Ch.9 Bottom-up/top-down inference in And-Or-Graph

--- Event Recognition and Intent Prediction

Earley-Stolcke parsing algorithm

- S->A B C
- S->D E F
- A->a1 A->a2
- B->b1 B->b2
- C->c1 C->c2
- D->a1 D->a2
- E->b1 E->b2
- F->c1 F->c2

- a1b1c1
- a1b1c2
- a1b2c1
- a1b2c2
- a2b1c1
- a2b1c2
- a2b2c1
- a2b2c2

Earley-Stolcke parsing algorithm

The input is a1 b1 c1

State set 0	State set 1	State set 2	State set 3
$_0$->.S Predicted $_0$S->.A B C $_0$S->.D E F $_0$A->.a1 $_0$A->.a2 $_0$D->.a1 $_0$D->.a2	Scanned $_0$A->a1. $_0$D->a1. Completed $_0$S->A. B C $_0$S->D. E F Predicted $_1$B->.b1 $_1$B->.b2 $_1$E->.b1 $_1$E->.b2	Scanned $_1$B->b1. $_1$E->b1. Completed $_0$S->A B. C $_0$S->D E. F Predicted $_2$C->.c1 $_2$C->.c2 $_2$F->.c1 $_2$F->.c2	Scanned $_2$C->c1. $_2$F->c1. Completed $_0$S->A B C. $_0$S->D E F. $_0$->S.

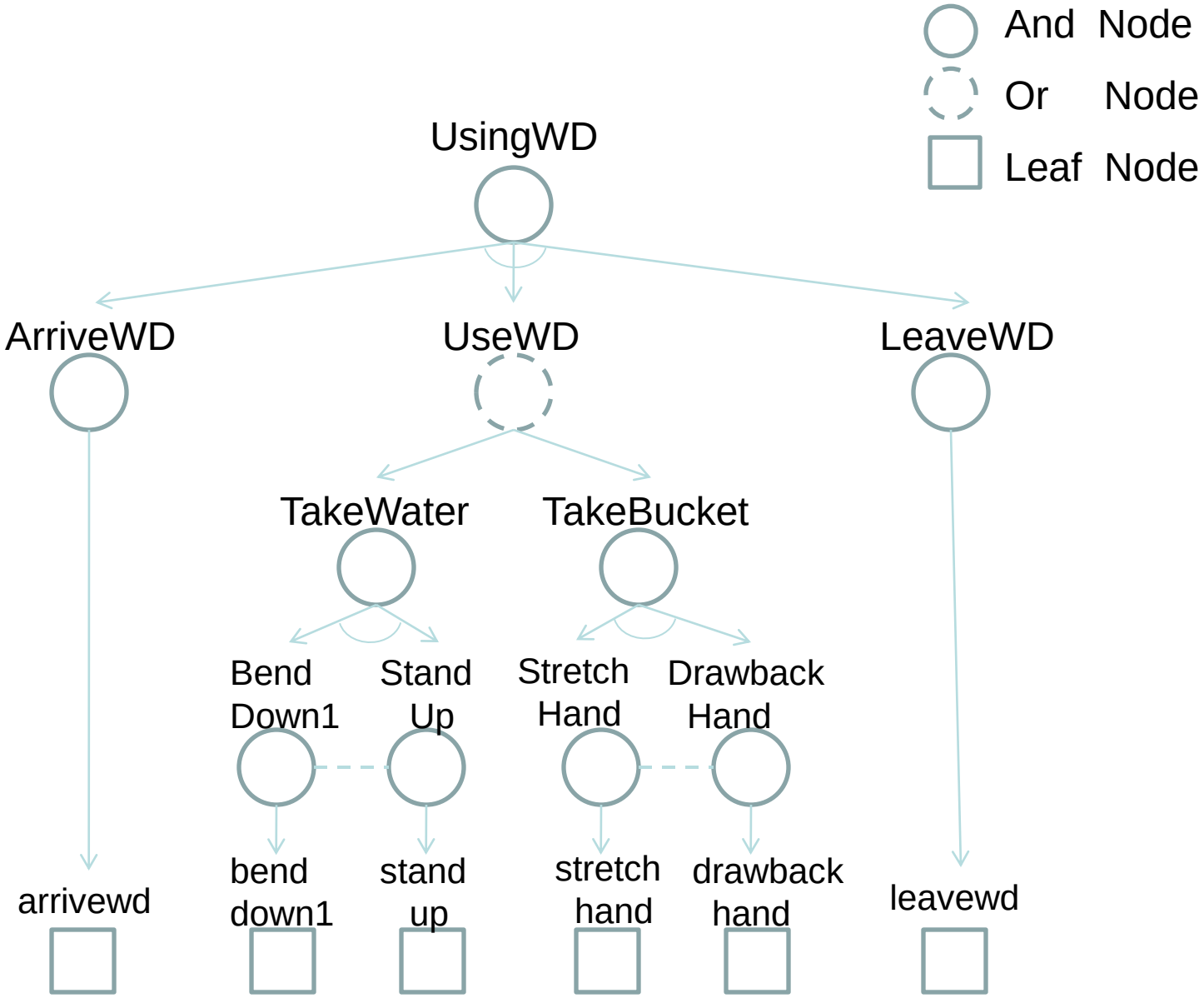
Grammars for Events

- UsingWD→ArriveWD UseWD LeaveWD
- ArriveWD→arrivewd
- UseWD→TakeWater
- UseWD→TakeBucket
- TakeWater→benddown1 standup
- TakeBucket→stretchhand drawbackhand
- LeaveWD→leavewd

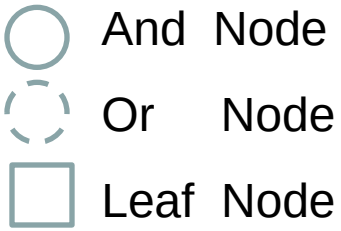
Grammars for Events

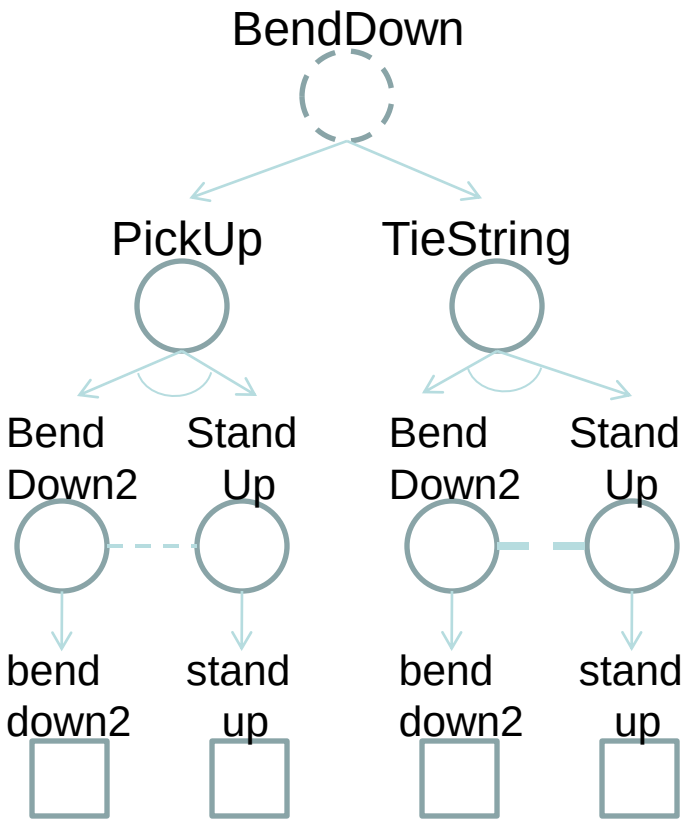
- BendDown→Pickup
- BendDown→TieString
- Pickup→benddown2 standup
- TieString→benddown2 standup

AOGs for Events

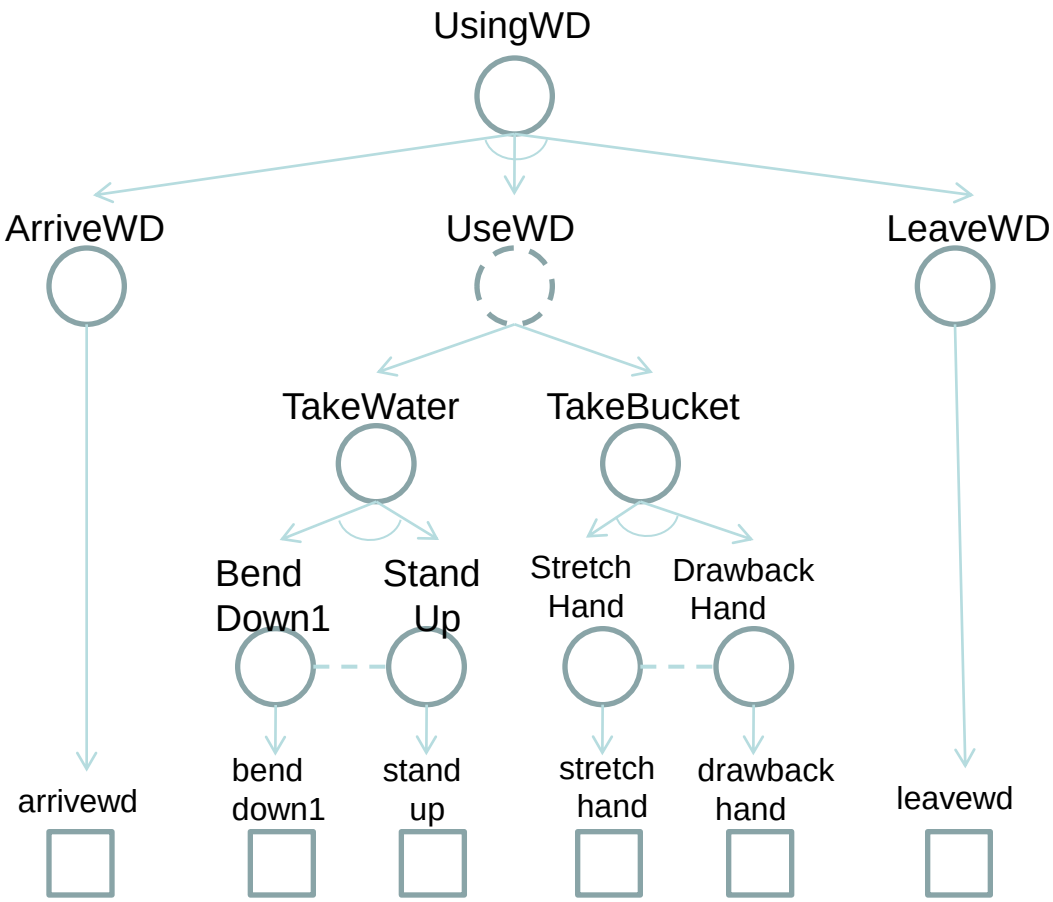


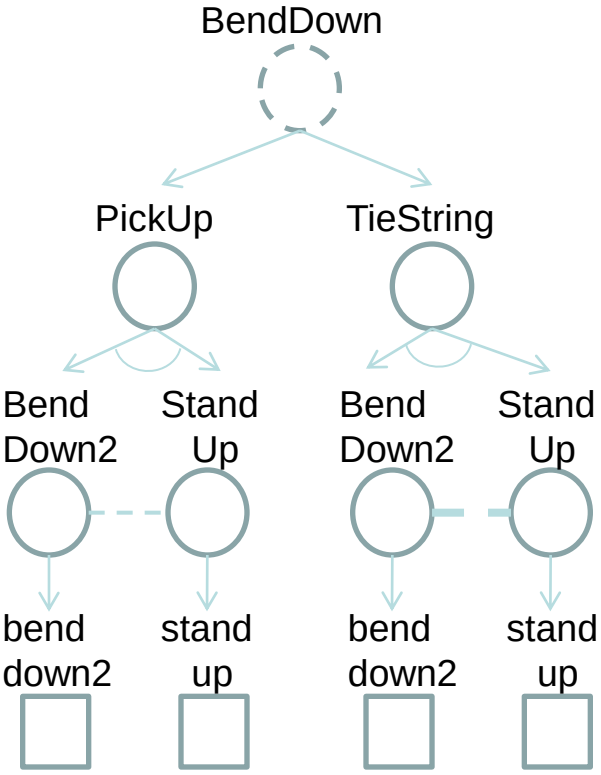
AOGs for Events





The parsing process





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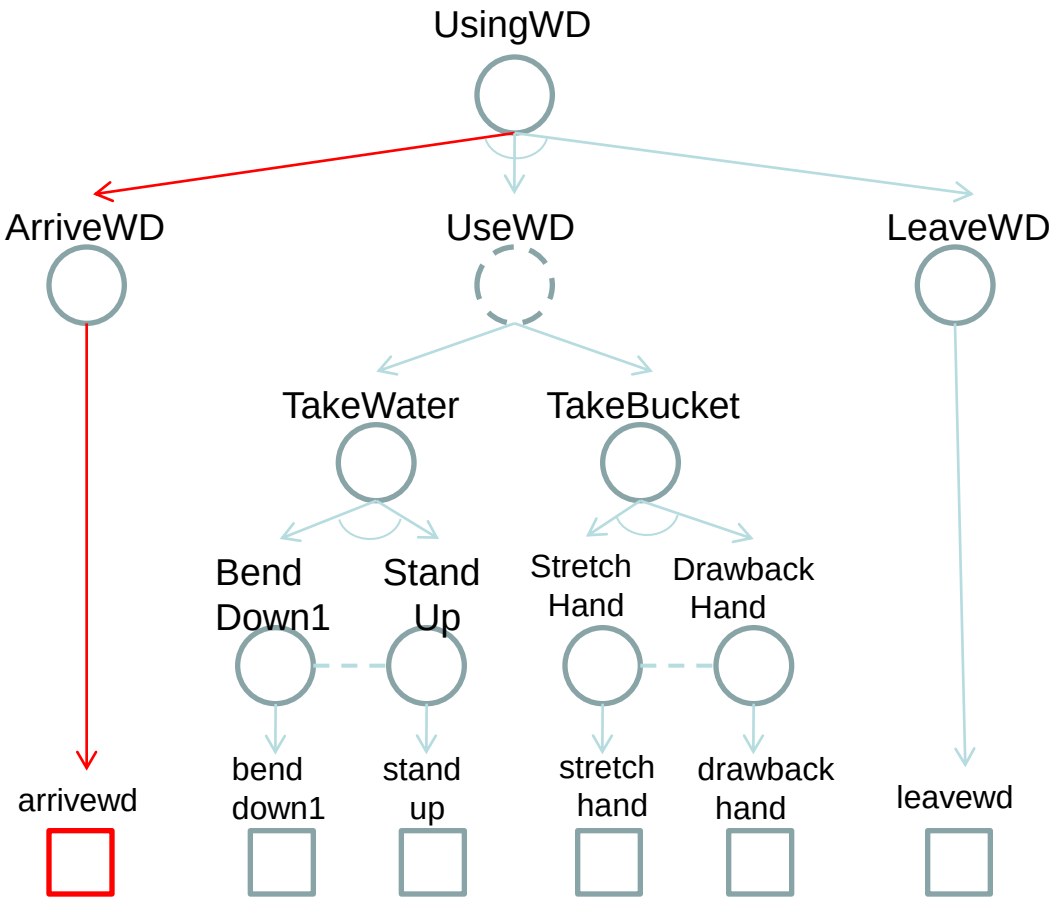

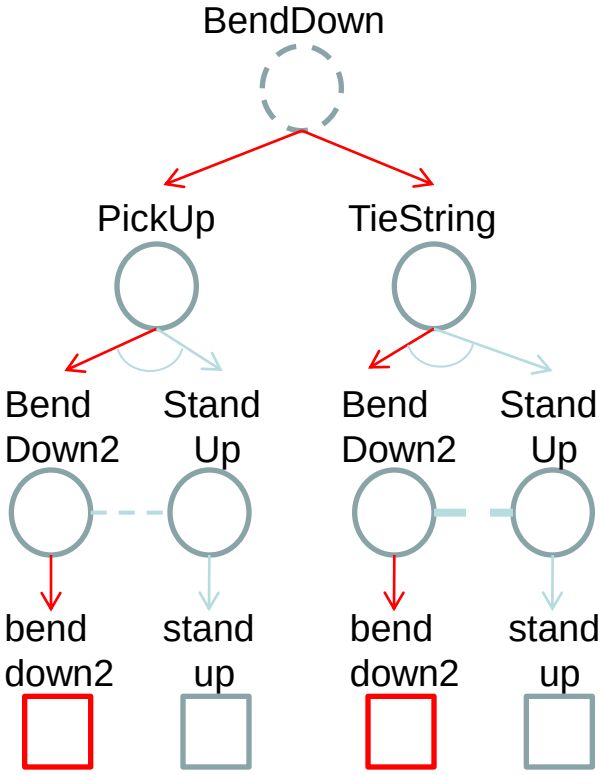

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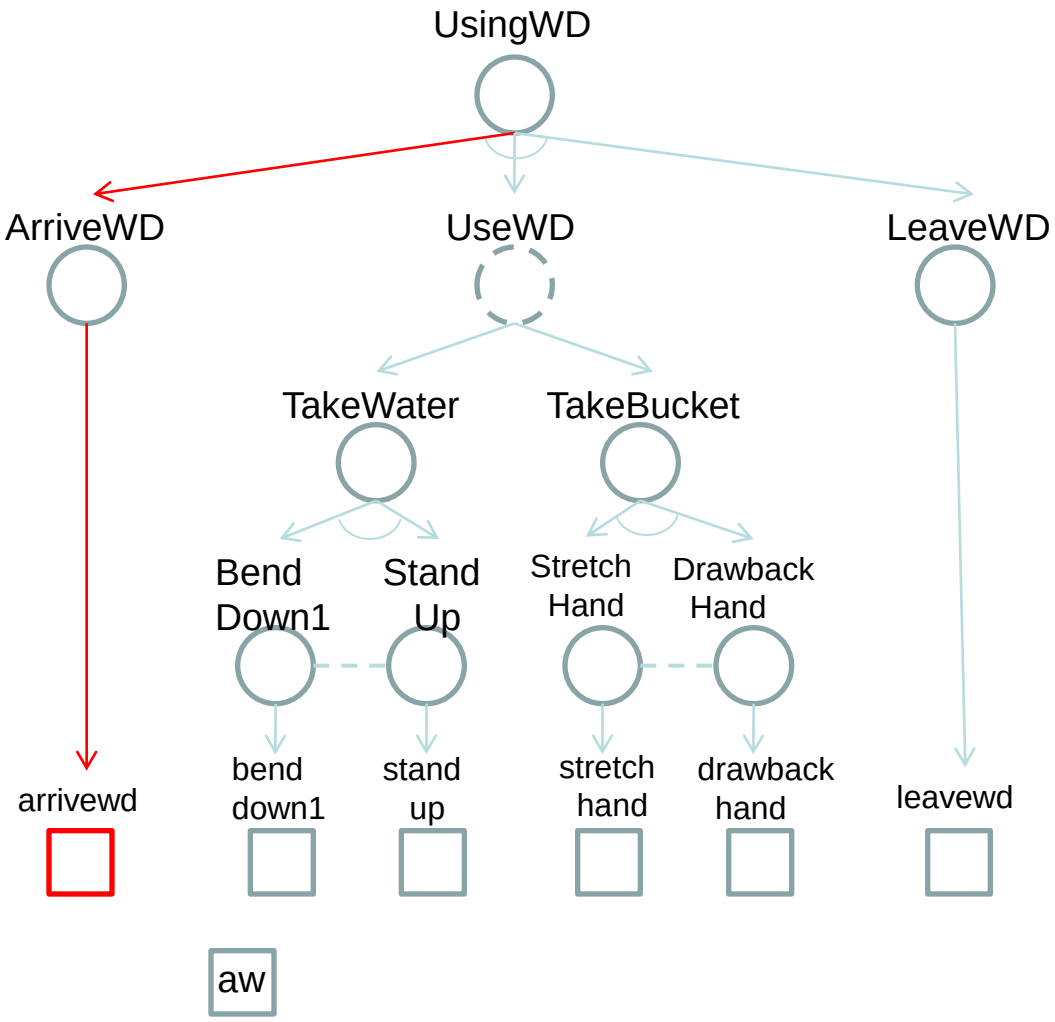

