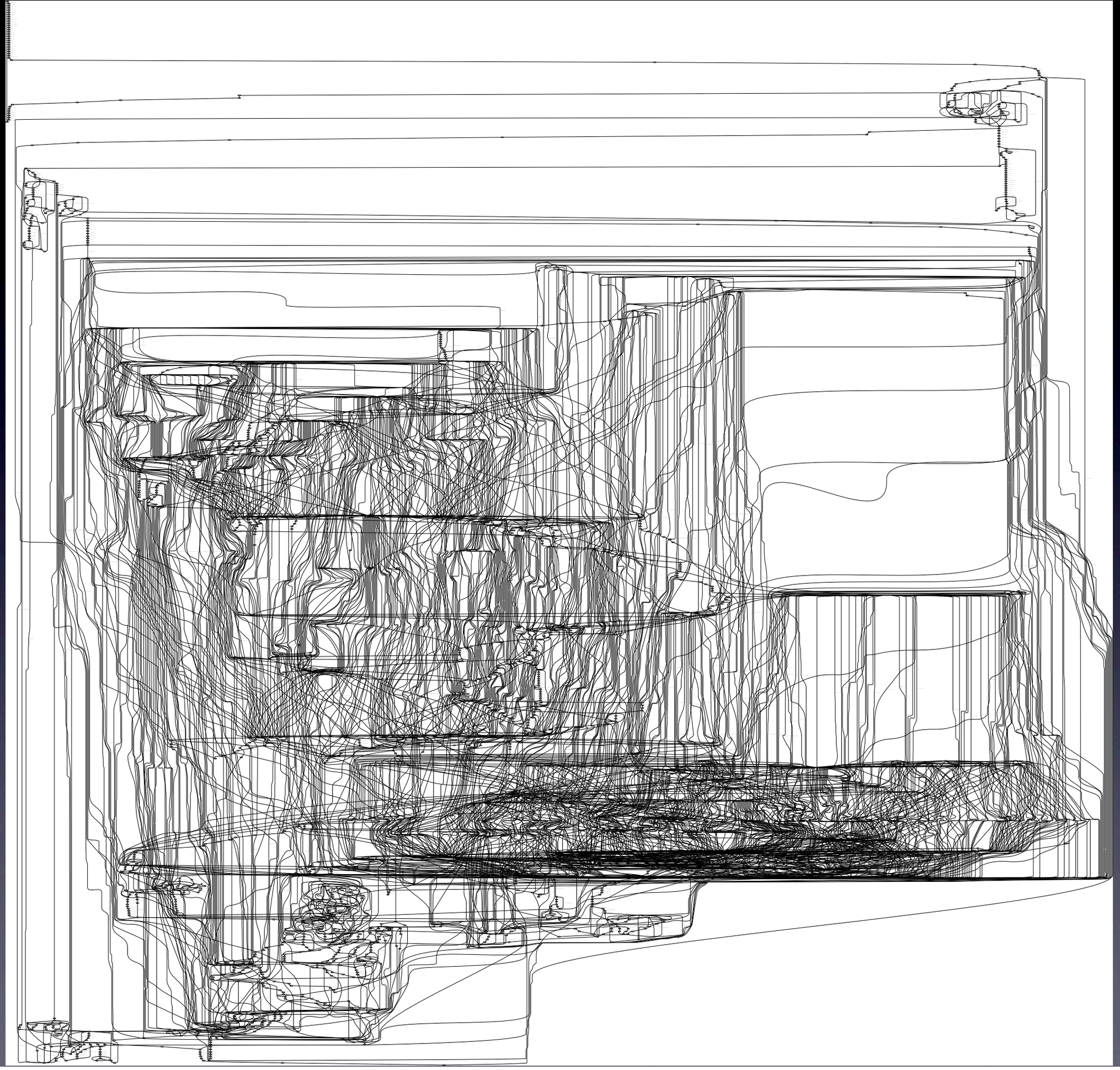
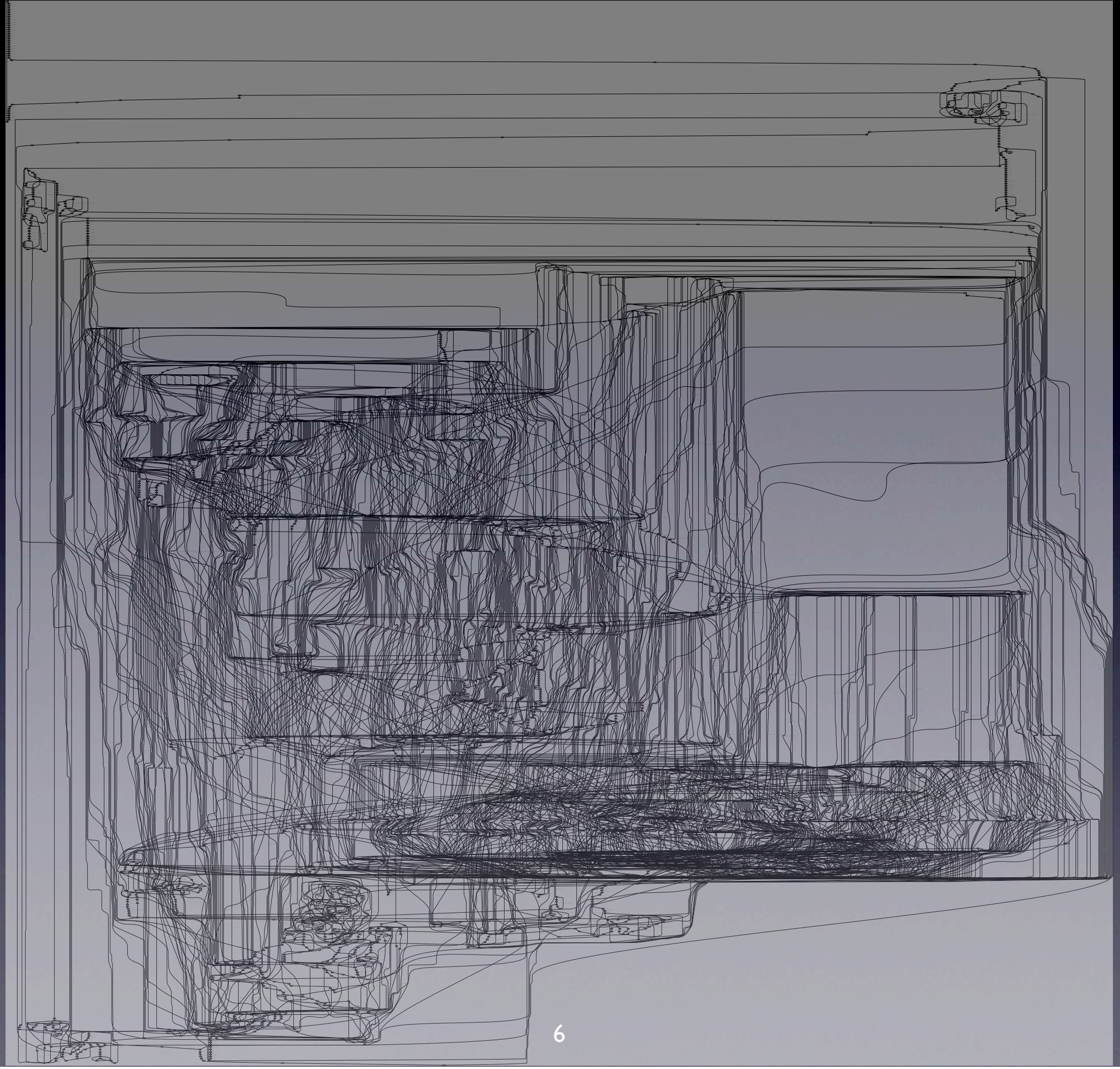
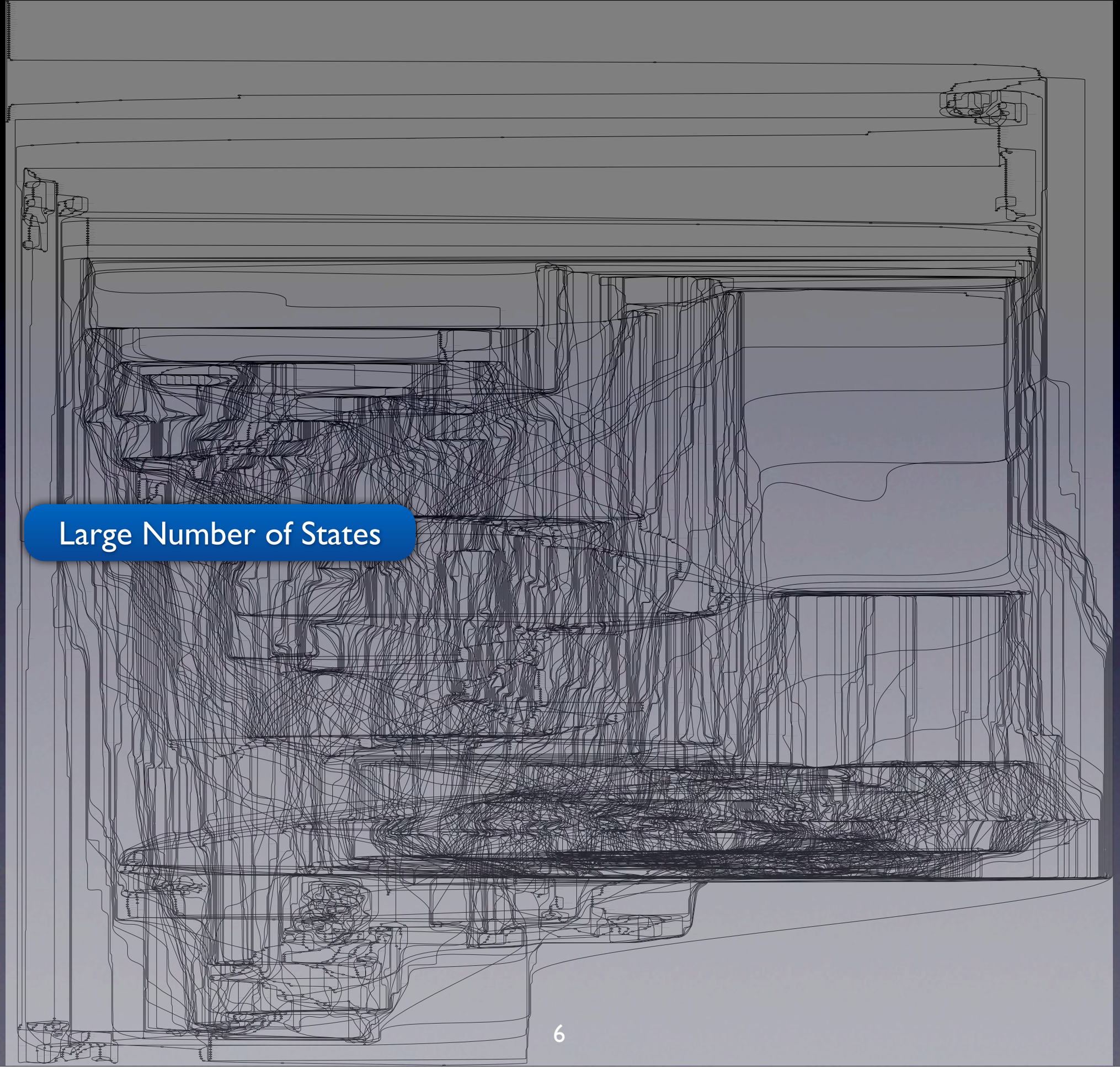
