

# Unified Rule Engine

Usage and Control

---

Nil Geisweiller

SingularityNetathon 2018

OpenCog Foundation

# URE: Unified Rule Engine

The URE is a tool to **evolve Inference Trees**

A     $A \rightarrow B$

----- (MP)

B

$A \rightarrow B$      $B \rightarrow C$

----- (DED)

A             $A \rightarrow C$

----- (MP)

C

ForAll X P(X)     $U(P(X), A)$

----- (INS)

A

$A \rightarrow B$      $B \rightarrow C$

----- (DED)

$A \rightarrow C$

----- (MP)

C

- Leaves are **premises**
- Roots are **conclusions**

# URE: Unified Rule Engine

Inference Trees are constructed by composing **Rules**

- **forward**: expand conclusion



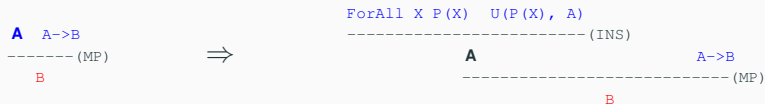
# URE: Unified Rule Engine

Inference Trees are constructed by composing **Rules**

- **forward**: expand conclusion



- **backward**: expand premises



# URE: Unified Rule Engine

## Inference Trees are **Atomese** Programs

A    A→B

----- (MP)

B

```
(BindLink
  (VariableList
    (TypedVariableLink
      (VariableNode "$A")
      (TypeChoice
        (TypeNode "LambdaLink")
        (TypeNode "PredicateNode")
      )
    )
    (TypedVariableLink
      (VariableNode "$B")
      (TypeChoice
        (TypeNode "LambdaLink")
        (TypeNode "PredicateNode")
      )
    )
  )
  (AndLink
    (ImplicationLink
      (VariableNode "$A")
      (VariableNode "$B")
    )
    (EvaluationLink
      (GroundedPredicateNode "scm: true-enough")
      (ImplicationLink
        (VariableNode "$A")
        (VariableNode "$B")
      )
    )
  )
  (EvaluationLink
    (GroundedPredicateNode "scm: true-enough")
    (VariableNode "$A")
  )
)
(ExecutionOutputLink
  (GroundedSchemaNode "scm: modus-ponens-formula")
  (ListLink
    (VariableNode "$B")
    (VariableNode "$A")
    (ImplicationLink
      (VariableNode "$A")
      (VariableNode "$B")
    )
  )
)
```

# URE: Unified Rule Engine

## Inference Trees are Atomese Programs

A   A→B  
----- (MP)  
  B

```
(ExecutionOutputLink
  (GroundedSchemaNode "scm: modus-ponens-formula")
  (ListLink
    (VariableNode "$B")
    (VariableNode "$A")
    (ImplicationLink
      (VariableNode "$A")
      (VariableNode "$B")
    )
  )
)
```

## Inference Trees are **Atomese** Programs

$A \rightarrow C$      $C \rightarrow B$   
 ----- (DED)  
 $A$              $A \rightarrow B$   
 ----- (MP)  
 $B$

```
(ExecutionOutputLink
  (GroundedSchemaNode "scm: modus-ponens-formula")
  (ListLink
    (VariableNode "$B")
    (VariableNode "$A")
  )
  (ExecutionOutputLink
    (GroundedSchemaNode "scm: deduction-formula")
    (ListLink
      (ImplicationLink
        (VariableNode "$A")
        (VariableNode "$B")
      )
      (ImplicationLink
        (VariableNode "$A")
        (VariableNode "$C")
      )
      (ImplicationLink
        (VariableNode "$C")
        (VariableNode "$B")
      )
    )
  )
)
```

## Algorithm

1. Select an inference tree to expand
2. Select a node from that tree to expand
3. Select a rule to expand with
4. Expand the inference tree and place it back to the pool of inference trees. Repeat till termination.