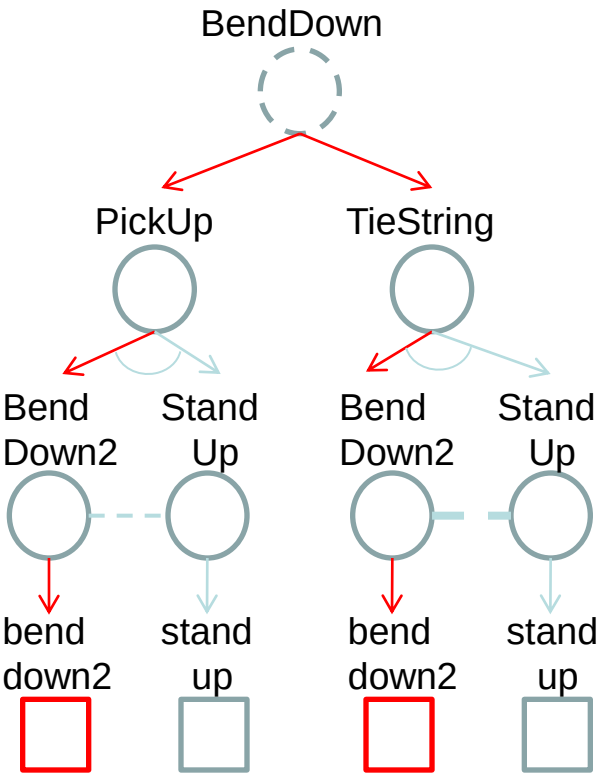

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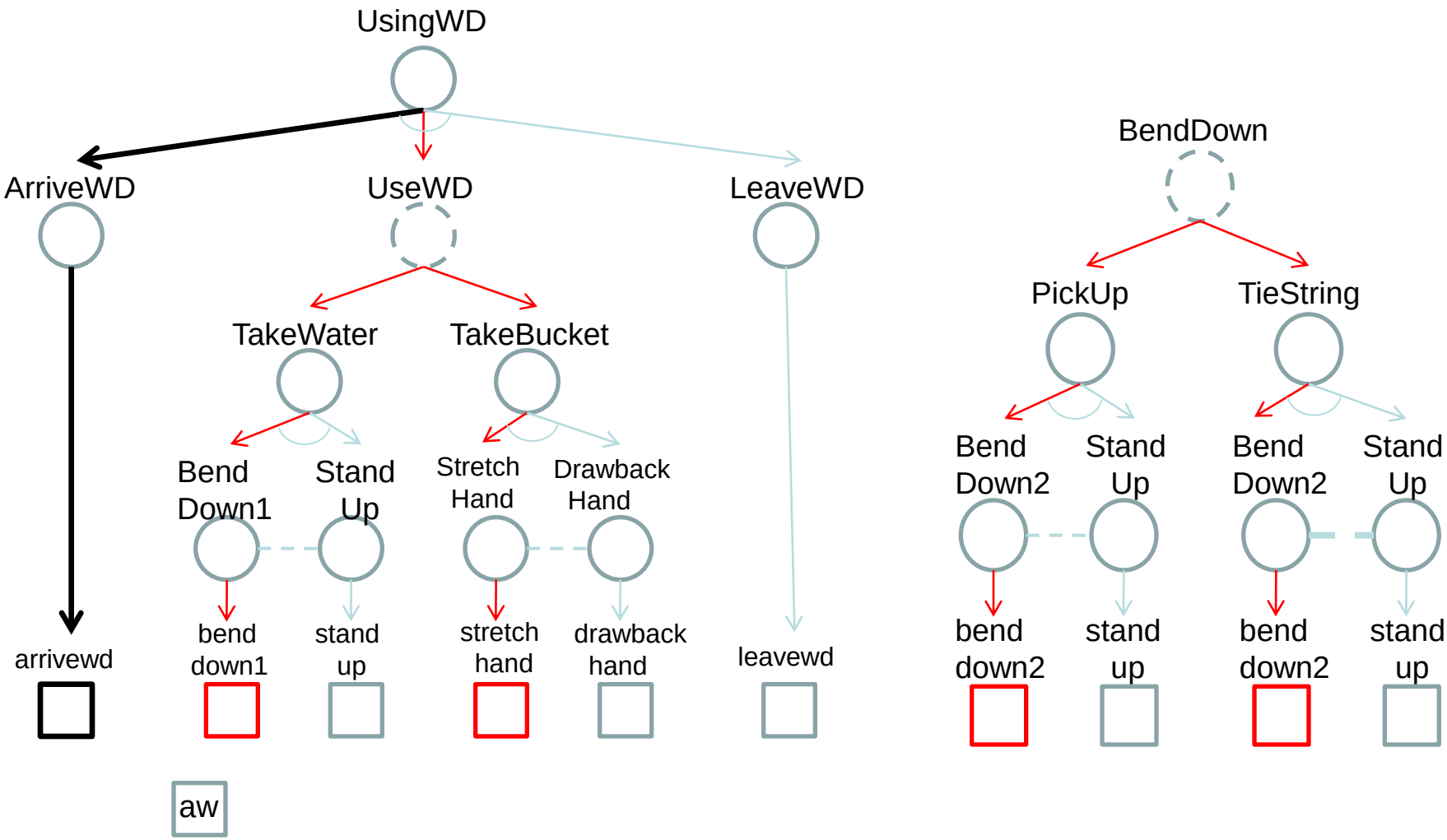

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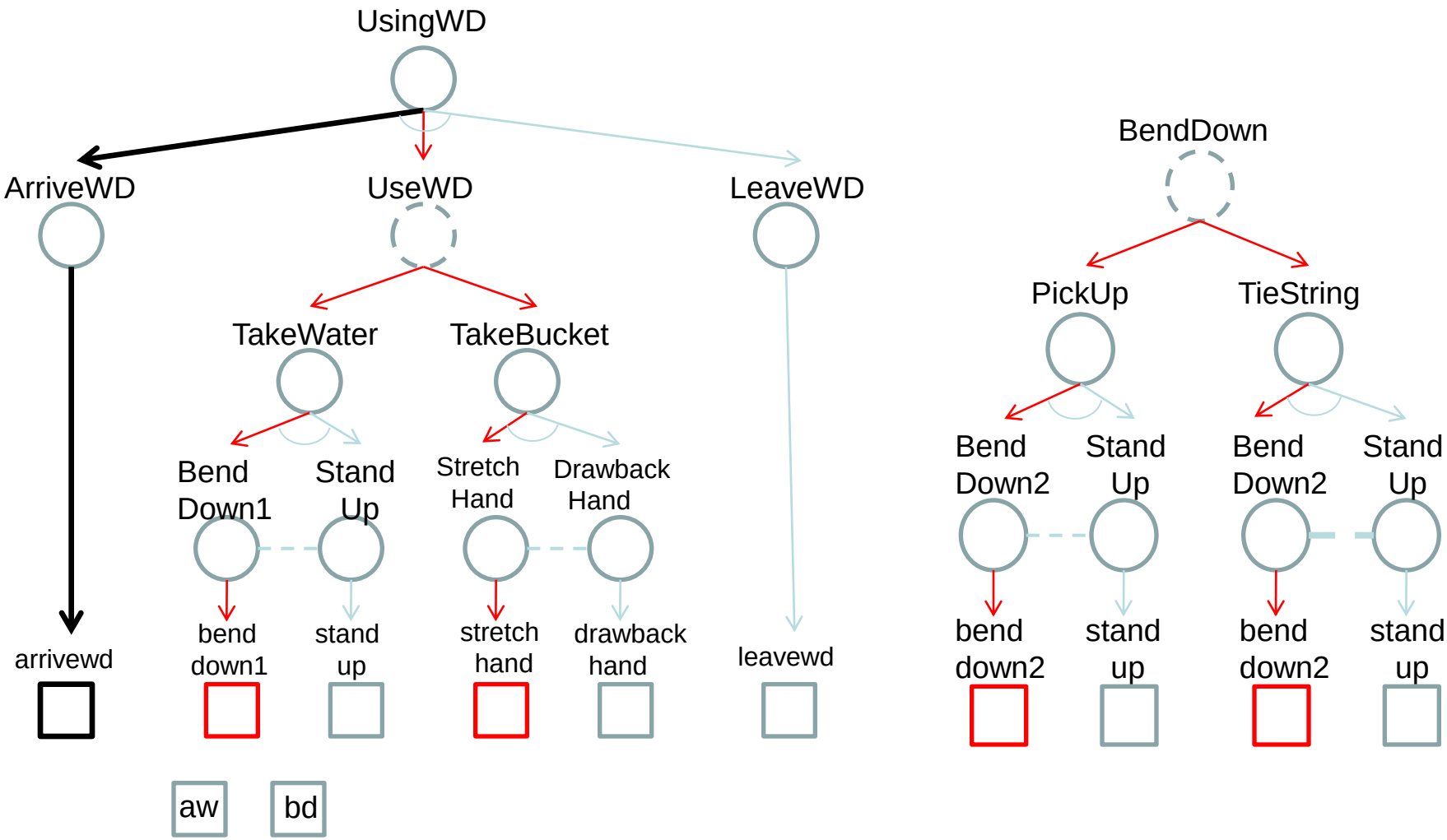

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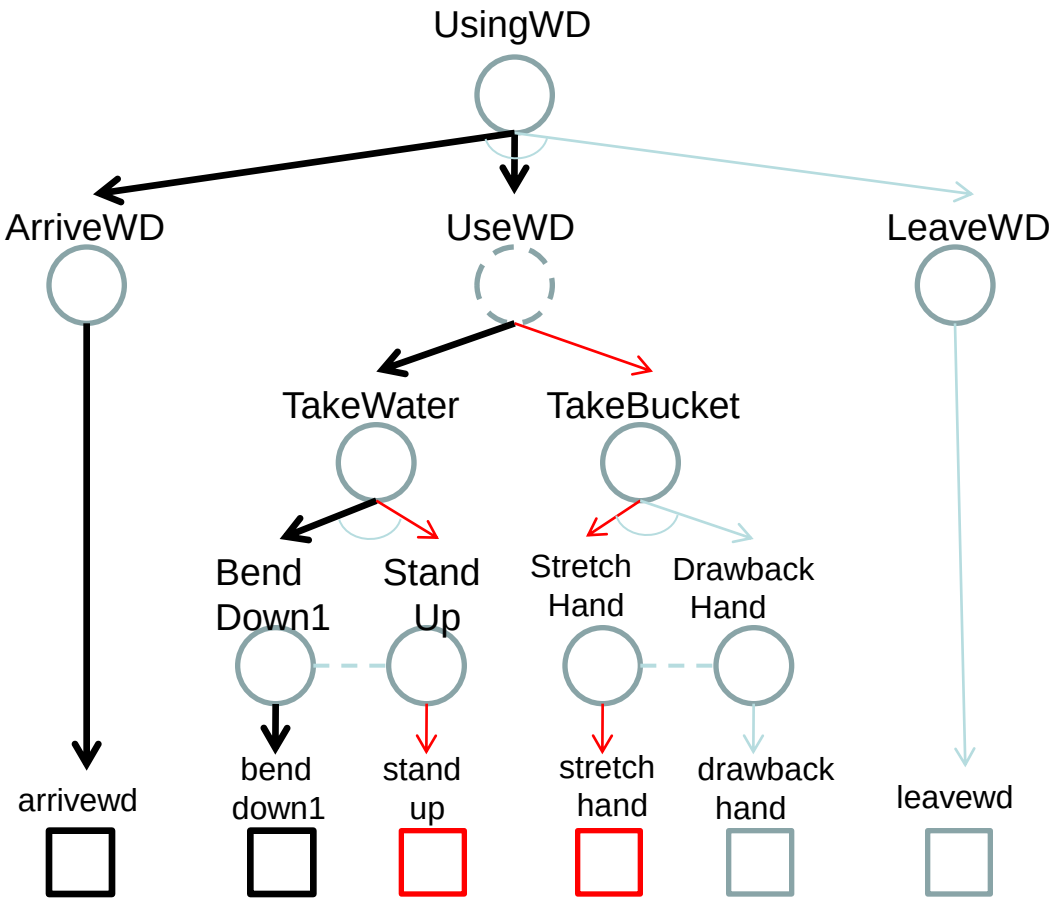

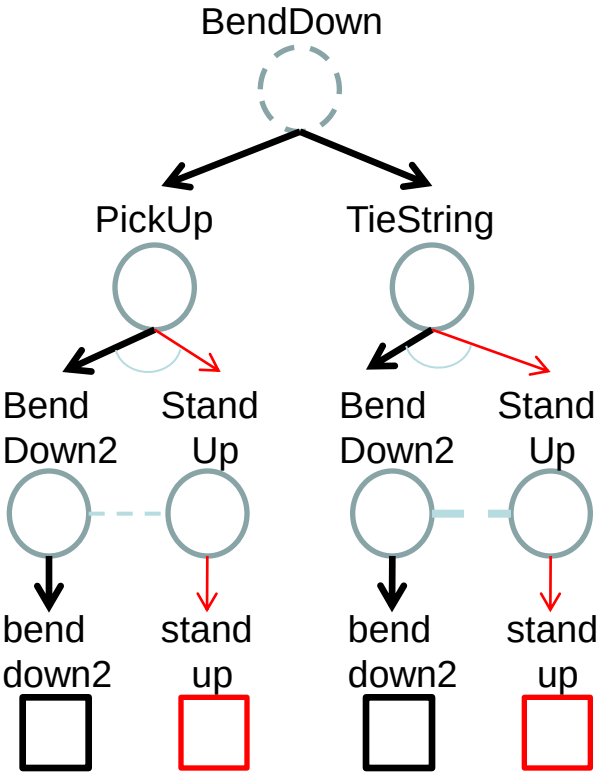

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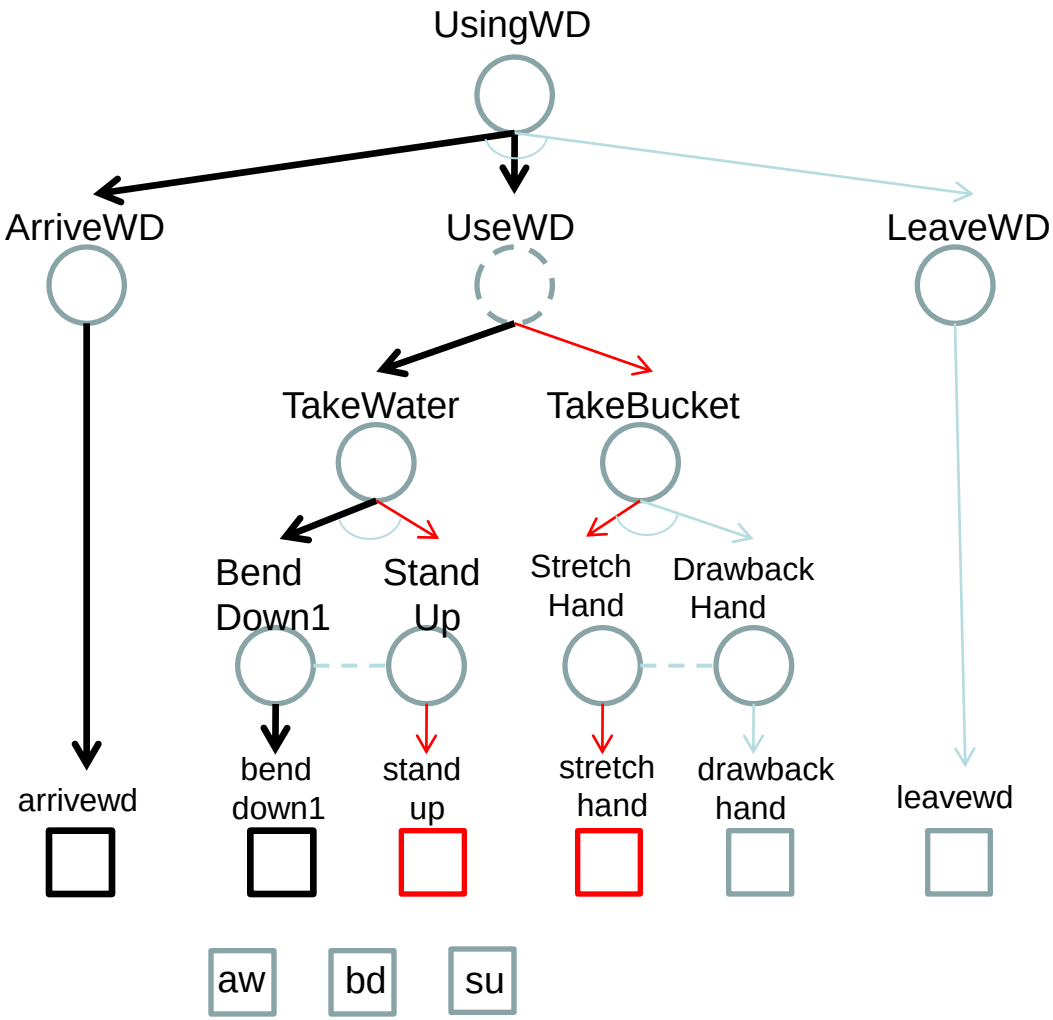