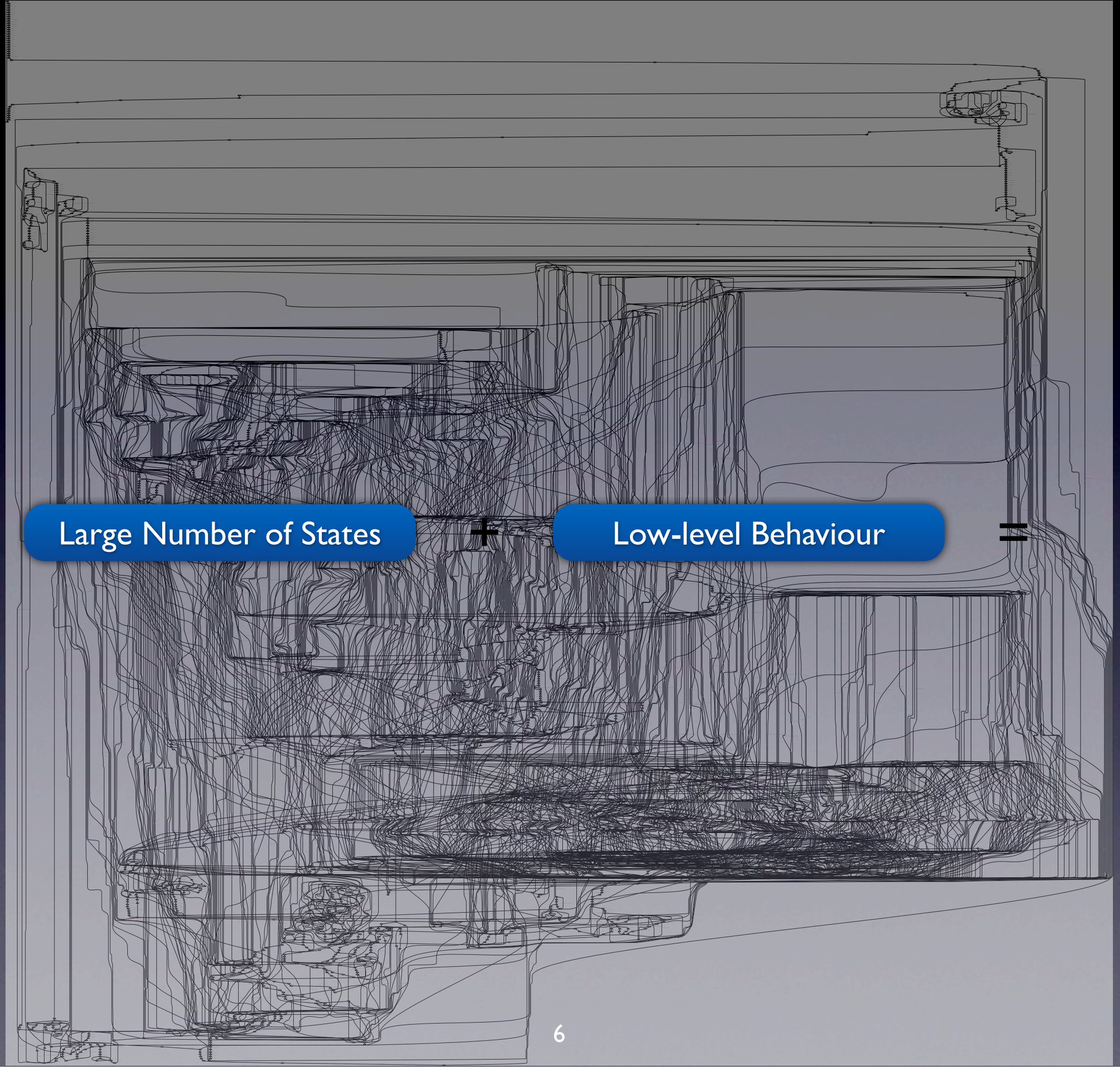
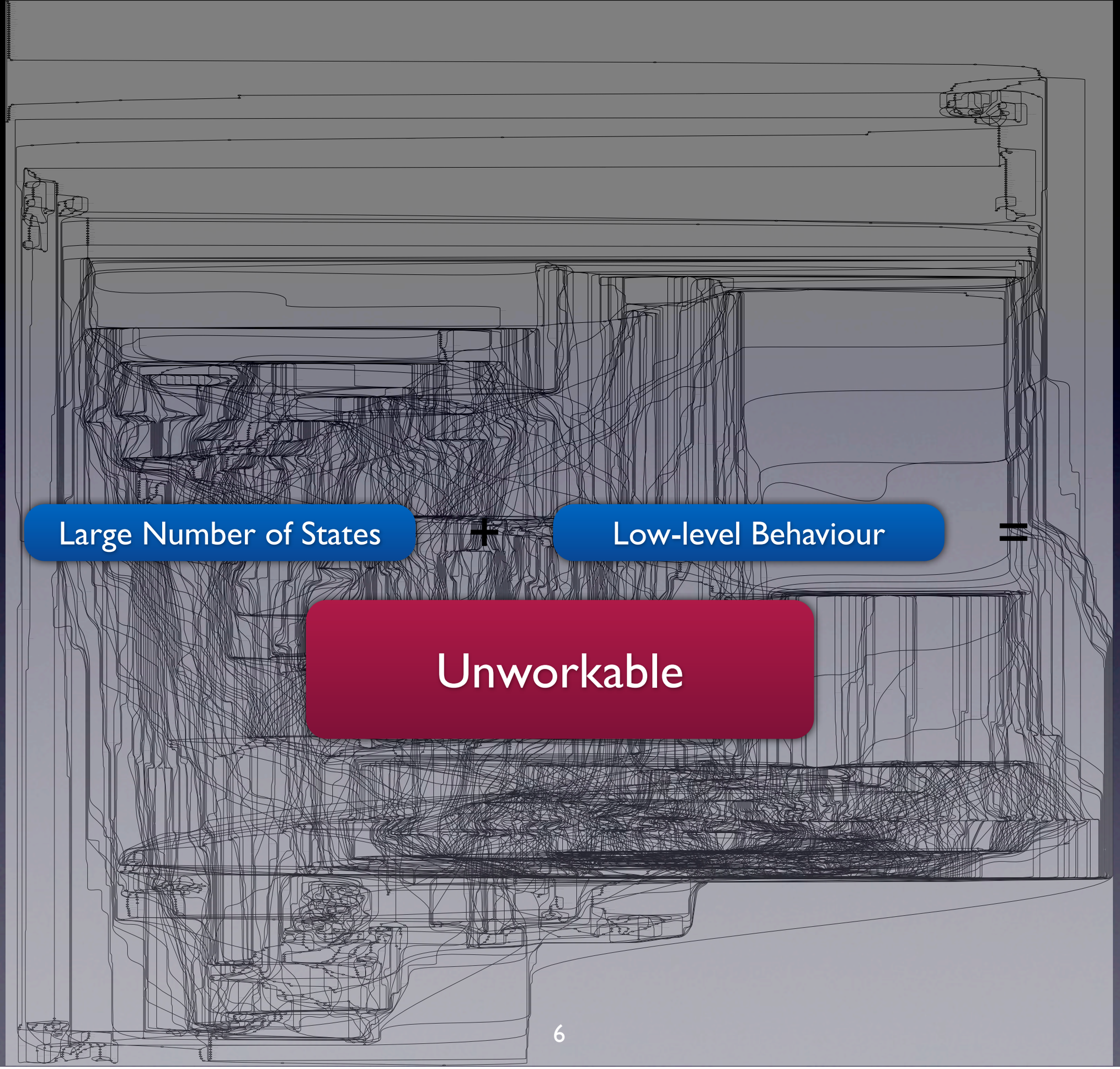