Combinatorial Explosion



# Inference Control

Delegate the hard decisions to a **cognitive process**

Cognitive Schematics:

**Context** & **Action**  $\Rightarrow$  **Goal**

Atomese:

Implication <TV>

And

<Context>

<Action>

<Goal>

Which rule to choose?

**A**    $A \rightarrow B$   
----- (MP)  
**B**

1. Modus Ponens
2. Universal Instantiation

Look for:

Implication <TV>

And

<inference-tree-pattern>

<node-pattern>

<rule-pattern>

<produce-good-inference>

## Examples of actual URE Cognitive Schematics

```
(ImplicationScopeLink (stv 0.45945946 0.04625)
  (VariableList
    (VariableNode "$T")
    (TypedVariableLink
      (VariableNode "$A")
      (TypeNode "DontExecLink")
    )
    (VariableNode "$I")
    (TypedVariableLink
      (VariableNode "$B")
      (TypeNode "DontExecLink")
    )
  )
  (AndLink
    (EvaluationLink
      (PredicateNode "URE:BC:preproof-of")
      (ListLink
        (VariableNode "$A")
        (VariableNode "$T")
      )
    )
  )
  (ExecutionLink
    (SchemaNode "URE:BC:expand-and-BIT")
    (ListLink
      (VariableNode "$A")
      (VariableNode "$I")
      (DontExecLink
        (DefinedSchemaNode "deduction-inheritance-rule")
      )
    )
    (VariableNode "$B")
  )
)
(EvaluationLink
  (PredicateNode "URE:BC:preproof-of")
  (ListLink
    (VariableNode "$B")
    (VariableNode "$T")
  )
)
```

```
(ImplicationScopeLink (stv 1 0.00625)
  (VariableList
    (VariableNode "$T")
    (TypedVariableLink
      (VariableNode "$A")
      (TypeNode "DontExecLink")
    )
    (VariableNode "$X")
    (TypedVariableLink
      (VariableNode "$B")
      (TypeNode "DontExecLink")
    )
  )
  (AndLink
    (EvaluationLink
      (PredicateNode "URE:BC:preproof-of")
      (ListLink
        (VariableNode "$A")
        (VariableNode "$T")
      )
    )
    (ExecutionLink
      (SchemaNode "URE:BC:expand-and-BIT")
      (ListLink
        (VariableNode "$A")
        (InheritanceLink
          (ConceptNode "a")
          (VariableNode "$X")
        )
      )
      (DontExecLink
        (DefinedSchemaNode "conditional-full-instantiation-implication-scope-meta-rule")
      )
    )
    (VariableNode "$B")
  )
)
(EvaluationLink
  (PredicateNode "URE:BC:preproof-of")
  (ListLink
    (VariableNode "$B")
    (VariableNode "$T")
  )
)
```

How to get Cognitive Schematics?

Answer: **Learning**

Record a **trace** of all decisions  
the URE takes and **learn** from it

How to learn Cognitive Schematics?

1. URE
2. Pattern Mining
3. MOSES
4. Others

## Inference Control Learning: URE Trace



Atomese:

## Inference Control Learning: URE Trace



Atomese:

# Inference Control Learning: URE

Call the URE with a Control Rule Template as target

```
(cog-bc icr-rb (QuoteLink
  (ImplicationScopeLink
    (UnquoteLink
      (VariableNode "$impl-vardecl")
    )
    (AndLink
      (EvaluationLink
        (PredicateNode "URE:BC:preproof-of")
        (UnquoteLink
          (VariableNode "$preproof-A-args")
        )
      )
      (ExecutionLink
        (SchemaNode "URE:BC:expand-and-BIT")
        (UnquoteLink
          (VariableNode "$expand-inputs")
        )
        (UnquoteLink
          (VariableNode "$expand-output")
        )
      )
    )
  )
  (EvaluationLink
    (PredicateNode "URE:BC:preproof-of")
    (UnquoteLink
      (VariableNode "$preproof-B-args")
    )
  )
)
)
```