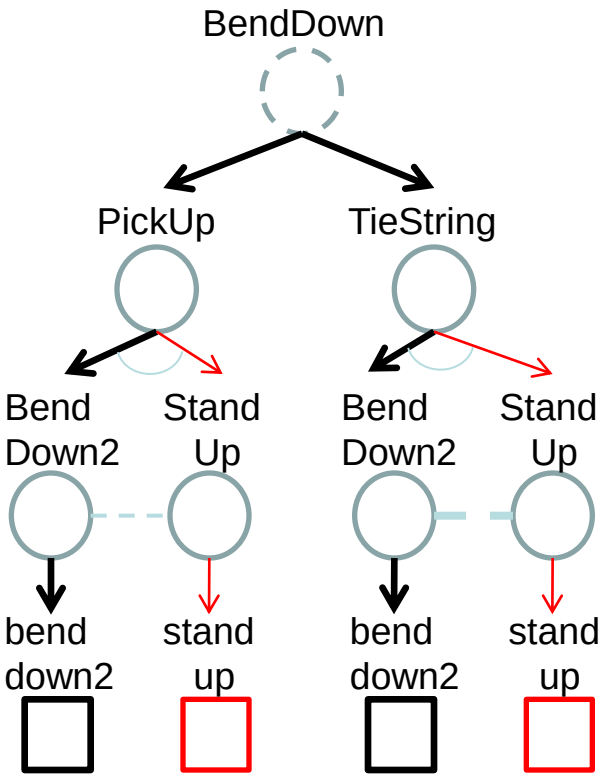

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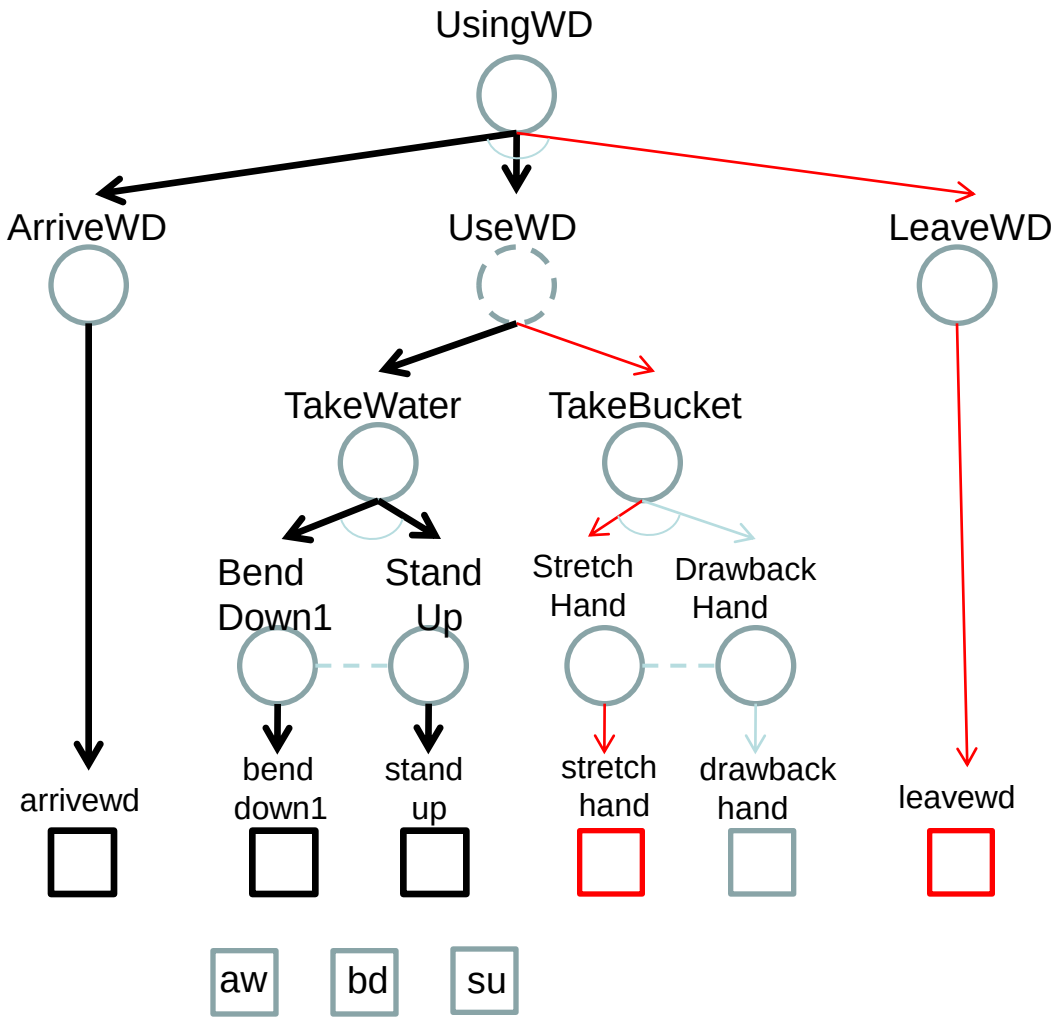

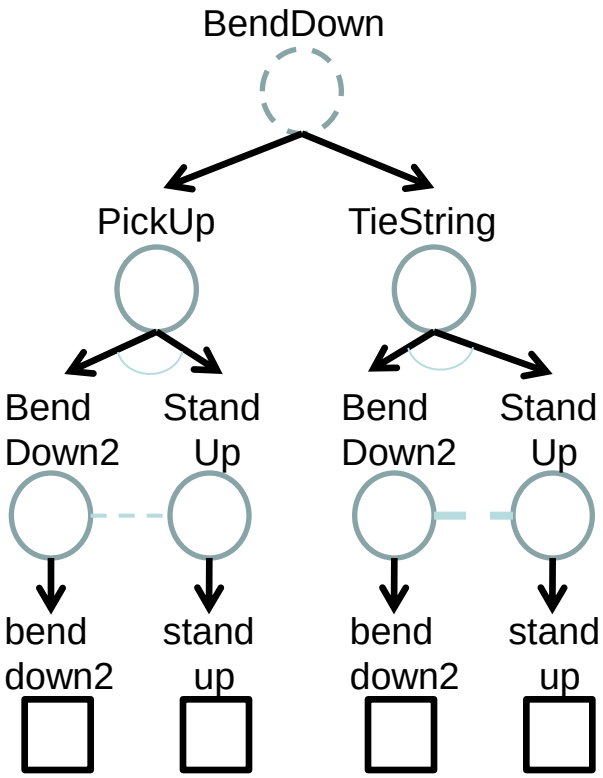

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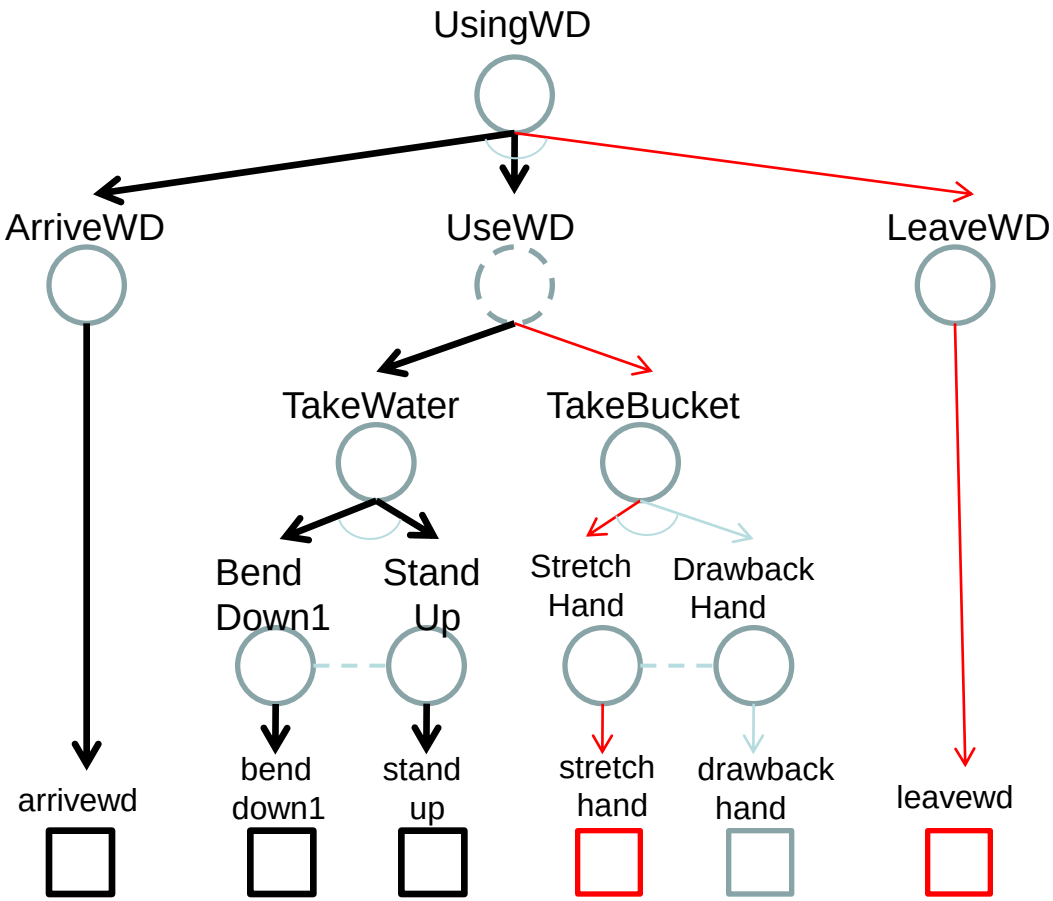

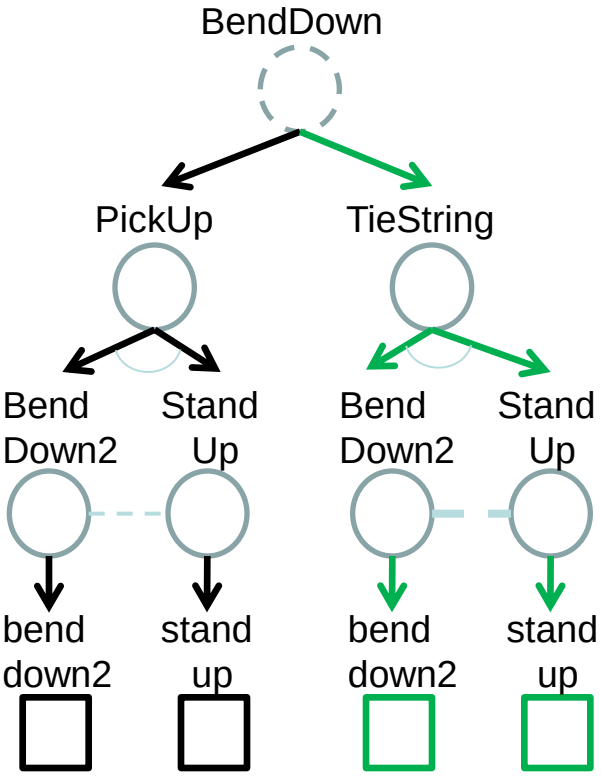

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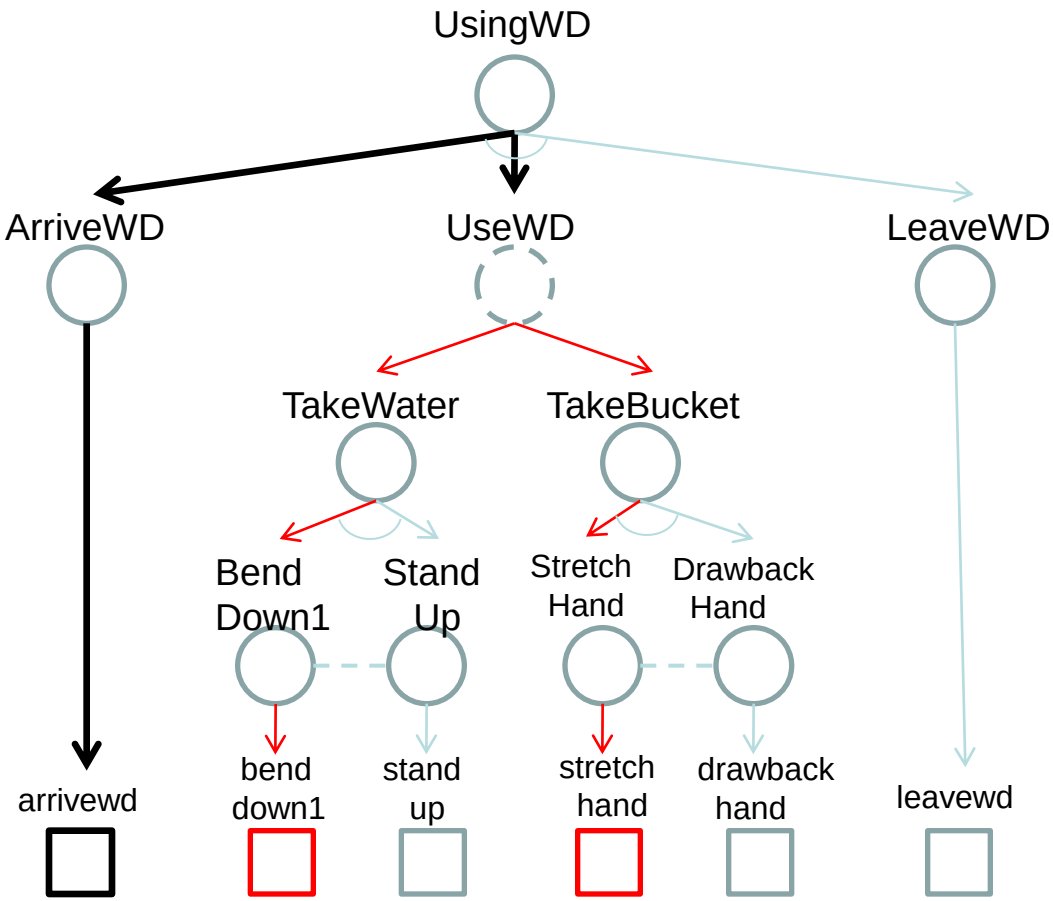

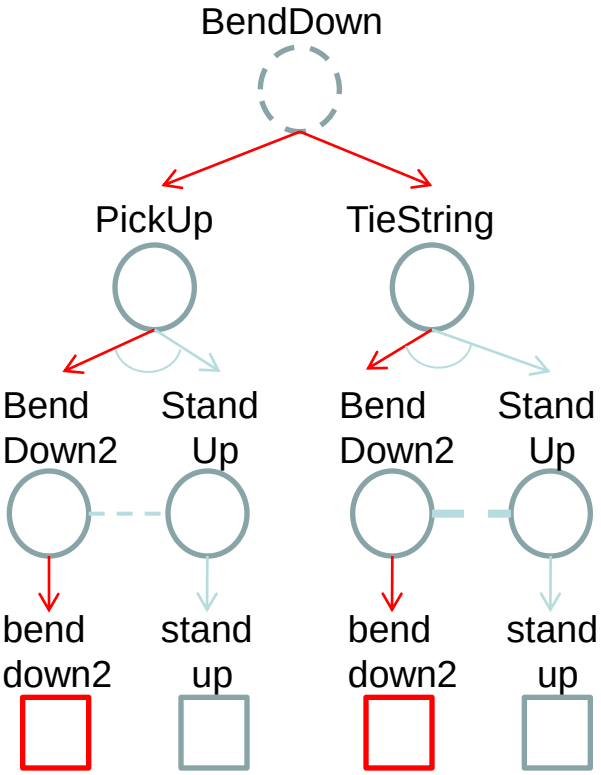

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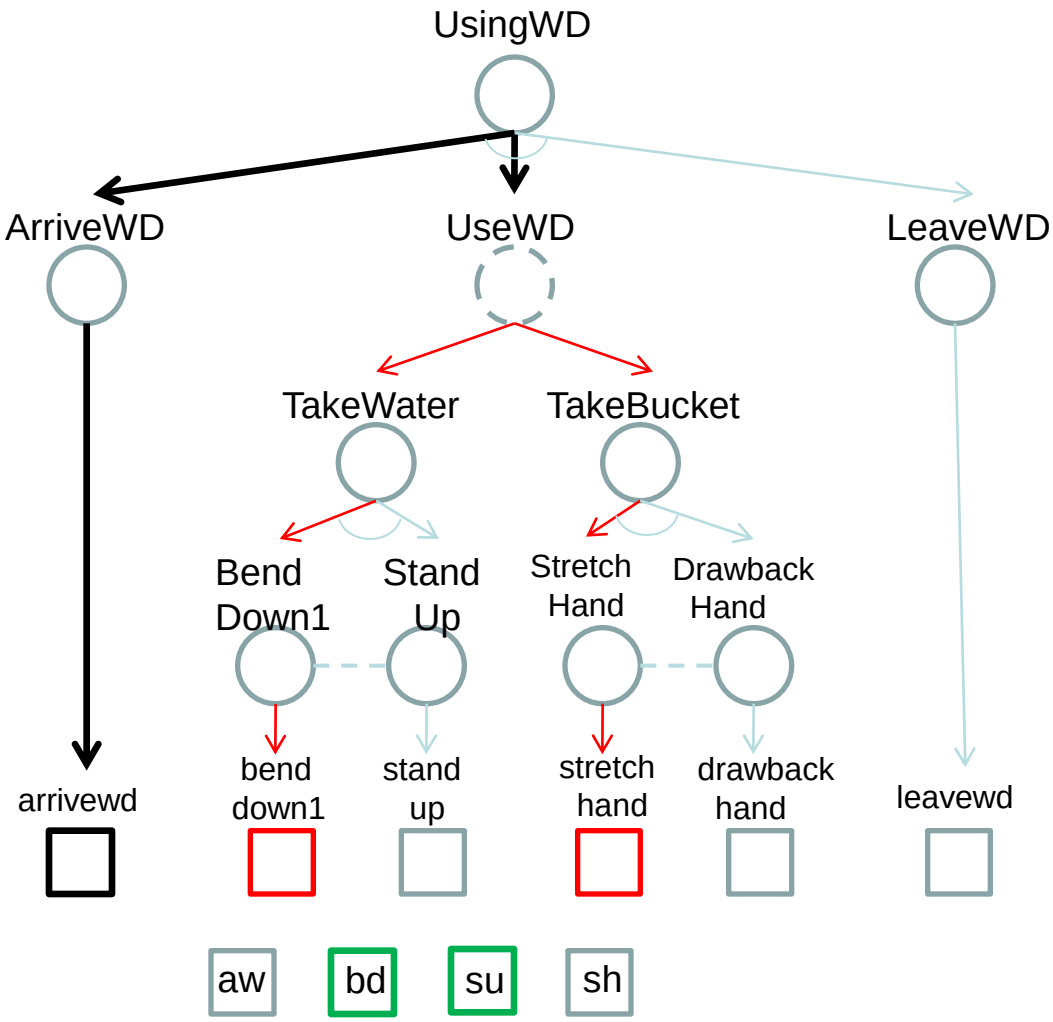