Large Number of States


Large Number of States
+
Low-level Behaviour
=


Large Number of States
+
Low-level Behaviour
=
Unworkable

Sizing up the Problem

- Machine built from traces
- Traces are method calls
- Very low-level behaviour

Statecharts

- Extension to state machines
- Composite and concurrent states
- Guards
- Events

Statecharts

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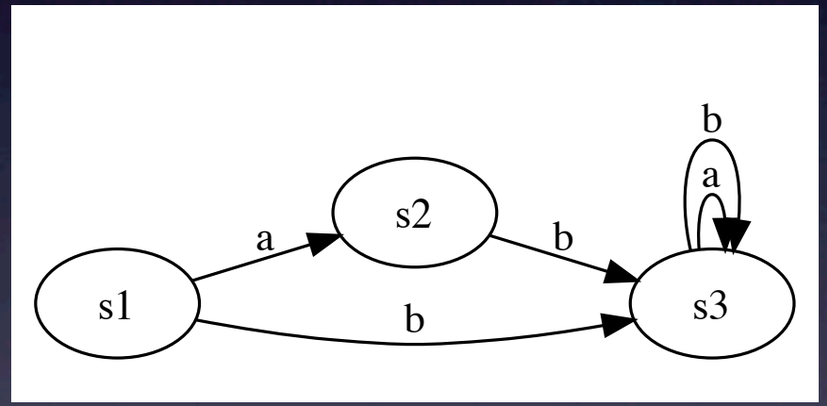
Hierarchical State Machines

- Superstate groups common behaviour



Hierarchical State Machines

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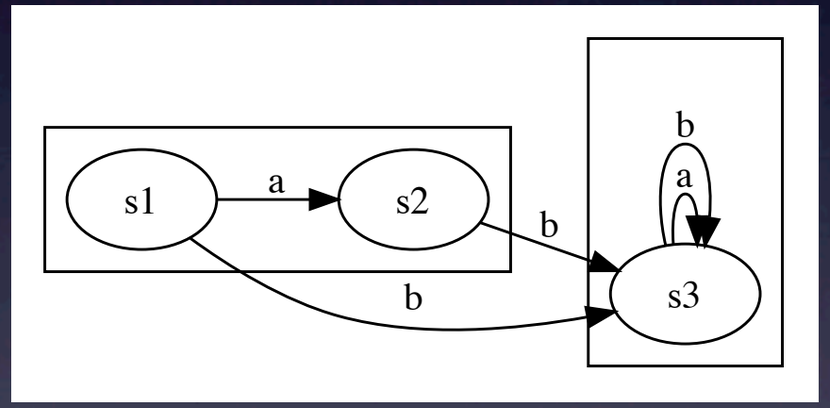
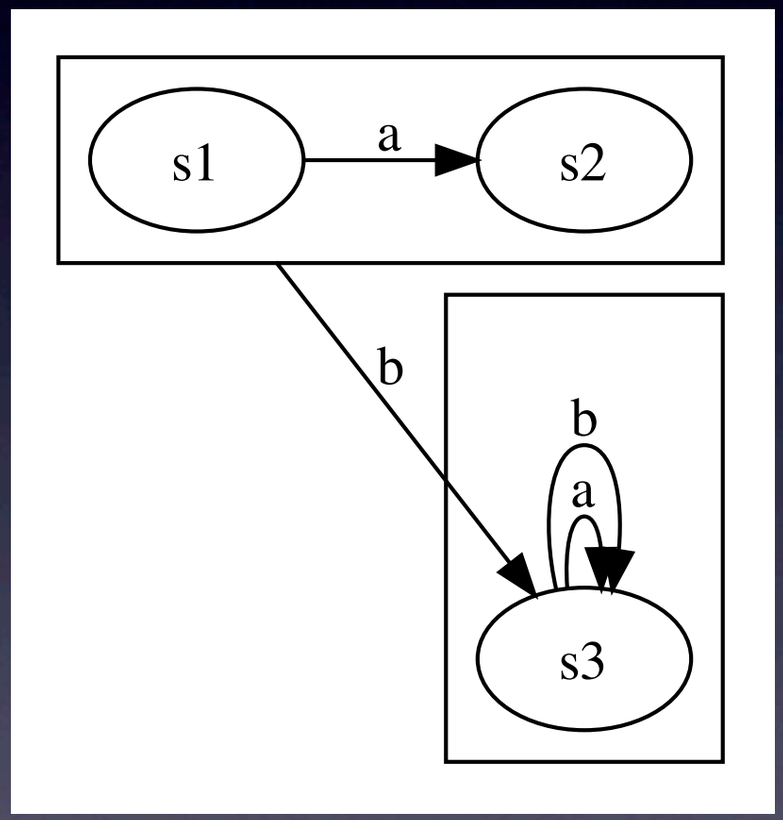


Hierarchical State Machines

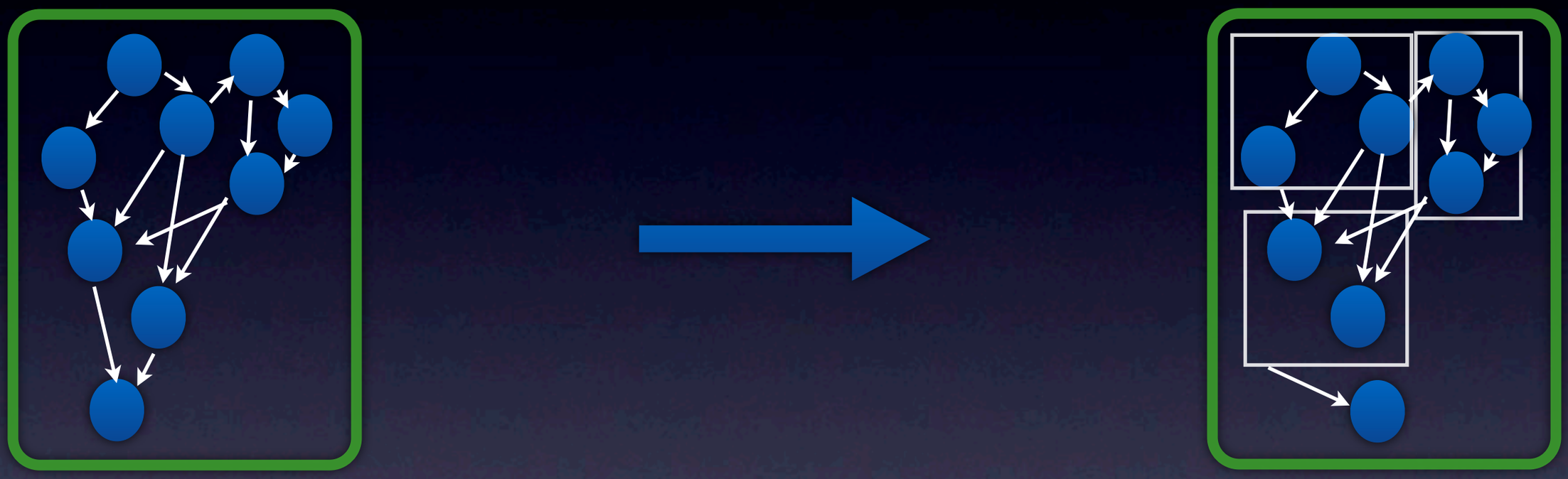
- Superstate groups common behaviour
- Transitions from all states in a superstate rewritten as one



FSM Size Problem

- HSM a potential solution
- Abstract low-level behaviour away
- Easier comprehension
- Allow variable level of detail

Goal



Existing Technique

- Rule based
- Identify groupings where edges could be reduced
- Kumar IACC09
- Need to check all pairs
- Rigid constraint

Related Technique

- Bunch - Mitchell & Mancoridis [TSE06]
- Search-based hierarchy generation for module dependency graphs
- Key contribution: MQ
- Lower number of edges between superstates is better

Related Technique

$$MQ = \sum_{i=1}^{k} CF_i$$

$$CF_i = \begin{cases} 0 & \mu_i = 0 \\ \dfrac{2\mu_i}{2\mu_i + \sum\limits_{\substack{j=1 \\ j \neq i}}^{k} (\epsilon_{i,j} + \epsilon_{j,i})} & \text{otherwise} \end{cases}$$