# Inference Control Learning: URE

## Call the URE with a Control Rule Template as target

```
(cog-bc icr-rb (QuoteLink
  (ImplicationScopeLink
    (UnquoteLink
      (VariableNode "$impl-vardecl")
    )
    (AndLink
      (EvaluationLink
        (PredicateNode "URE:BC:preproof-of")
        (UnquoteLink
          (VariableNode "$preproof-A-args")
        )
      )
      (ExecutionLink
        (SchemaNode "URE:BC:expand-and-BIT")
        (UnquoteLink
          (VariableNode "$expand-inputs")
        )
        (UnquoteLink
          (VariableNode "$expand-output")
        )
      )
    )
  )
  (EvaluationLink
    (PredicateNode "URE:BC:preproof-of")
    (UnquoteLink
      (VariableNode "$preproof-B-args")
    )
  )
)
)
```

```
(ImplicationScopeLink (stv 0.45945946 0.04625)
  (VariableList
    (VariableNode "$T")
    (TypedVariableLink
      (VariableNode "$A")
      (TypeNode "DontExecLink")
    )
    (VariableNode "$L")
    (TypedVariableLink
      (VariableNode "$B")
      (TypeNode "DontExecLink")
    )
  )
  (AndLink
    (EvaluationLink
      (PredicateNode "URE:BC:preproof-of")
      (ListLink
        (VariableNode "$A")
        (VariableNode "$T")
      )
    )
    (ExecutionLink
      (SchemaNode "URE:BC:expand-and-BIT")
      (ListLink
        (VariableNode "$A")
        (VariableNode "$L")
        (DontExecLink
          (DefinedSchemaNode "deduction-inheritance-rule")
        )
      )
    )
  )
  (EvaluationLink
    (PredicateNode "URE:BC:preproof-of")
    (ListLink
      (VariableNode "$B")
      (VariableNode "$T")
    )
  )
)
```

# Inference Control Learning: URE + Pattern Miner

Call the URE with a Control Rule Template as target + Pattern Miner

```
(cog-bc icr-rb (QuoteLink
  (ImplicationScopeLink
    (UnquoteLink
      (VariableNode "$impl-vardecl")
    )
    (AndLink
      (EvaluationLink
        (PredicateNode "URE:BC:preproof-of")
        (UnquoteLink
          (VariableNode "$preproof-A-args")
        )
      )
      (ExecutionLink
        (SchemaNode "URE:BC:expand-and-BIT")
        (UnquoteLink
          (VariableNode "$expand-inputs")
        )
        (UnquoteLink
          (VariableNode "$expand-output")
        )
      )
    )
  )
  (EvaluationLink
    (PredicateNode "URE:BC:preproof-of")
    (UnquoteLink
      (VariableNode "$preproof-B-args")
    )
  )
)
)
```

```
(ImplicationScopeLink (stv 1 0.00625)
  (VariableList
    (VariableNode "$T")
    (TypedVariableLink
      (VariableNode "$A")
      (TypeNode "DontExecLink")
    )
  )
  (VariableNode "$X")
  (TypedVariableLink
    (VariableNode "$B")
    (TypeNode "DontExecLink")
  )
)
(AndLink
  (EvaluationLink
    (PredicateNode "URE:BC:preproof-of")
    (ListLink
      (VariableNode "$A")
      (VariableNode "$T")
    )
  )
  (ExecutionLink
    (SchemaNode "URE:BC:expand-and-BIT")
    (ListLink
      (VariableNode "$A")
      (InheritanceLink
        (ConceptNode "a")
        (VariableNode "$X")
      )
    )
    (DontExecLink
      (DefinedSchemaNode "conditional-full-instantiation-implication-scope-meta-rule")
    )
  )
  (VariableNode "$B")
)
)
(EvaluationLink
  (PredicateNode "URE:BC:preproof-of")
  (ListLink
    (VariableNode "$B")
    (VariableNode "$T")
  )
)
)
```

Feel free to ask

- How to weight compatible control rules?
- How to decide which rule to trigger?