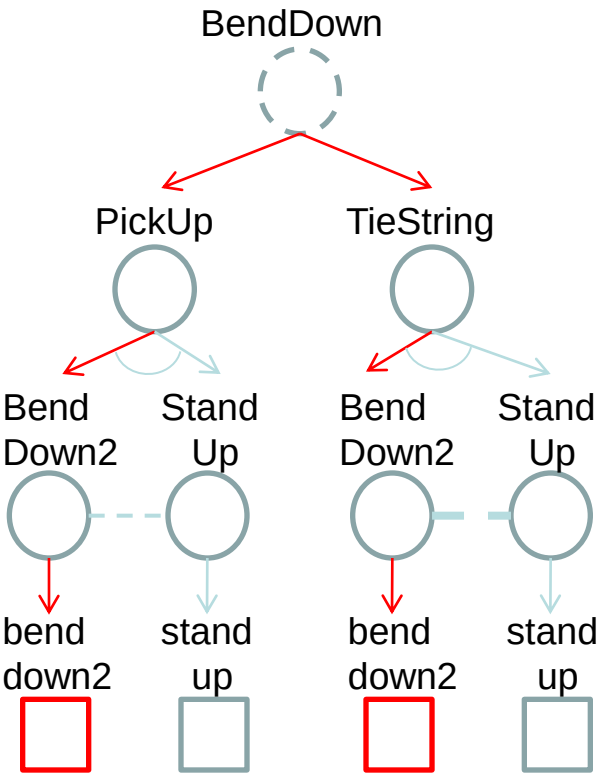

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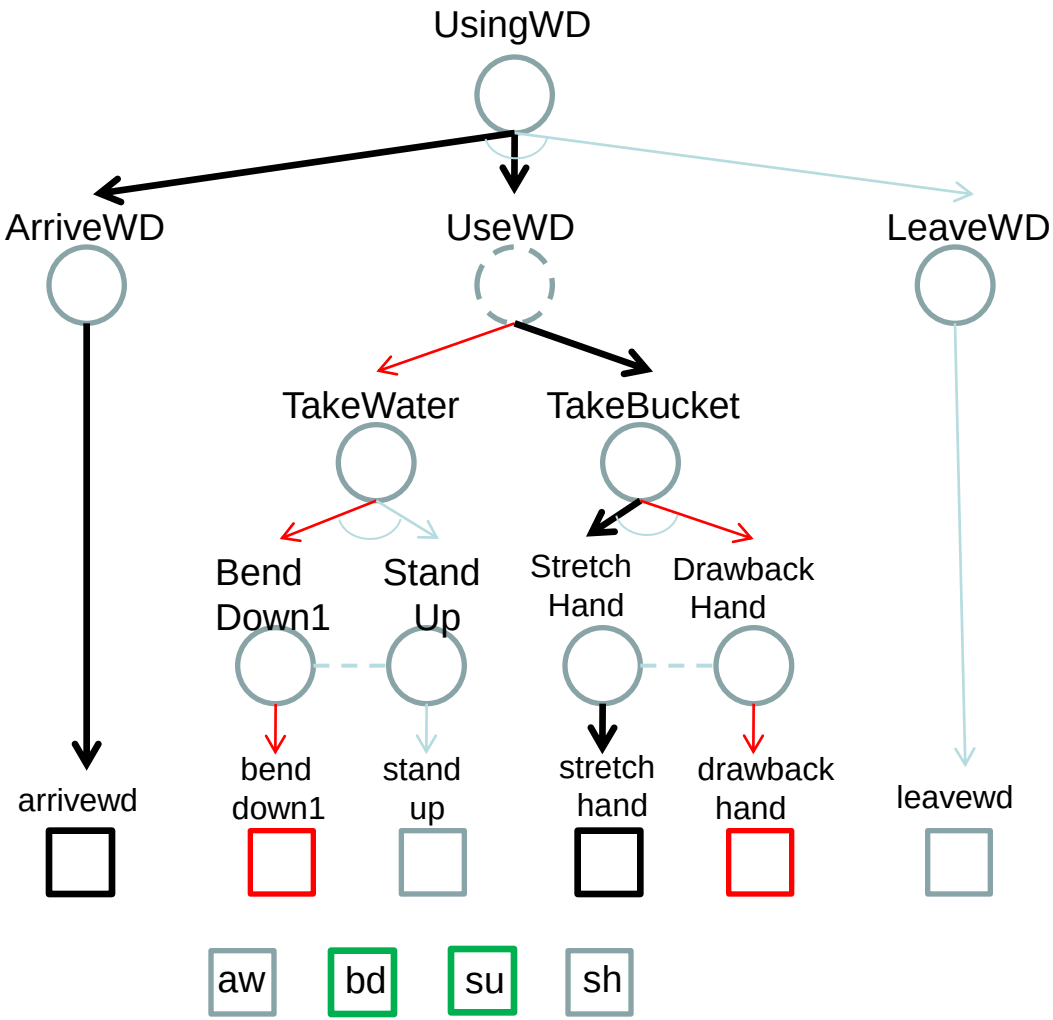

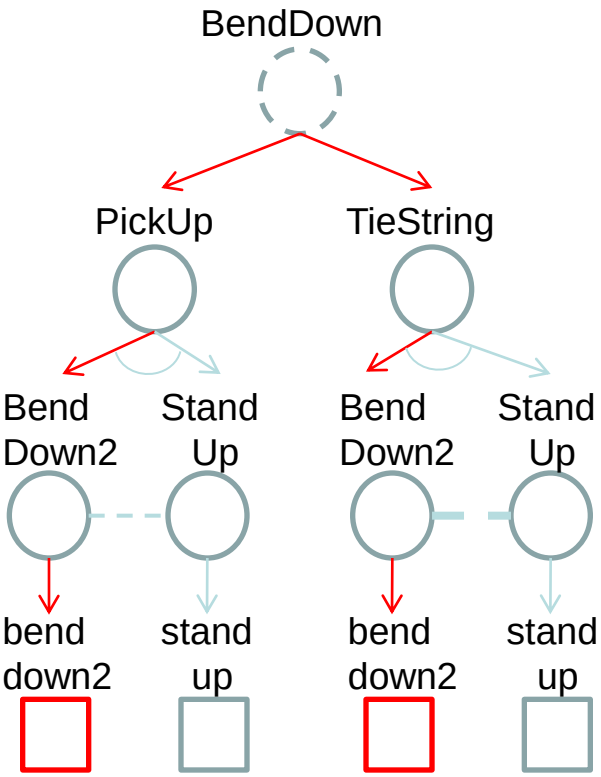

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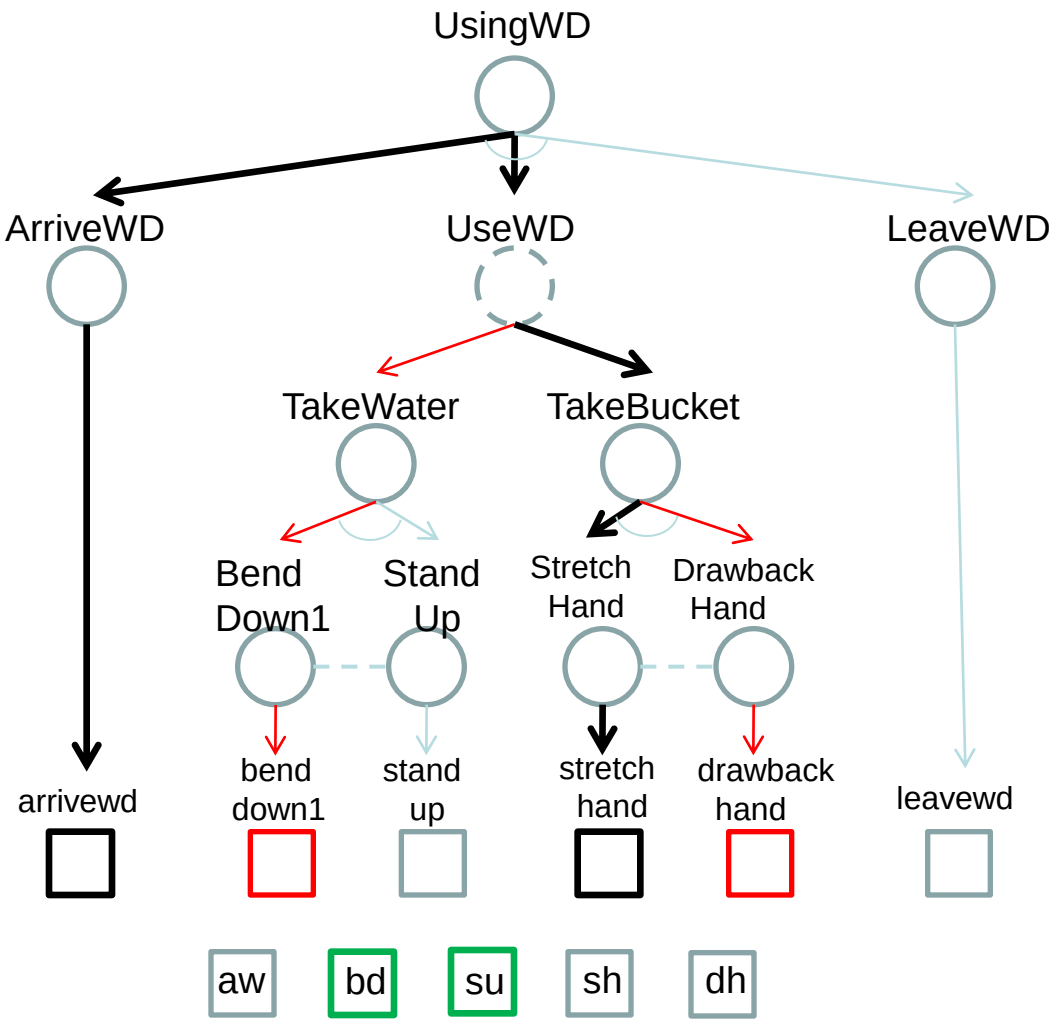

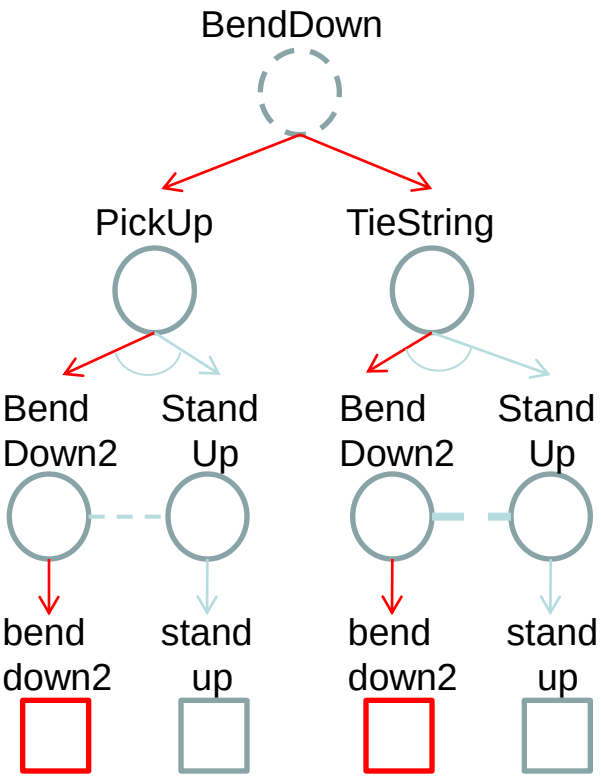

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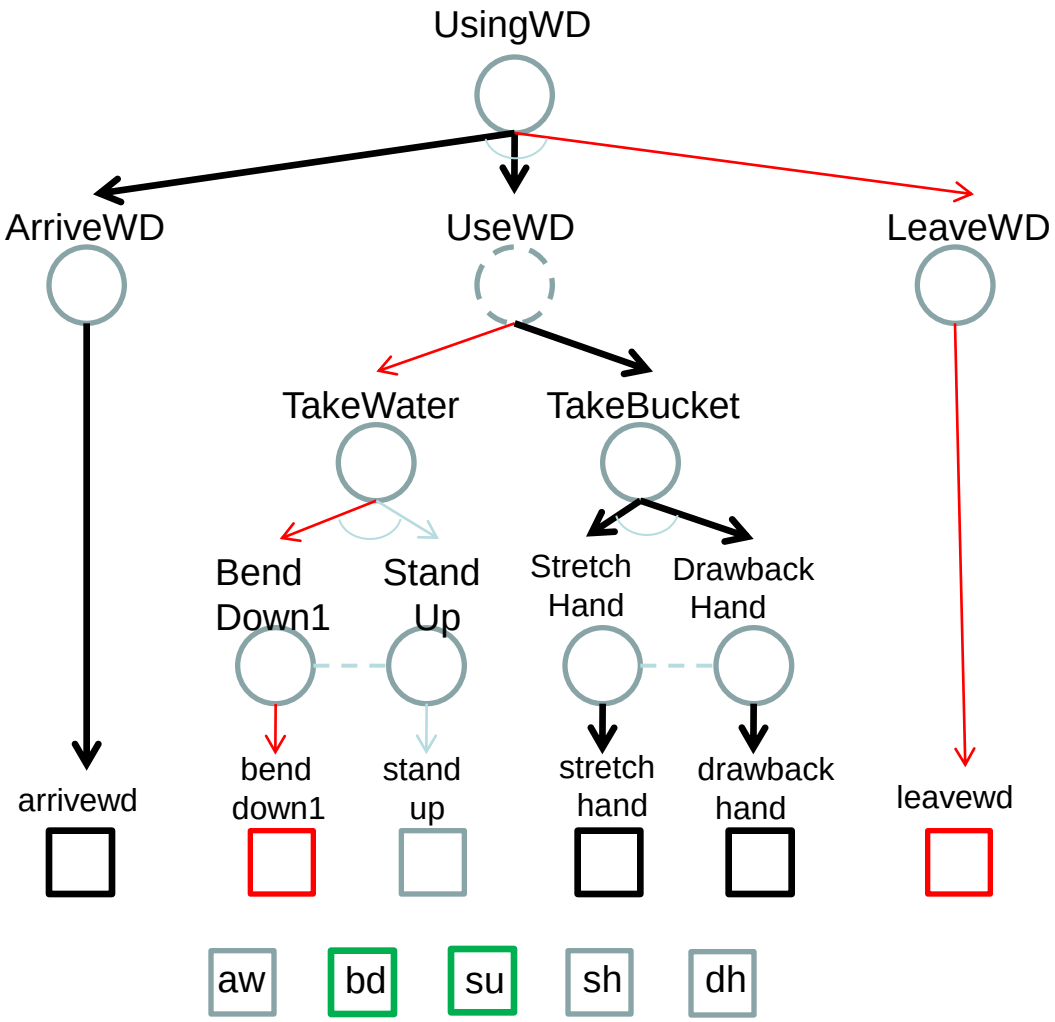

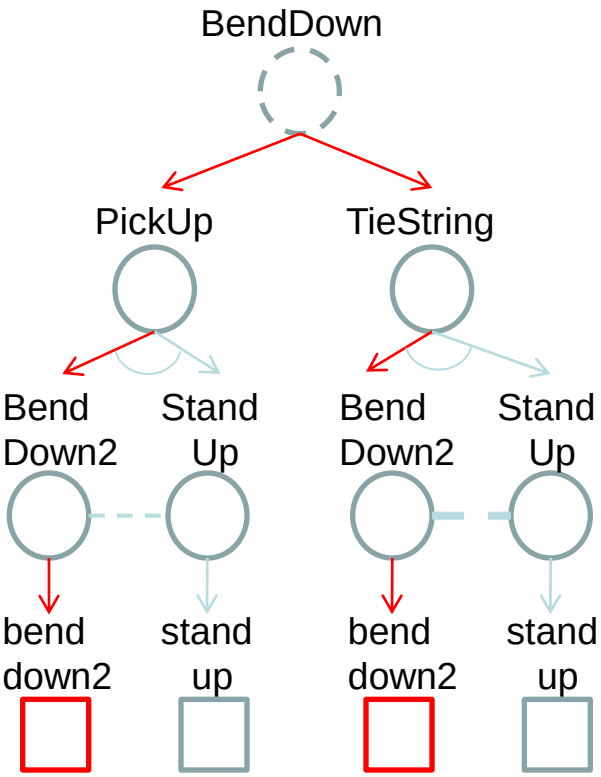

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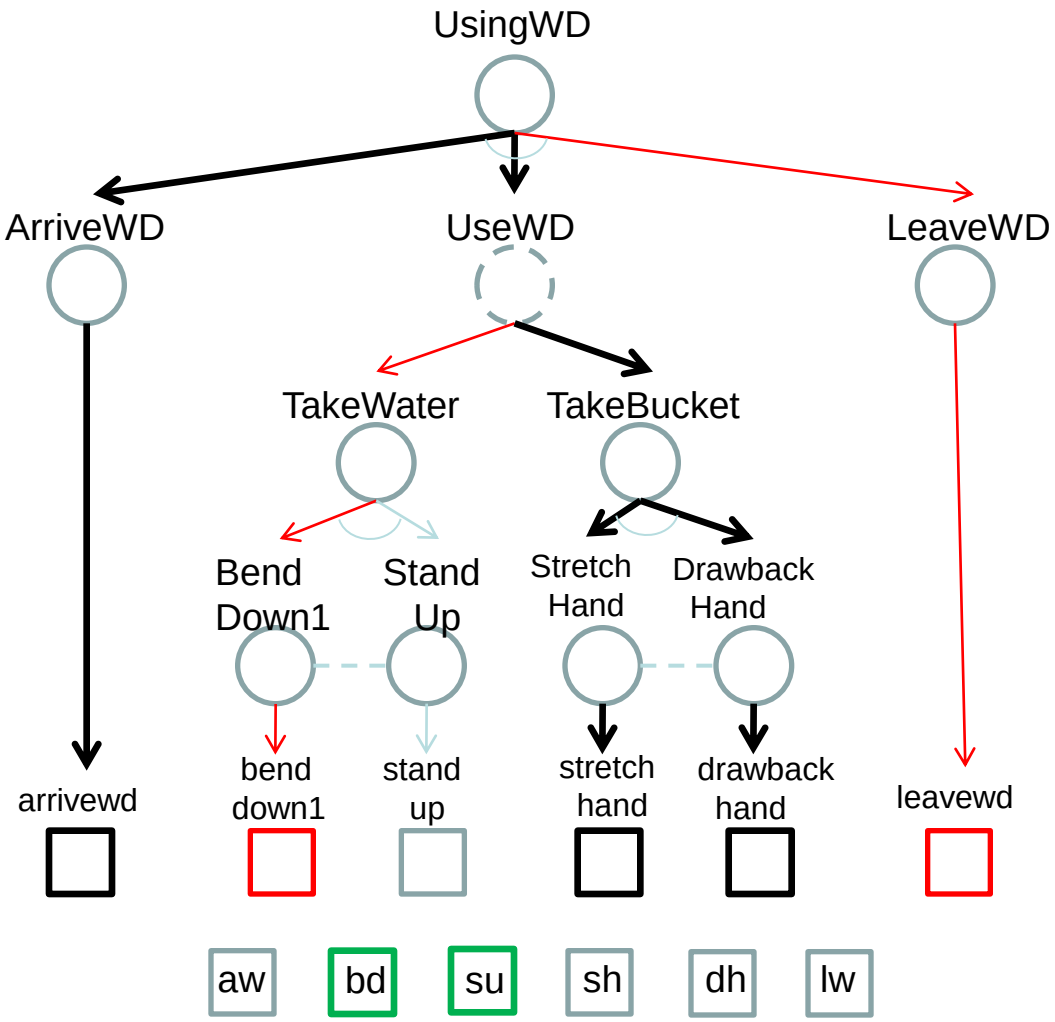