- μ: Number of edges within a module
- ε: Number of edges that leave a module

FSM to HSM

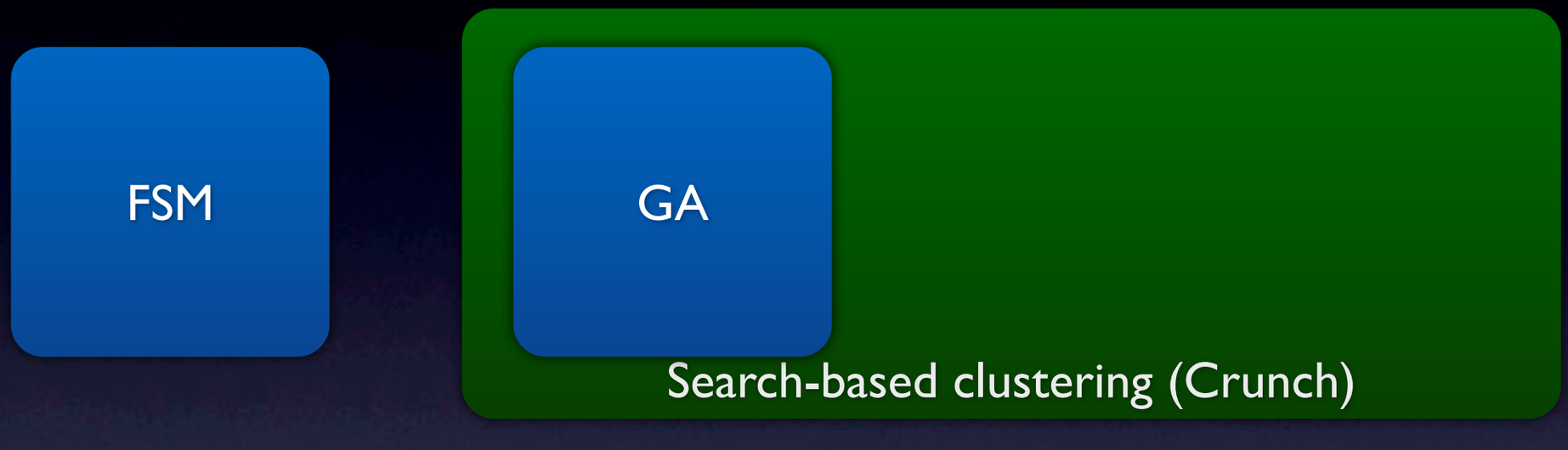
FSM to HSM

FSM to HSM

FSM

Search-based clustering (Crunch)

FSM to HSM



FSM to HSM

FSM to HSM


FSM
GA
Fitness Function
Individual: Hierarchy
Search-based clustering (Crunch)

FSM to HSM

FSM

GA

Fitness Function

Individual: Hierarchy

Search-based clustering (Crunch)

HSM

Output

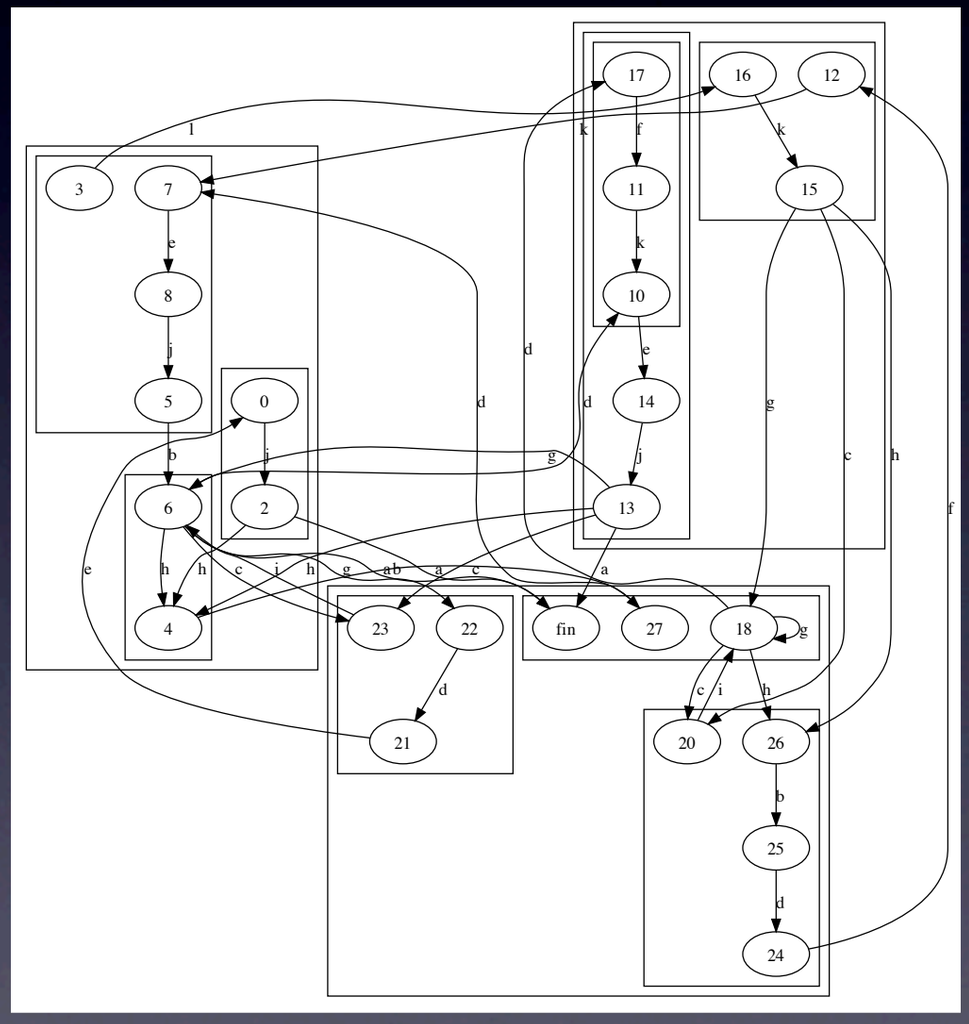
How can you tell how good a solution is?

Evaluating an HSM

- Existing metric for FSMs is CC
- E - N + 2
- Ignores hierarchy
- Need a better alternative...

TLCC

- Treat each superstate as a simple state
- Ignore all edges within superstates
- Calculate CC



TLCC

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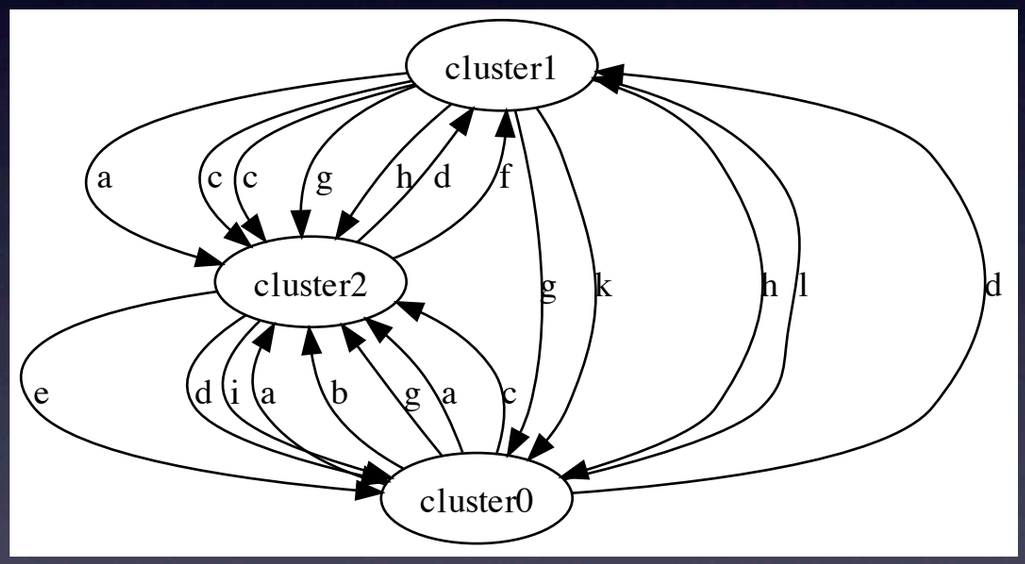
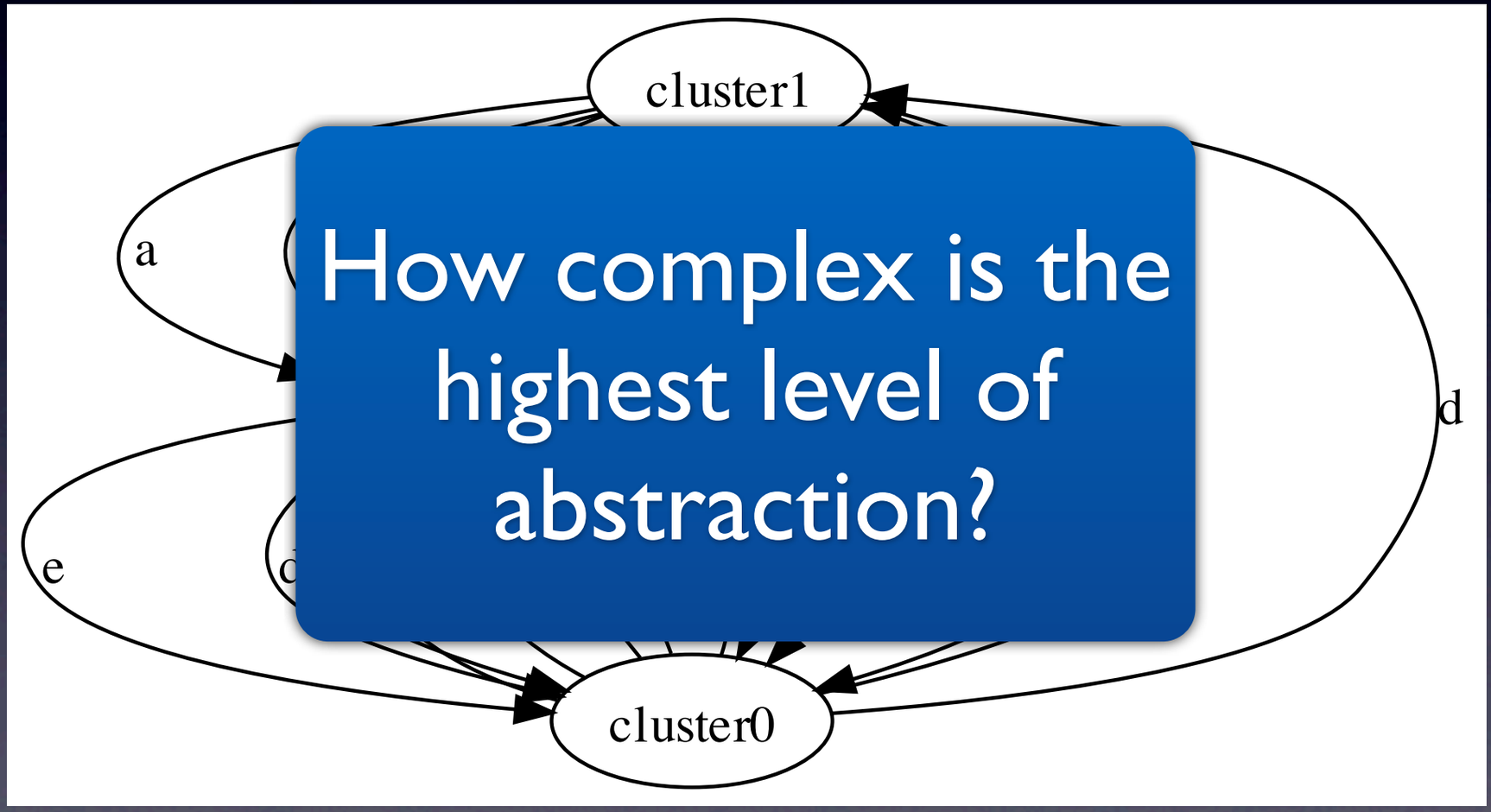