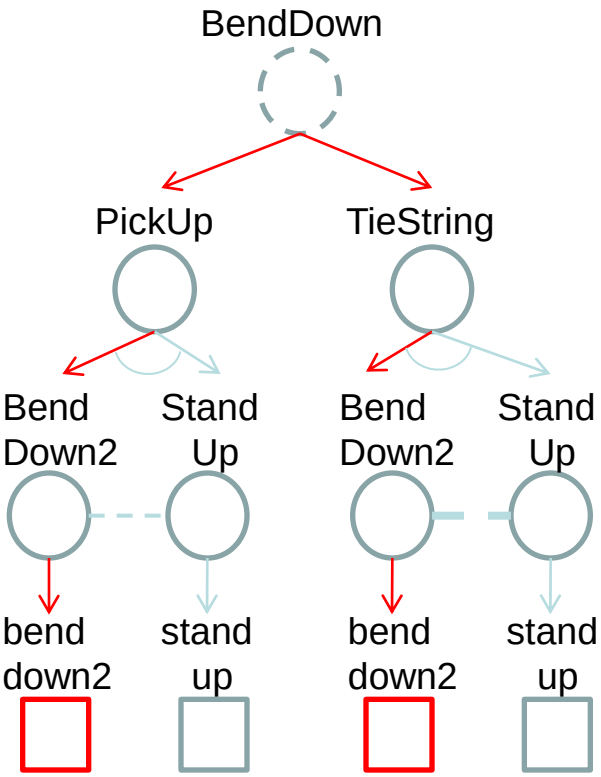

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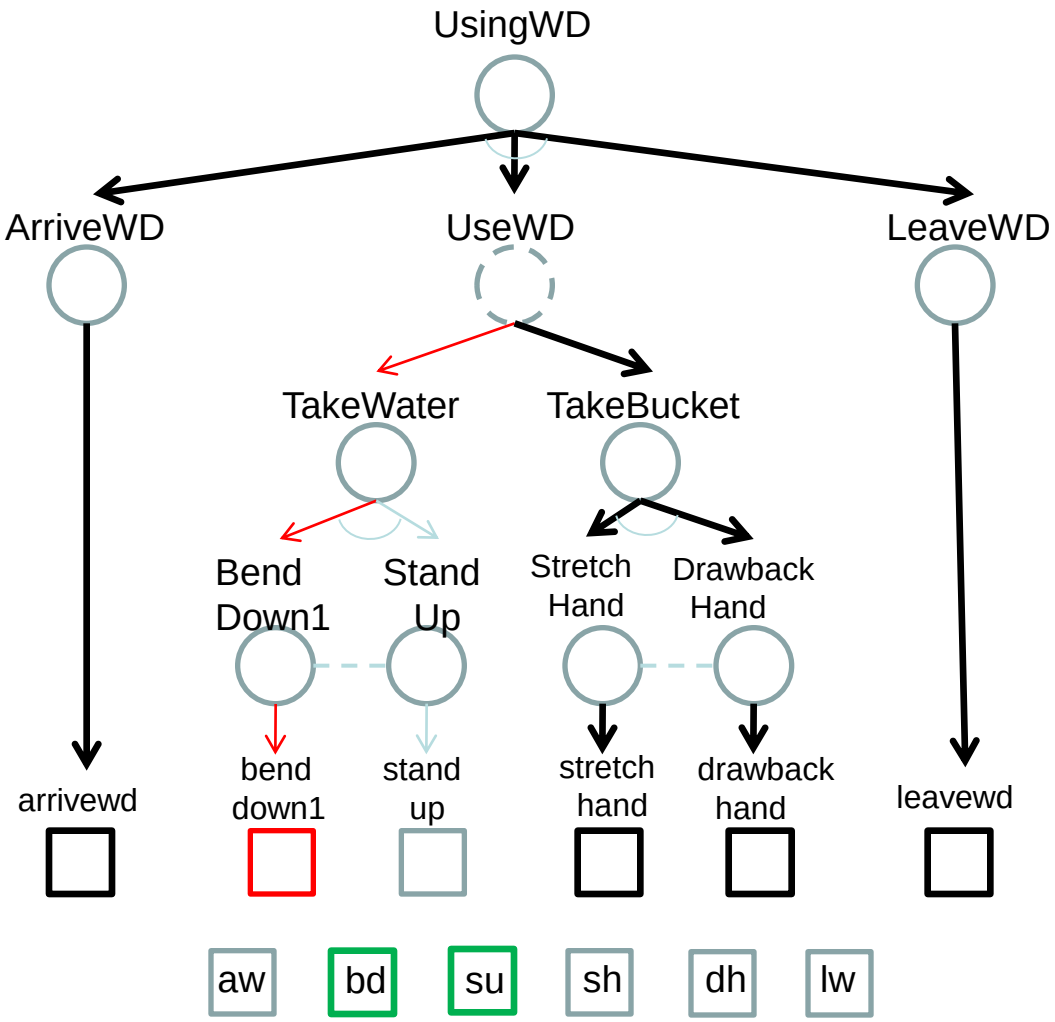
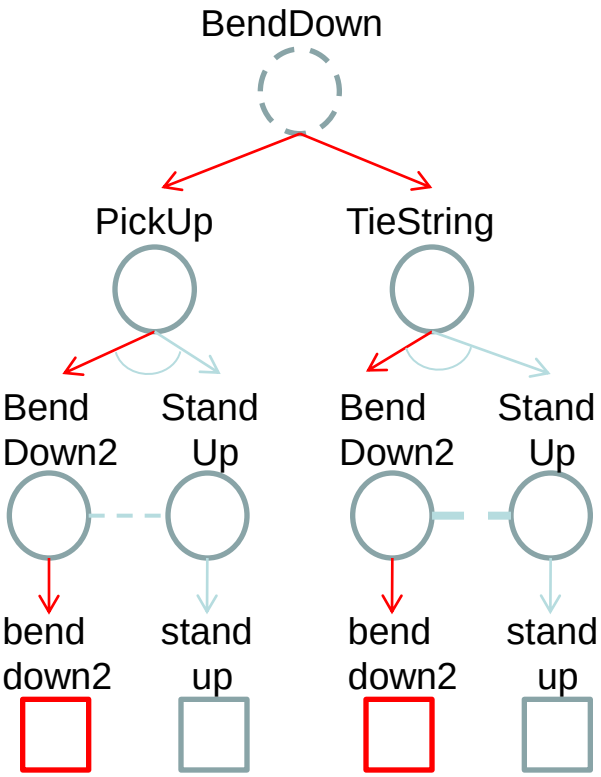
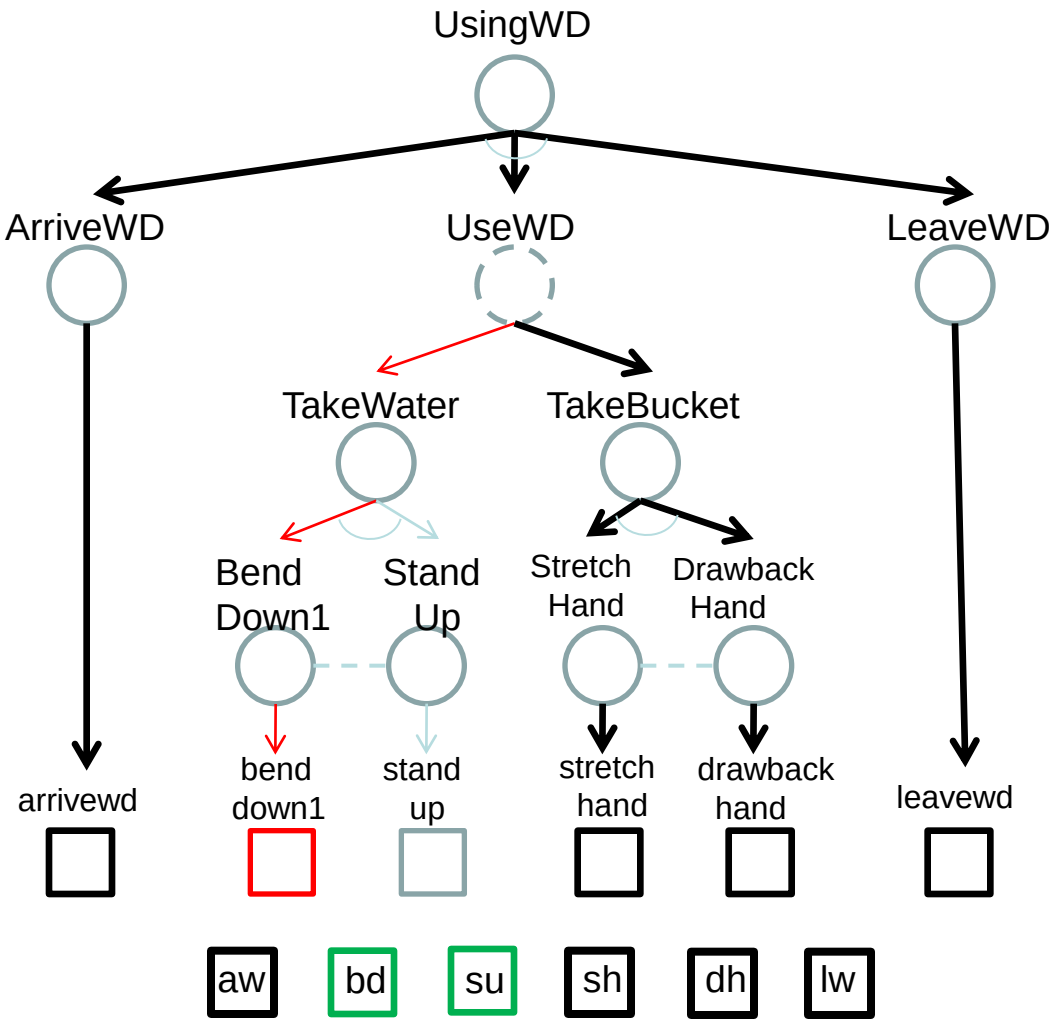
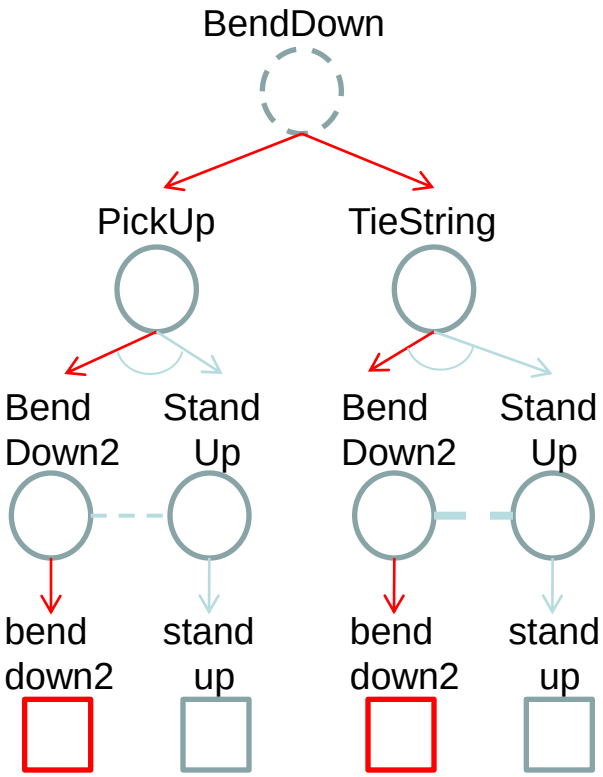




The parsing process





Goal: Recognize events in daily scenes

For example, in an office scene

Work by Mingtao Pei, UCLA

Challenges

1. Events happen over an extended time period
   - Variant time-span
   - Could be interrupted
   - Multiple routes
   - Intention and prediction

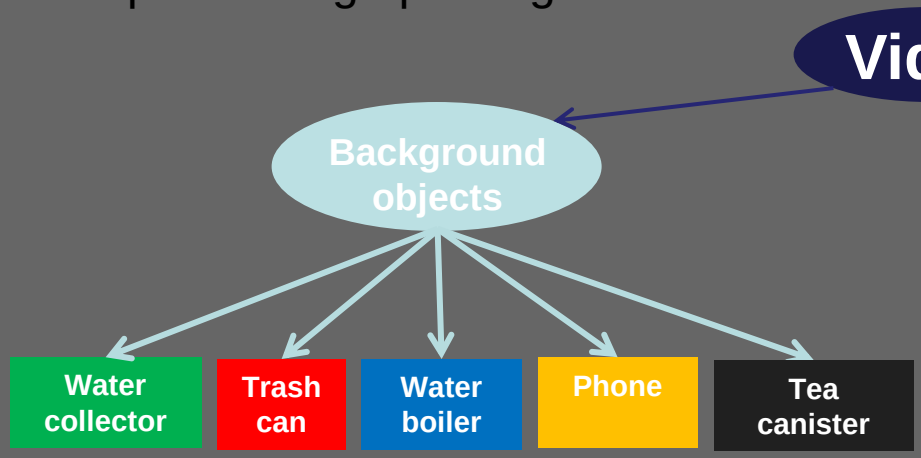
2. Actions are hard to recognize
   - Subtle and similar
   - No salient motion/pose at most of the time
   - Contextual OBJCTS are key!!

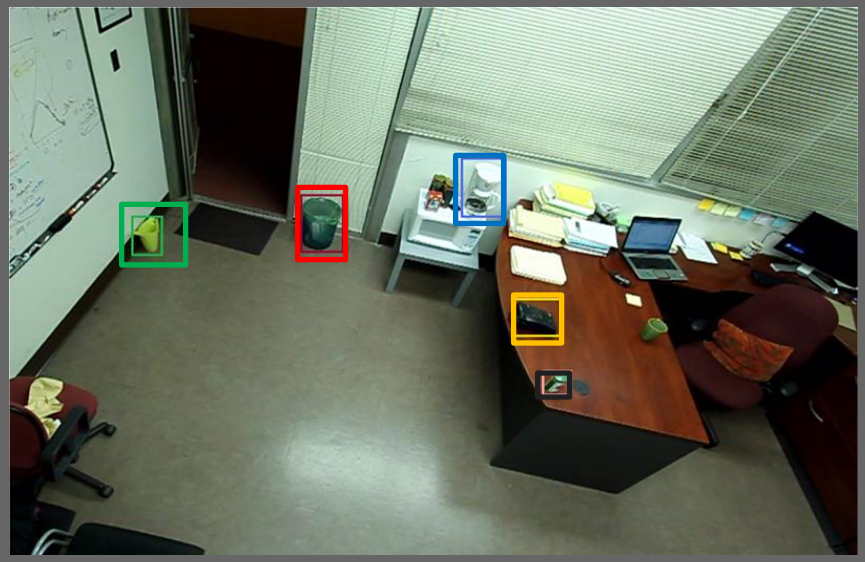
Use laptop | Read book | Dump water | Use microwave

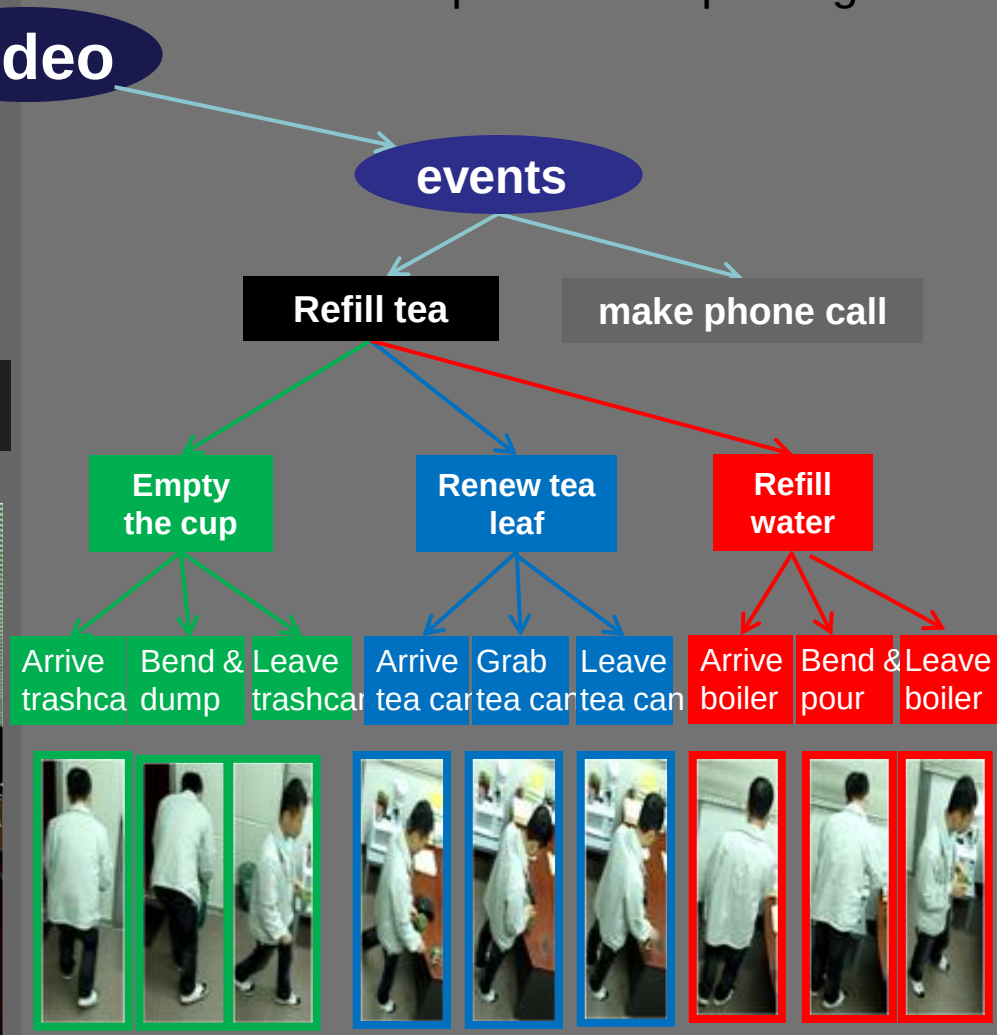
Overview of our approach

Spatial image parsing

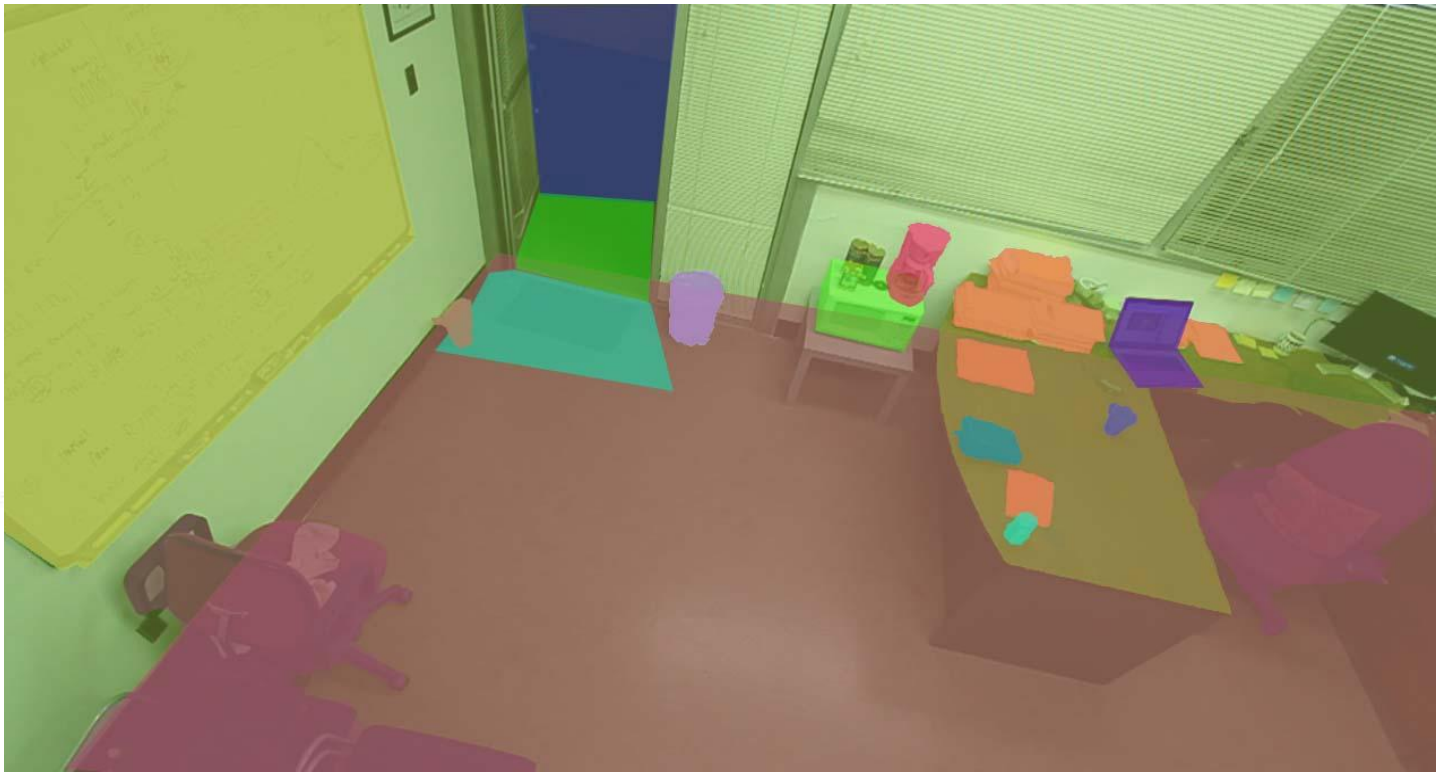
Temporal event parsing



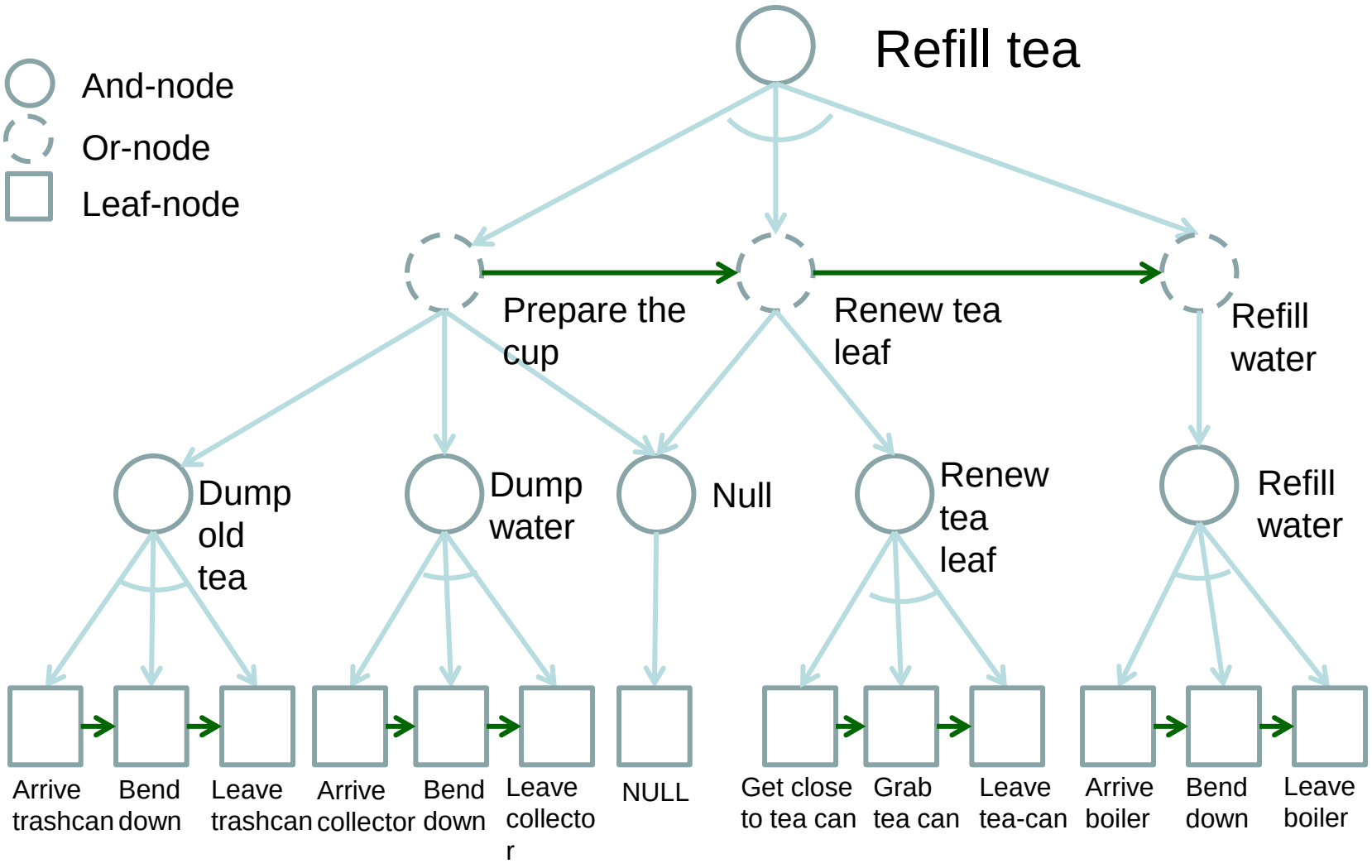




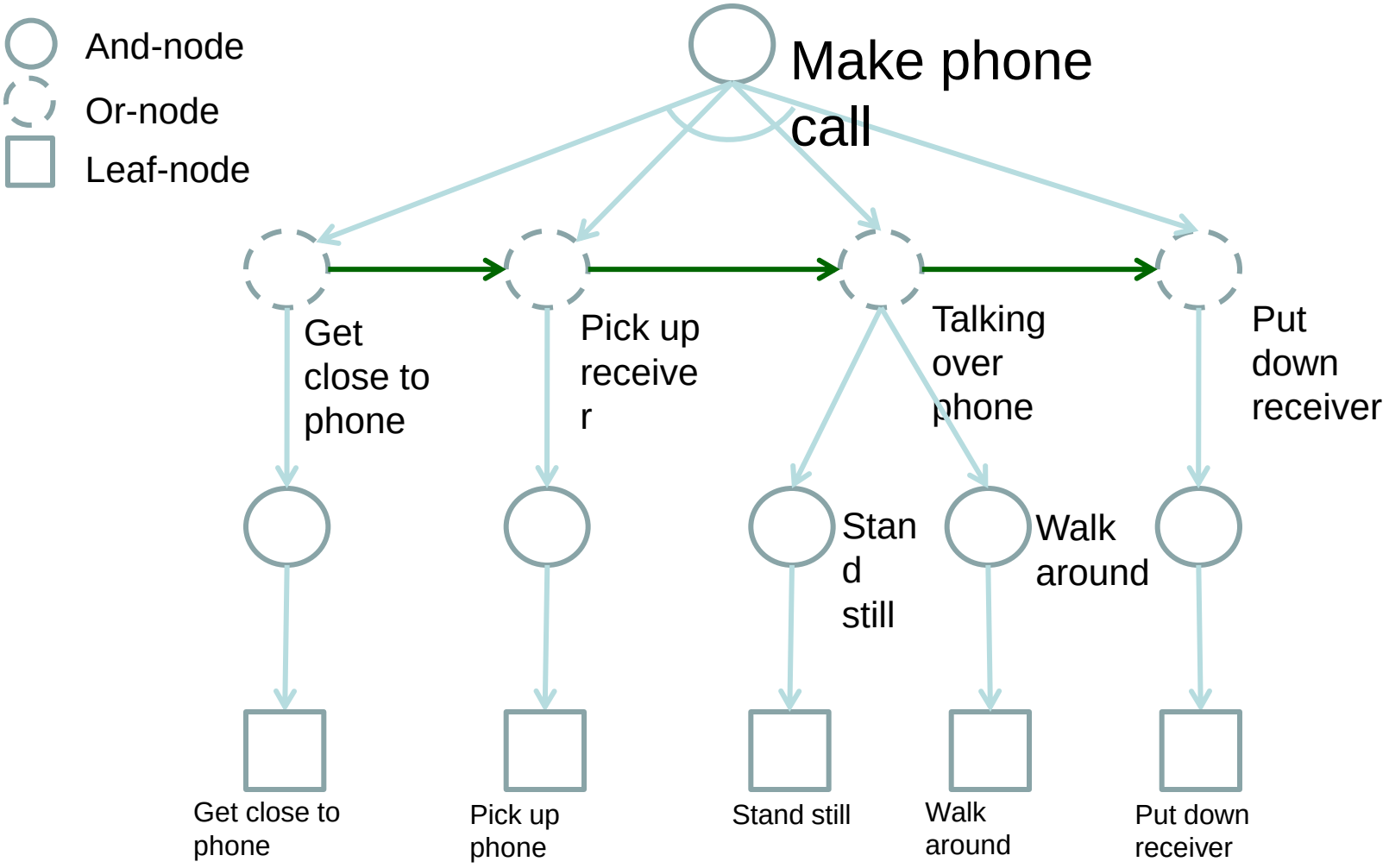
Scene parsing



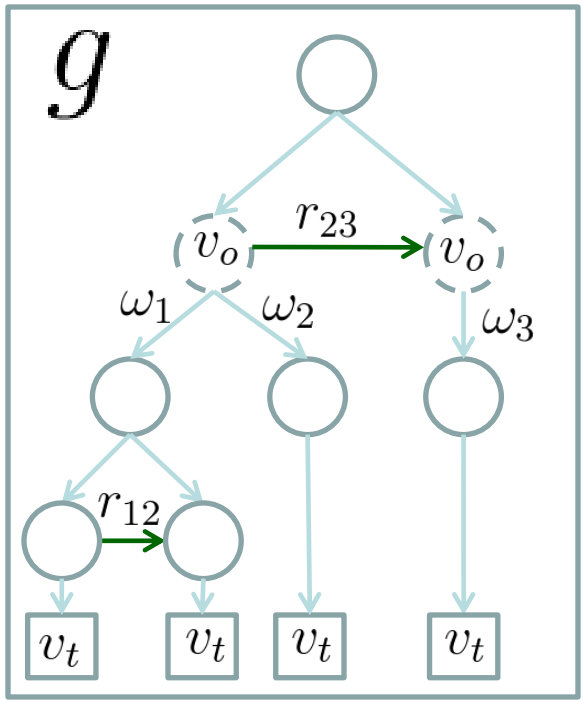
Event as temporal And-Or-Graph



Event as temporal And-Or-Graph



Formulation



$$p(g) = \frac{1}{Z} exp\{score(g)\}$$

Gramma

r

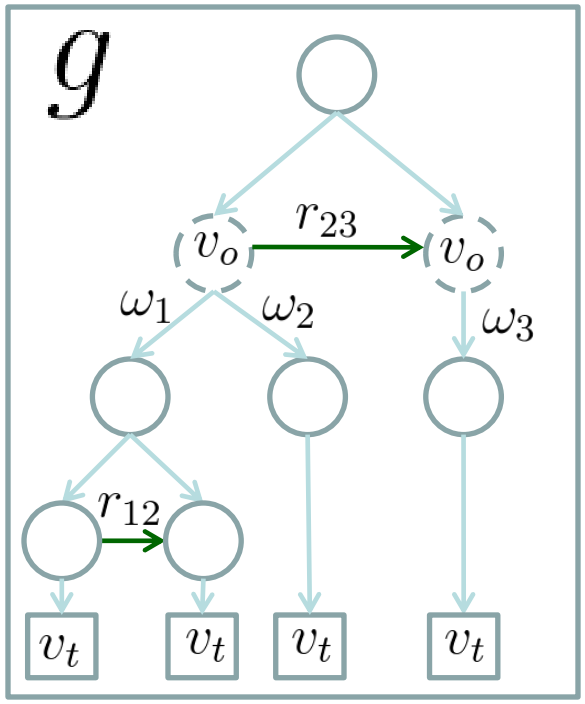
$$score(g) = \sum_{v_t \in T(g)} \lambda_{v_t} \alpha(v_t) + \sum_{v \in V_o(g)} \lambda_v \omega(v) + \sum_{(i,j) \in E(g)} \lambda_{ij} r_{ij}(v_i, v_j)$$

Data term

Or node Frequency term

Temporal Relations

Formulation



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Data term

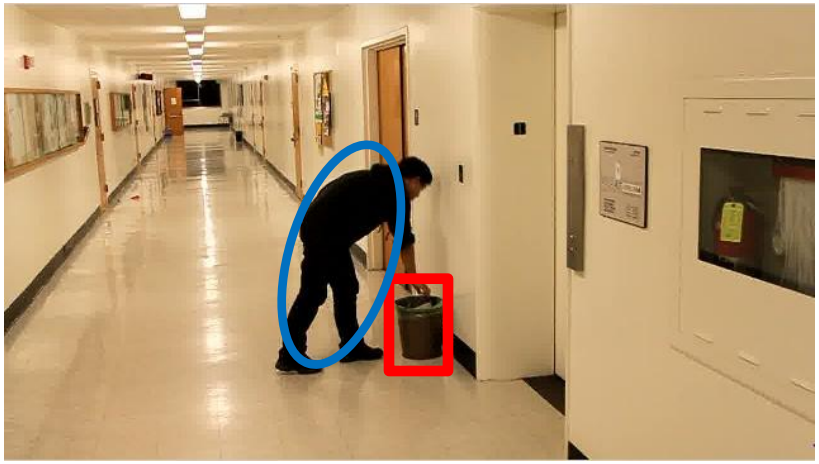
Or node Frequenc

y

Temporal Relations

$$\alpha(v_t) = \sum_{i \in \mathcal{F}} \beta_i, h_i(v_t) - dist(P_{person}, P_{obj})$$