TLCC = 20 - 3 + 2 = 19



How complex is the highest level of abstraction?

Problems with TLCC

- Doesn't measure all the hierarchy
- Invalid solutions can get high results
  - When top level contains all states TLCC = 1

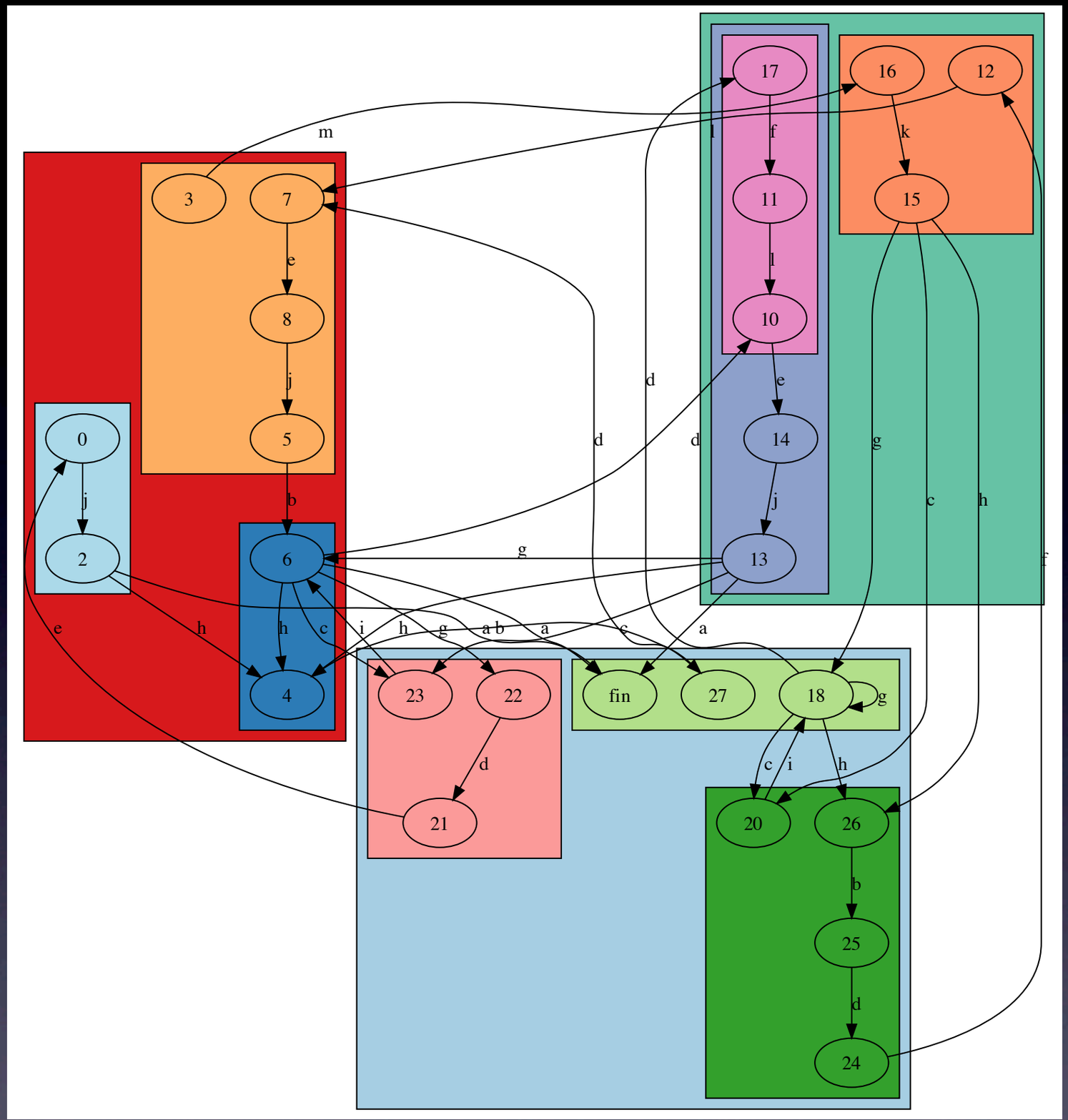
HCC

$$HCC(S,T,d) = \frac{TLCC(H,T)}{d} + \sum_{c \in H} HCC(c,T,d+1)$$

- Favours solutions that place lower level behaviour further down the hierarchy