Combing action and contextual object



Bend down action

+

Close to Trash Can

=

Event1:
Drop waste

Reach out action

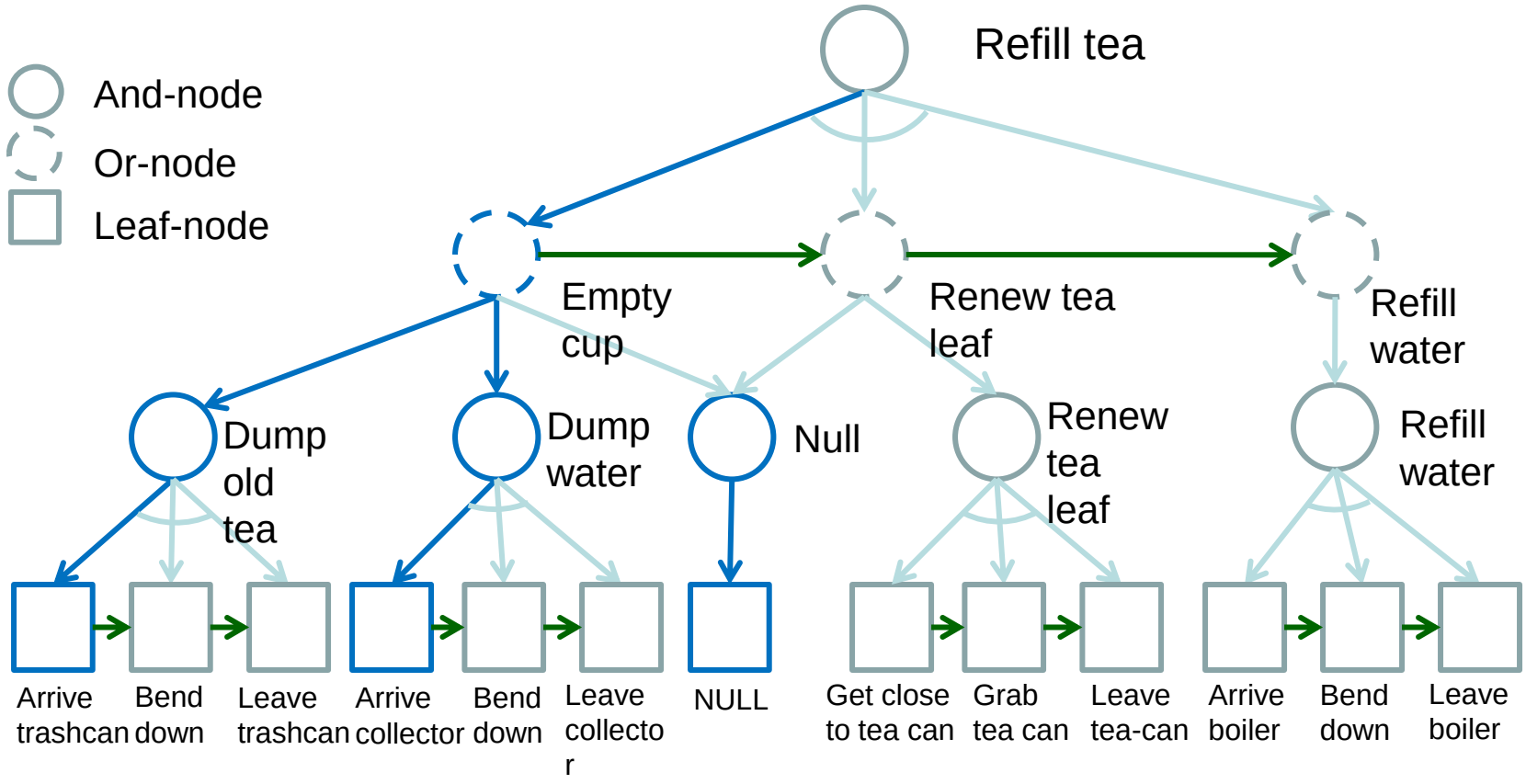
+

Close to Elevator

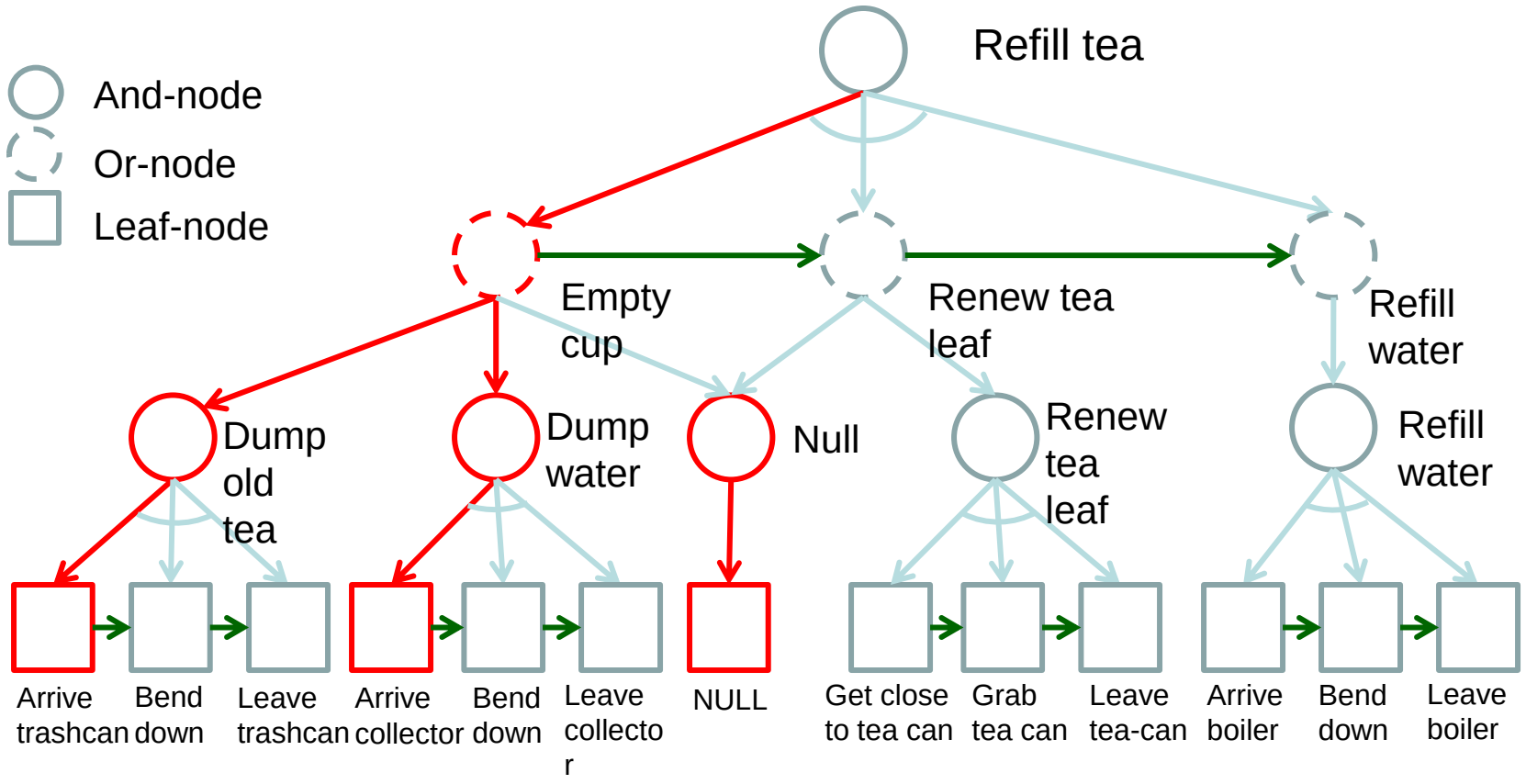
=

Event2:
Use elevator

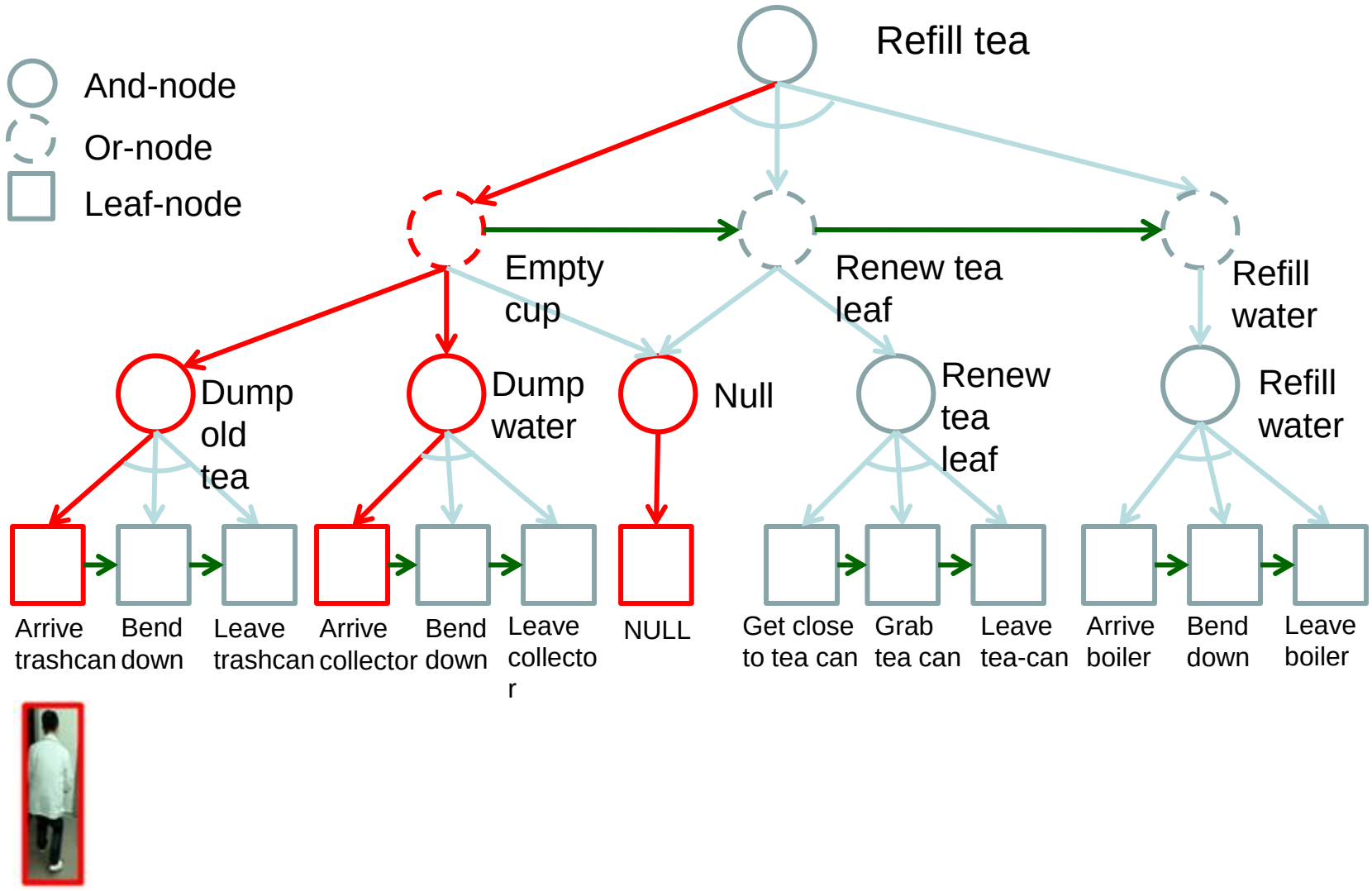
Parsing process (Earley Parser [Earley 1970])



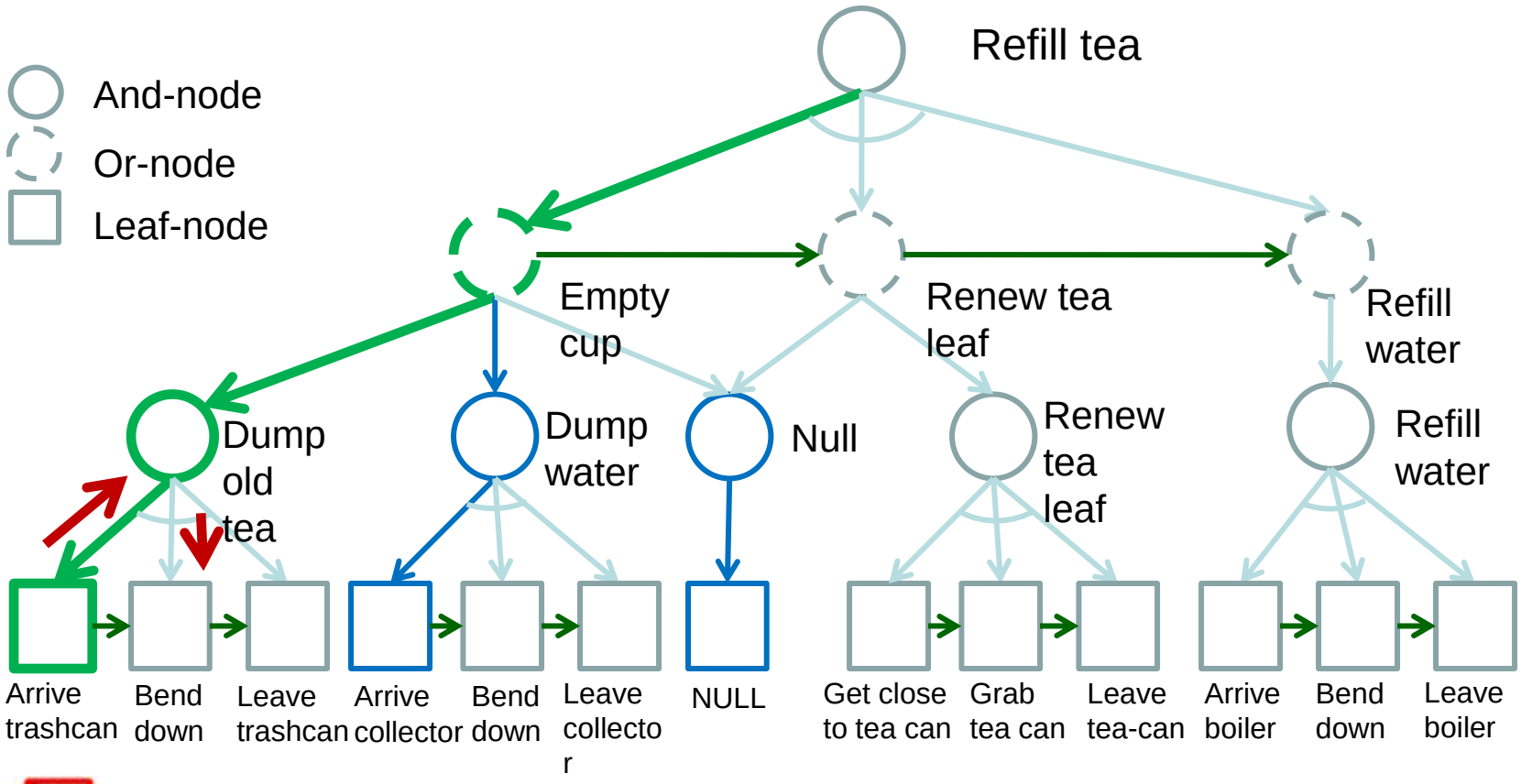
Parsing process (Earley Parser [Earley 1970])



Parsing process (Earley Parser [Earley 1970])



Parsing process (Earley Parser [Earley 1970])



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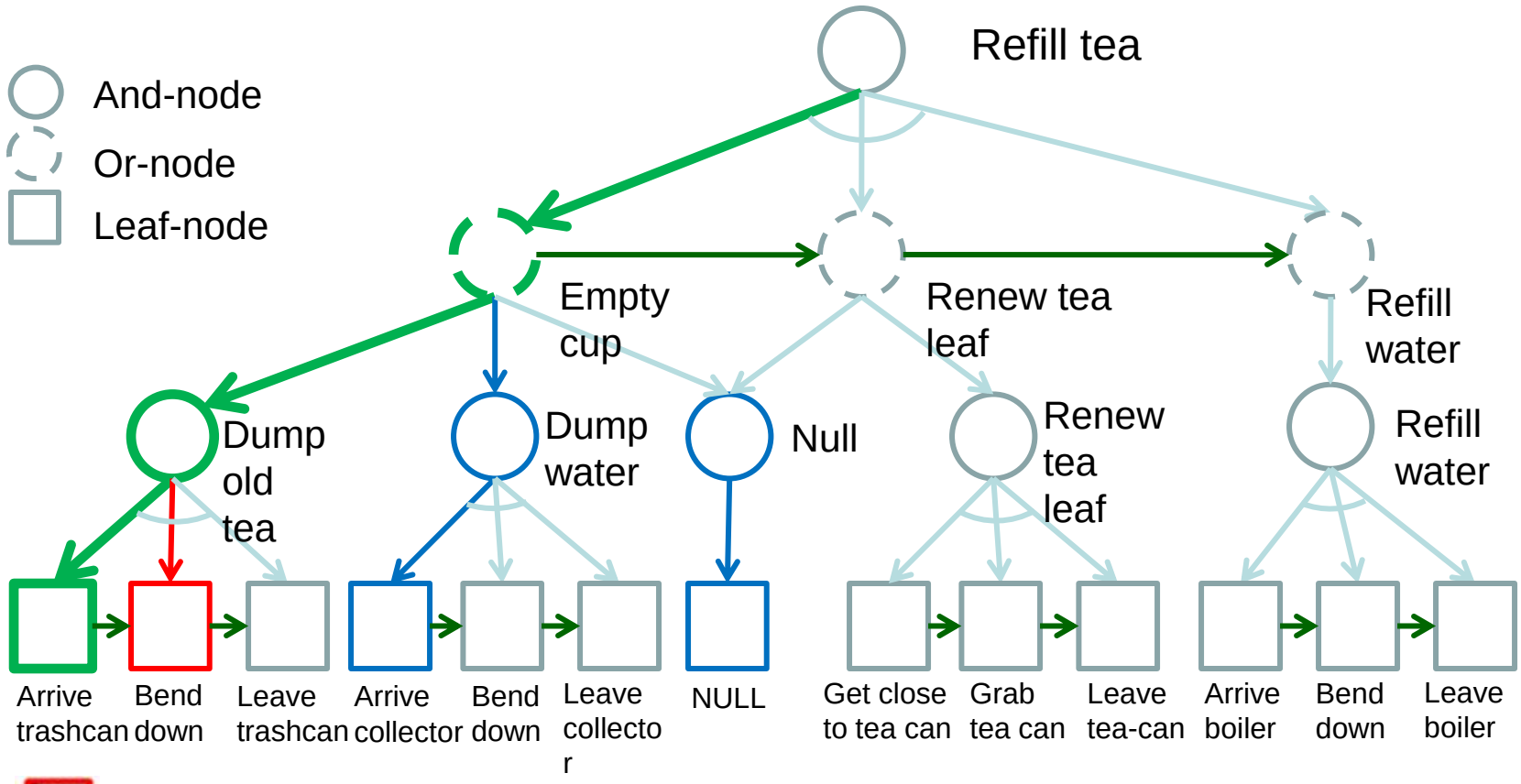
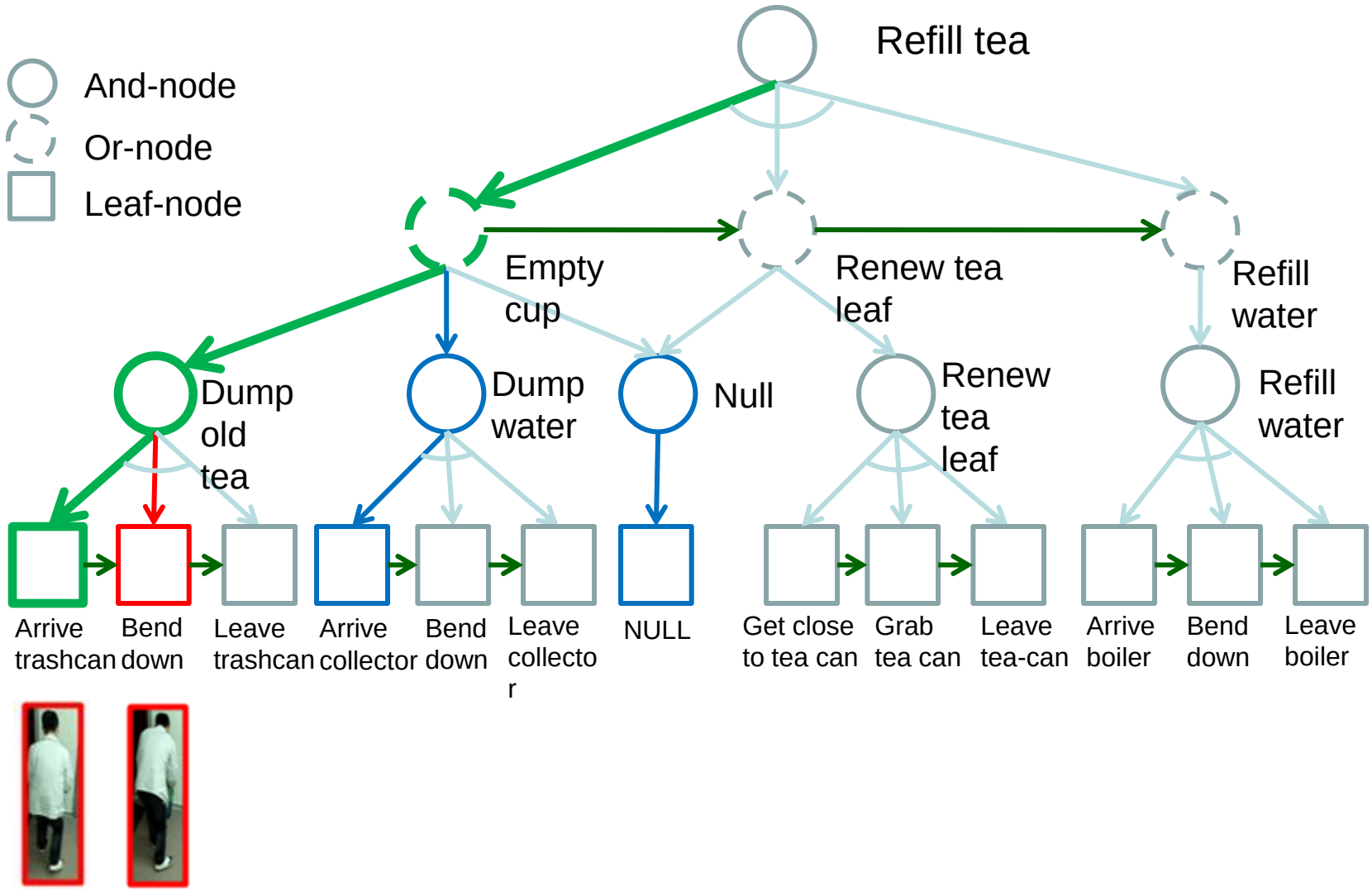
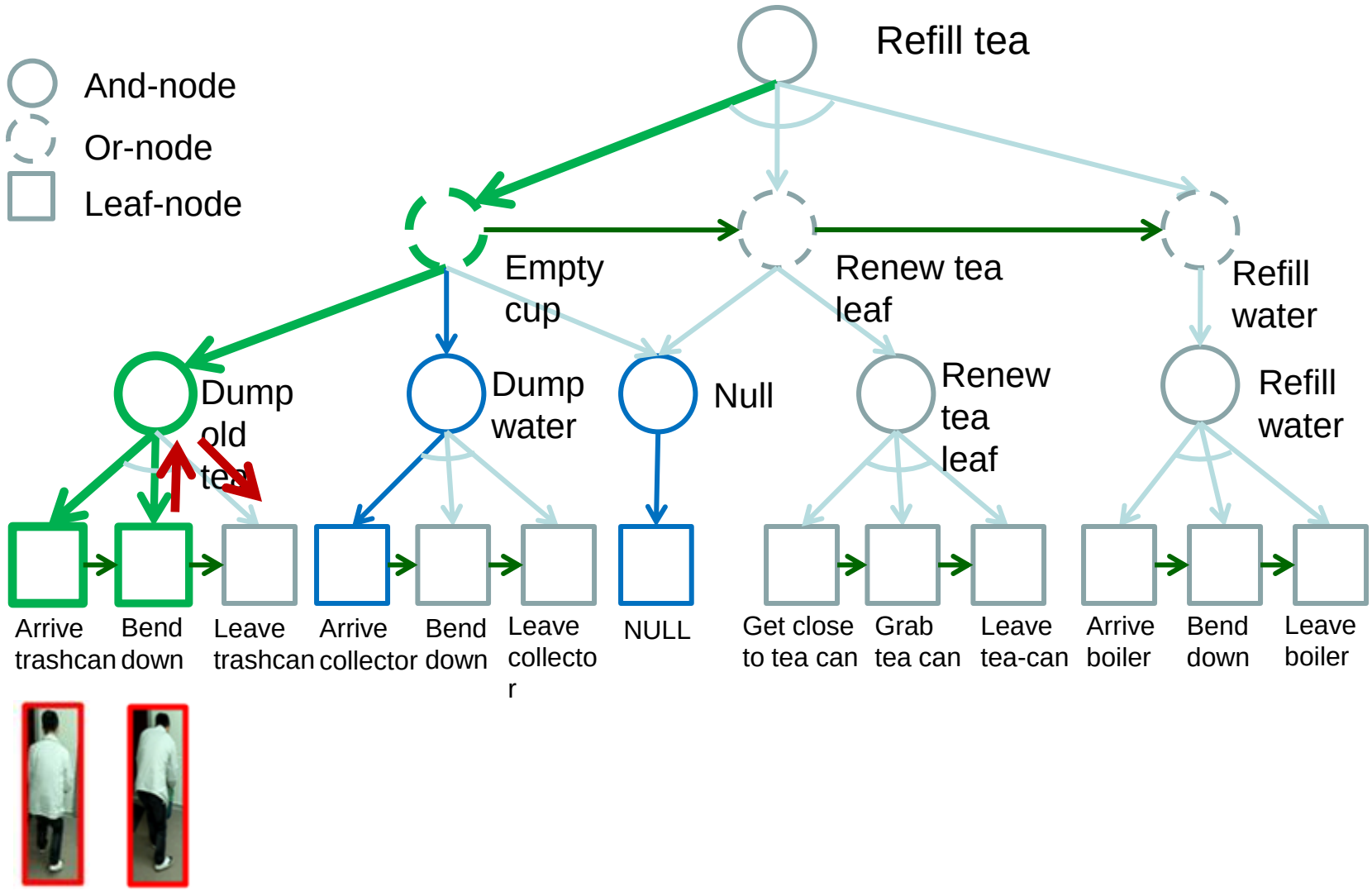