HCC

2-4+2
1-2+2
+ 1-2+2)
/3



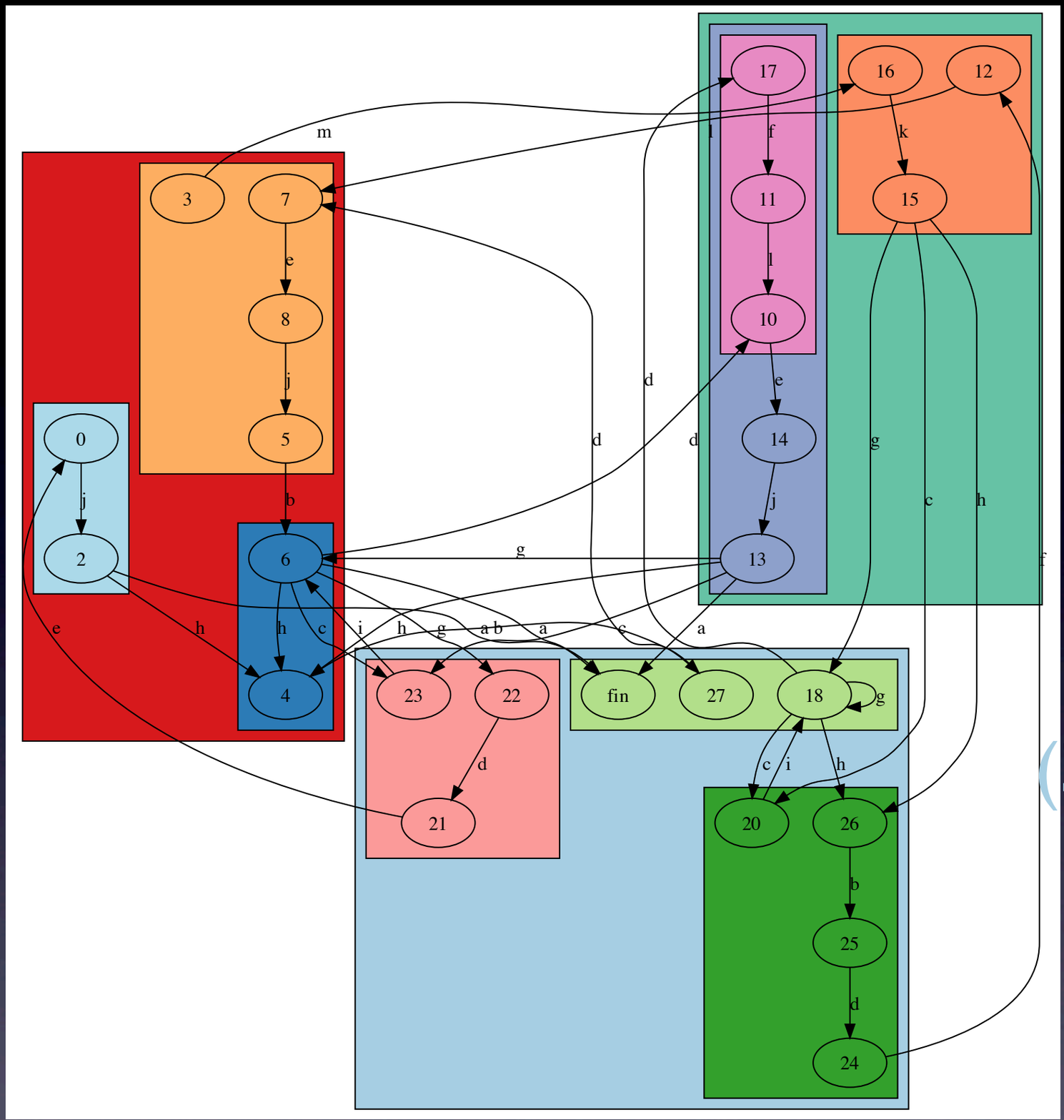
(1-3+2
+2-3+2)/3
+2-3+2/4

(2-4+2
+ 1-3+2
+1-3+2)
/3

HCC

2-4+2
1-2+2
+ 1-2+2)
/3

(2-3+2) / 2



HCC

(1-3+2
+2-3+2)/3
+2-3+2/4

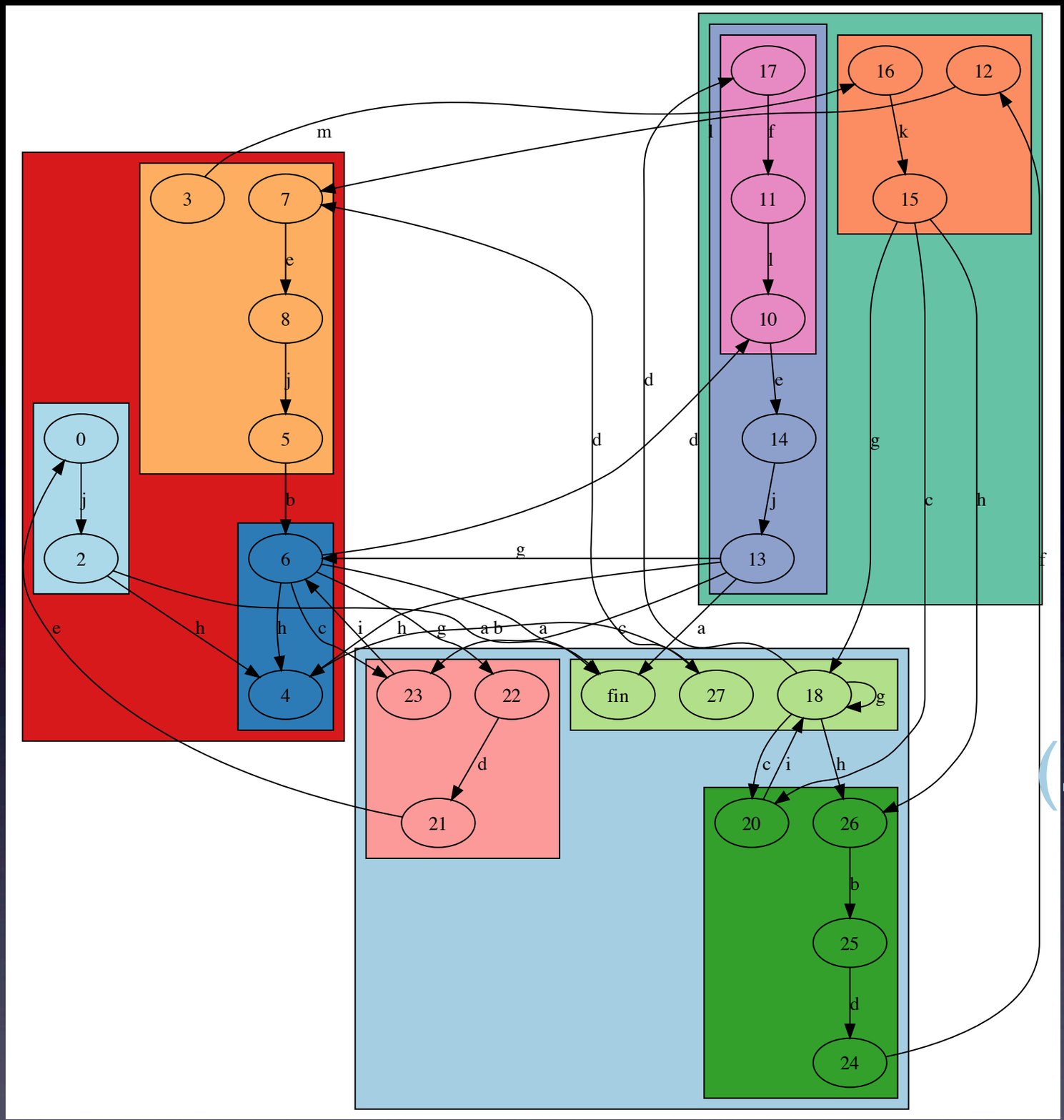
(0-2+2)/2

(3-3+2)/2

(2-4+2
+ 1-3+2
+1-3+2)
/3

2-4+2
1-2+2
+ 1-2+2)
/3

(2-3+2) / 2



(1-3+2
+2-3+2)/3
+2-3+2/4

(0-2+2)/2

(3-3+2)/2

(2-4+2
+ 1-3+2
+1-3+2)
/3

HCC

19 + (1+0+2)/2 + (2+2+0)/3 + 1/4

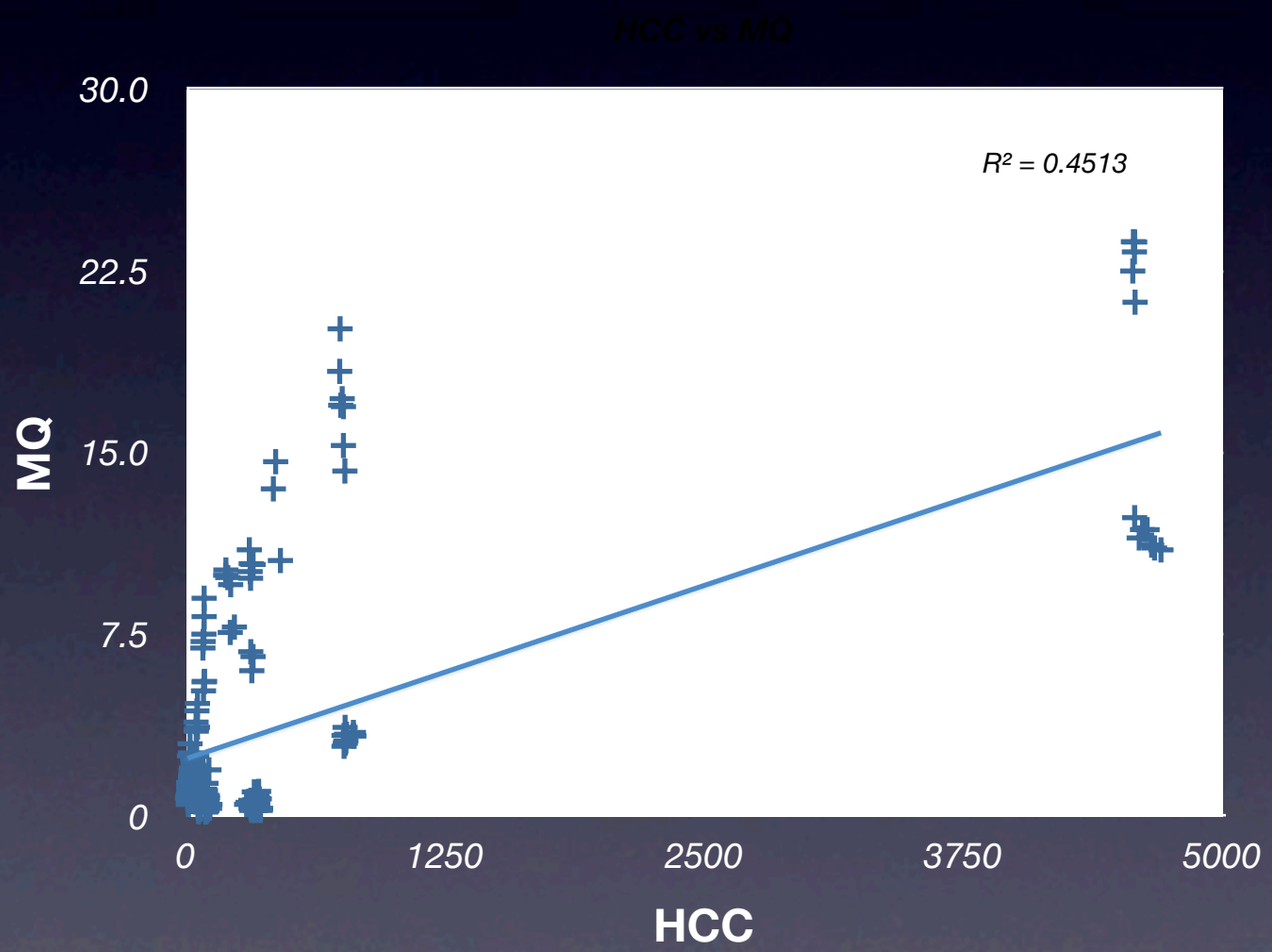
Problems with HCC

- Easy to cheat
- Still based on CC
- Subject to same criticisms

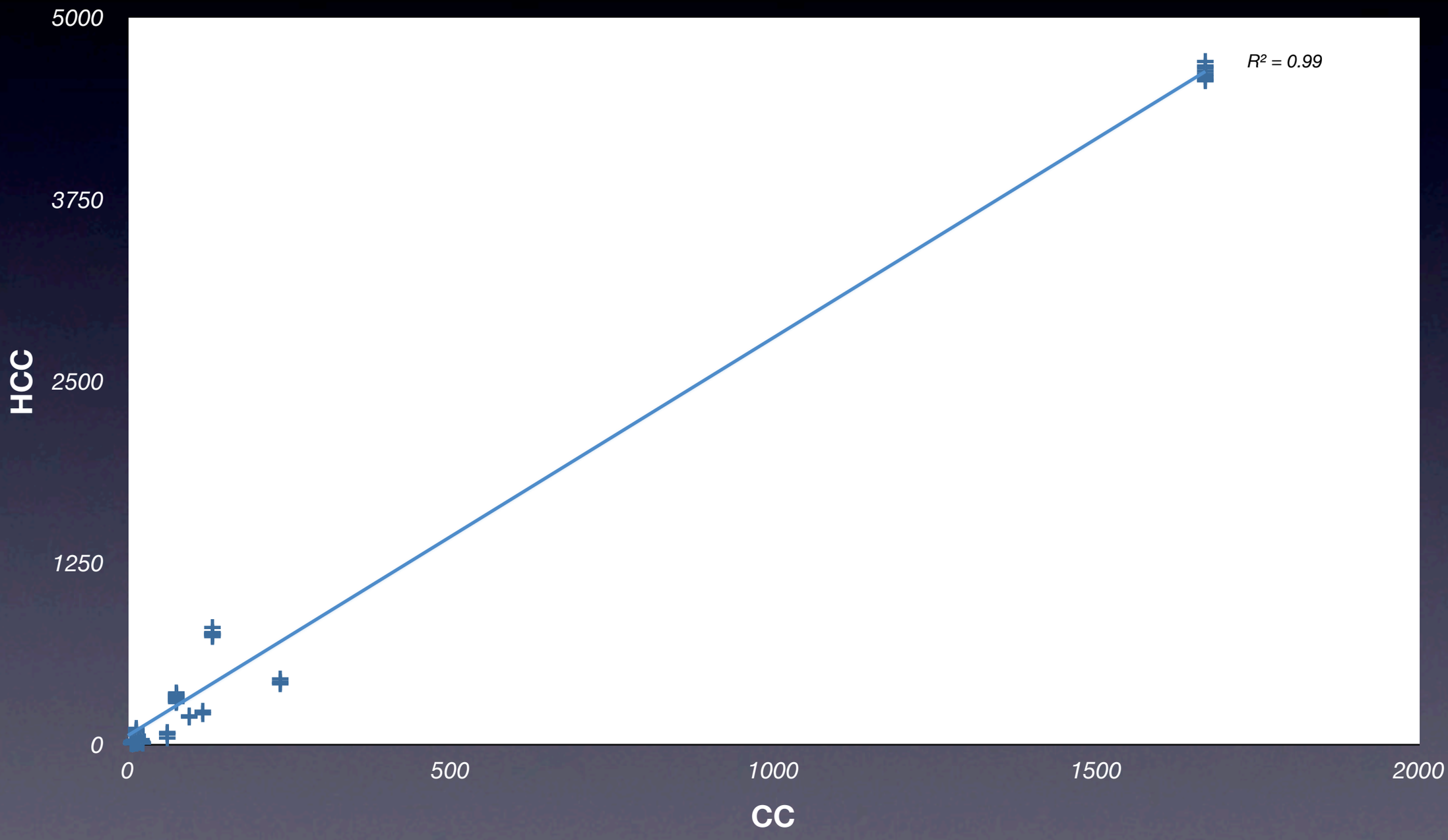
HCC vs MQ

HCC vs MQ

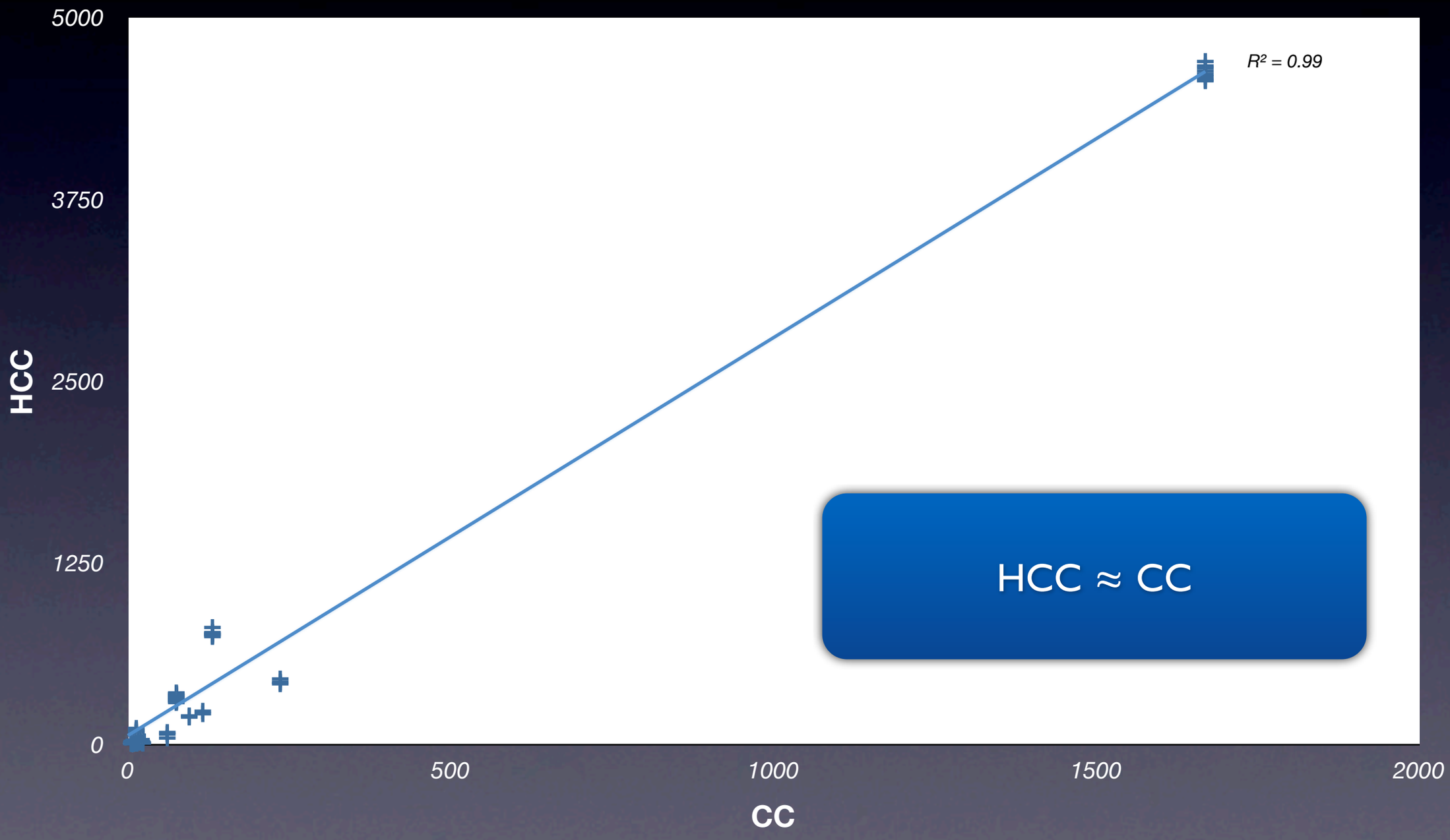
- 27 FSMs
- size between 5 and 1400 states
- results from 5 different fitness functions
- 202 points total



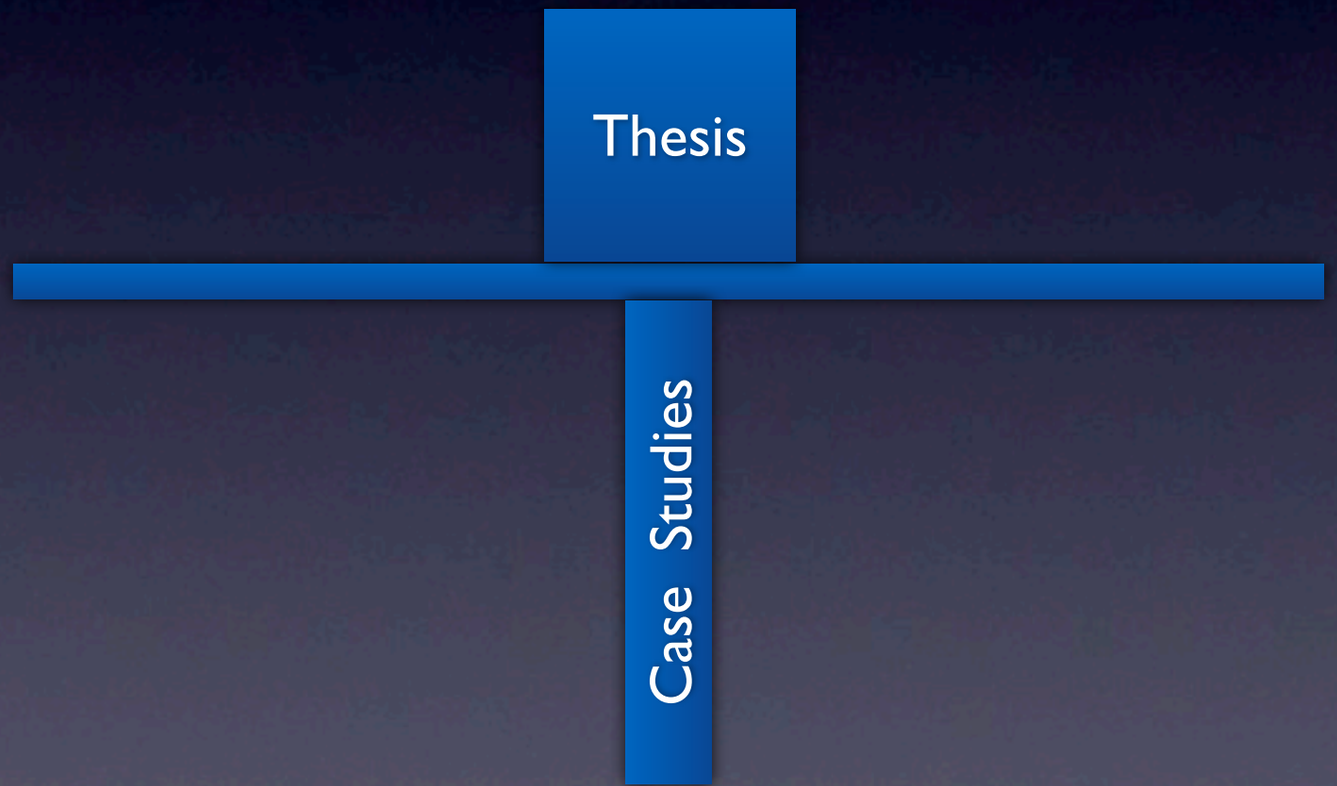
HCC vs CC



HCC vs CC



PhD



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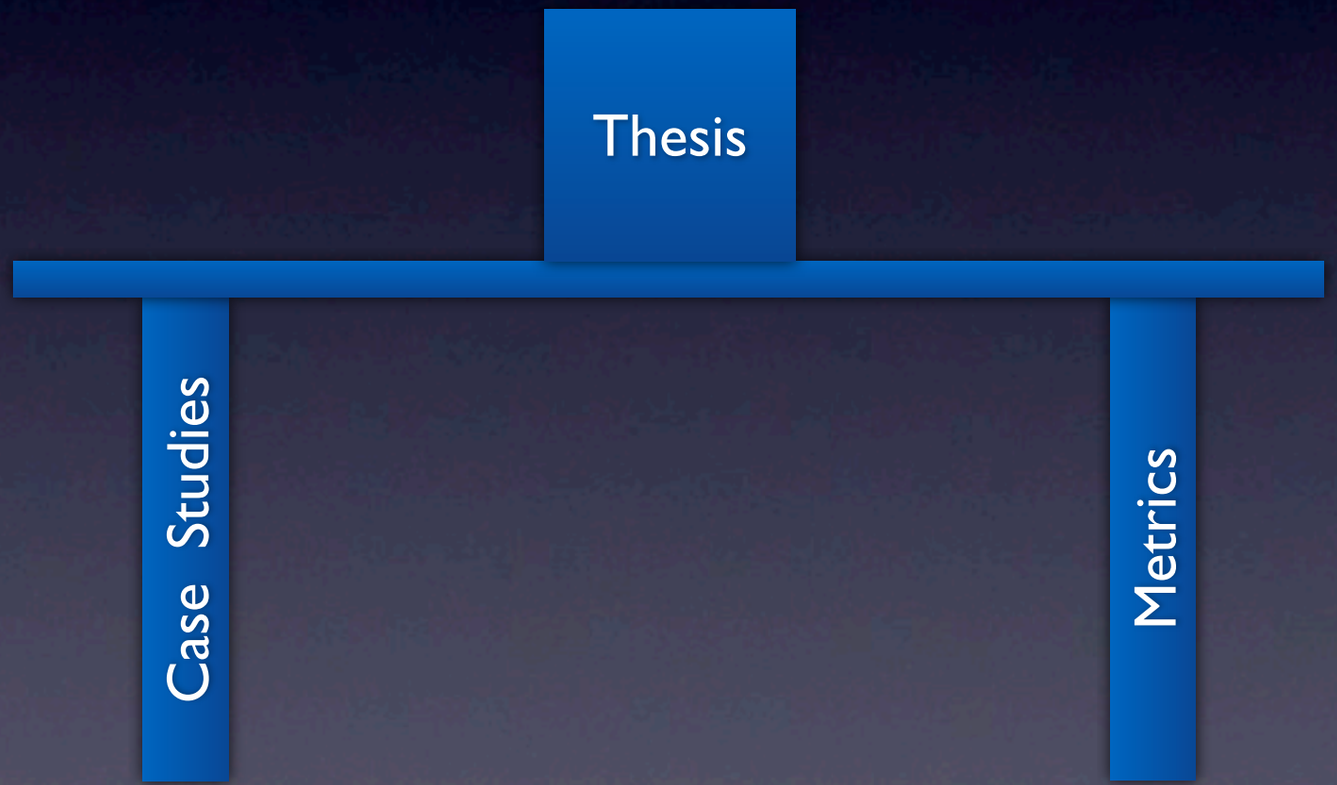

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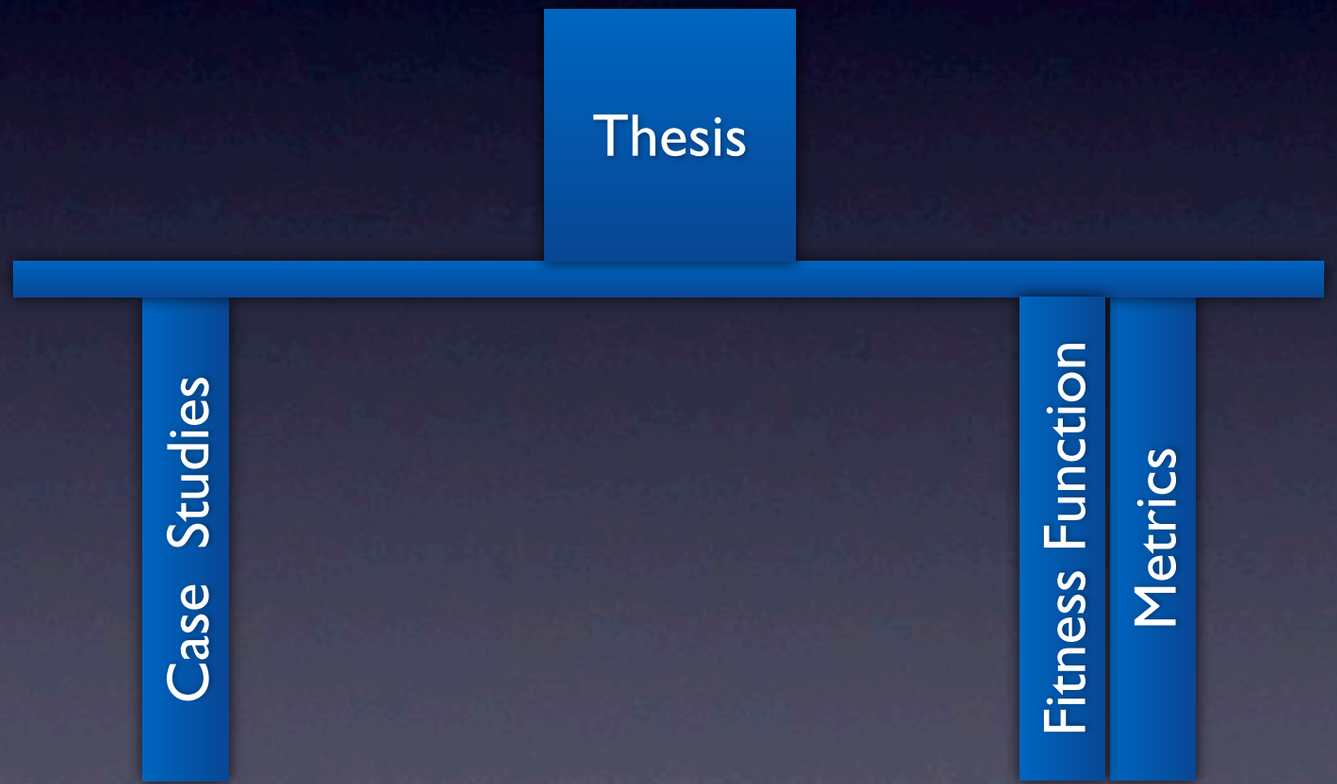

Metrics

- Looking into SE metrics to adapt to HSMs
- Many depend on unavailable information
- Can also be used as a fitness function

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Current Work

- Look… HSMs
- Many … tion
- Can also be used as a fitness function

Need to find or develop an appropriate metric

Considerations

- How big can a superstate be before it's considered too large?
- Is there enough information in the machine structure?
- Is it enough to maximise some metric?
- Multiobjective?

PhD: Intended Contributions

- Crunch: search-based graph clustering tool
- Survey and evaluation of metrics
- *Superstate Name Generation*
- *Human study*

Conclusion

- Reverse engineered state machines are too large
- It's possible to reduce CC through hierarchy introduction
- Introduced a way to compare CC of HSMs
- ...but HCC still subject to same problems as CC