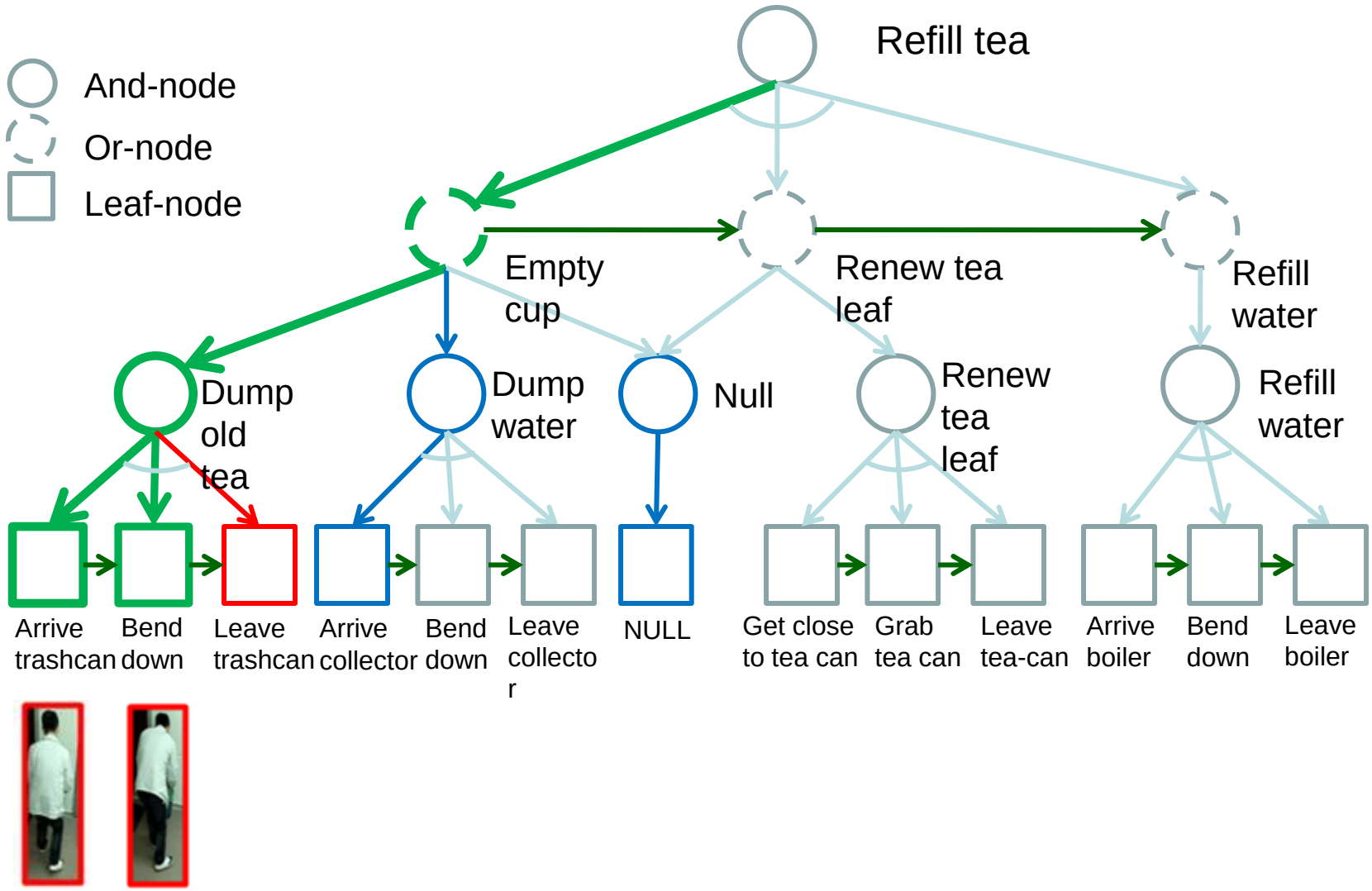
Parsing process (Earley Parser [Earley 1970])



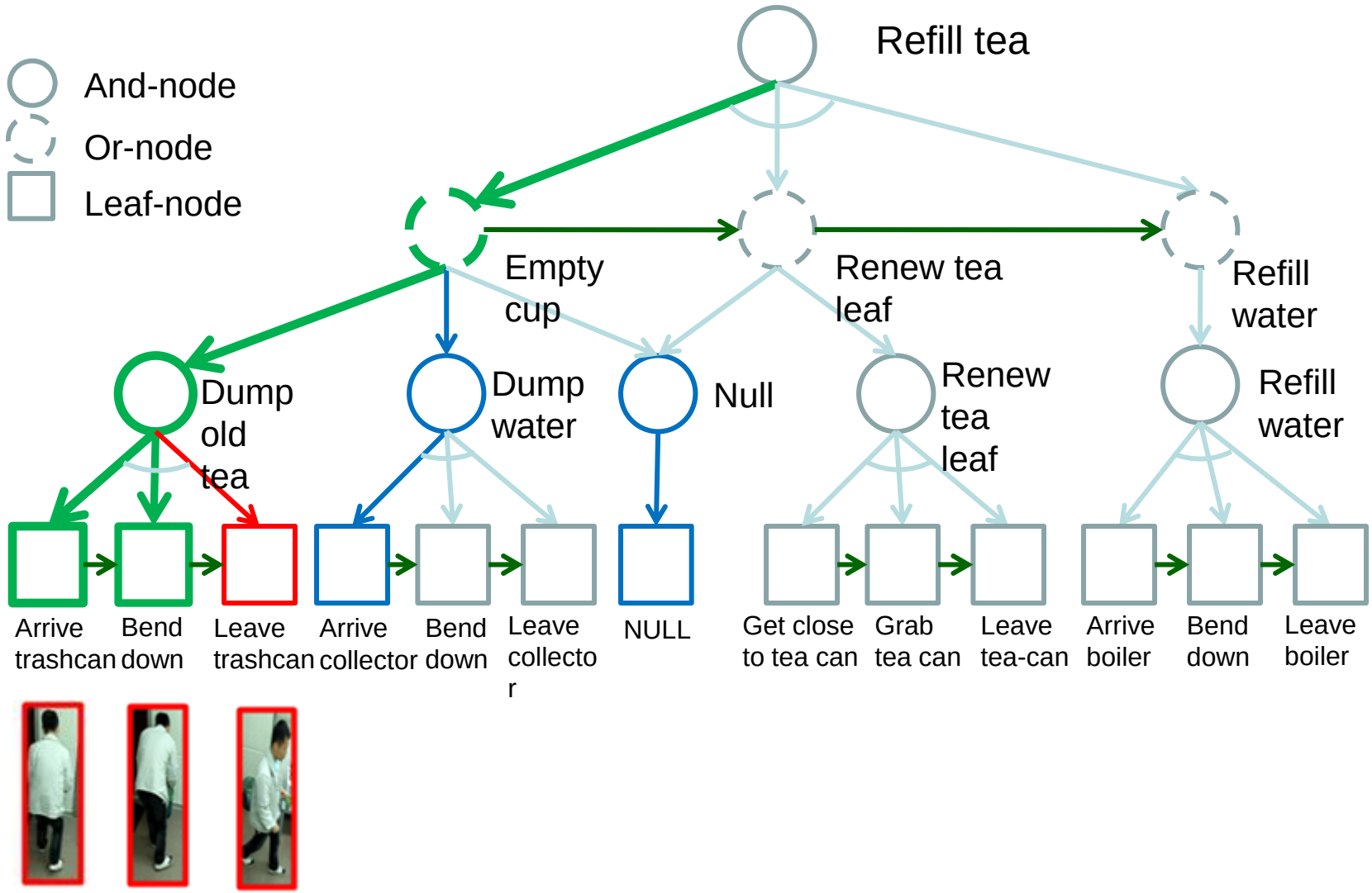
Parsing process (Earley Parser [Earley 1970])



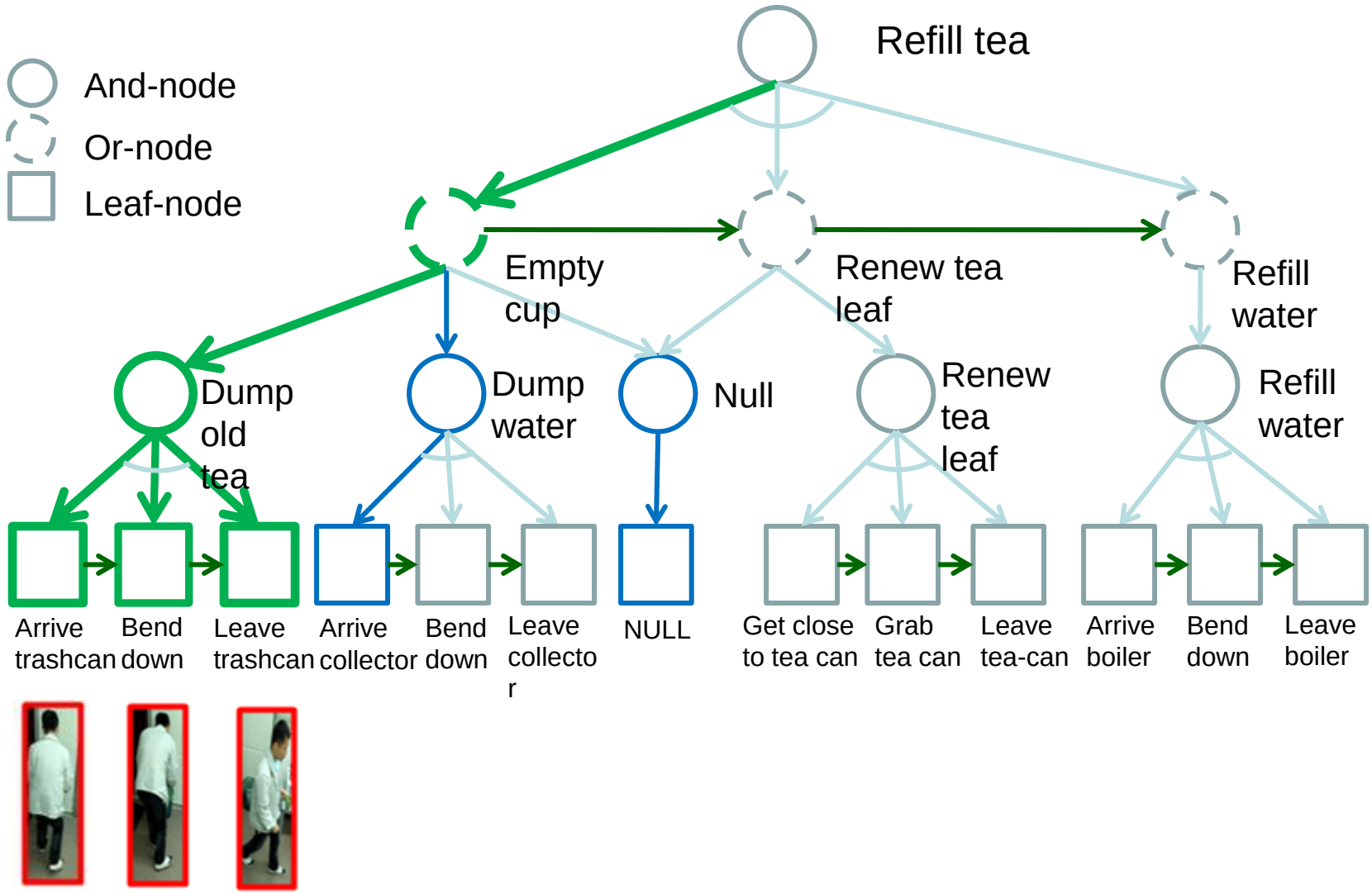
Parsing process (Earley Parser [Earley 1970])



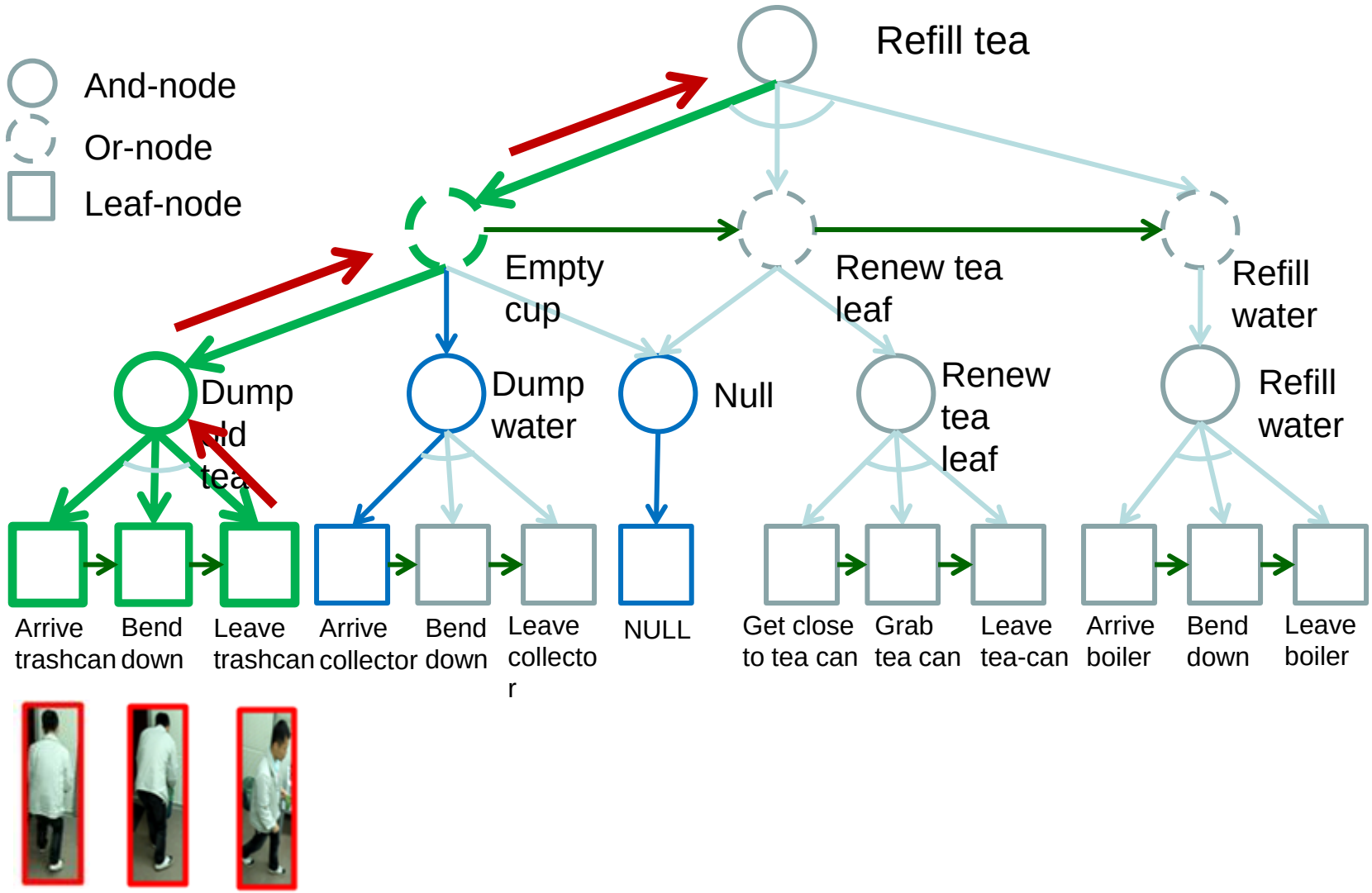
Parsing process (Earley Parser [Earley 1970])



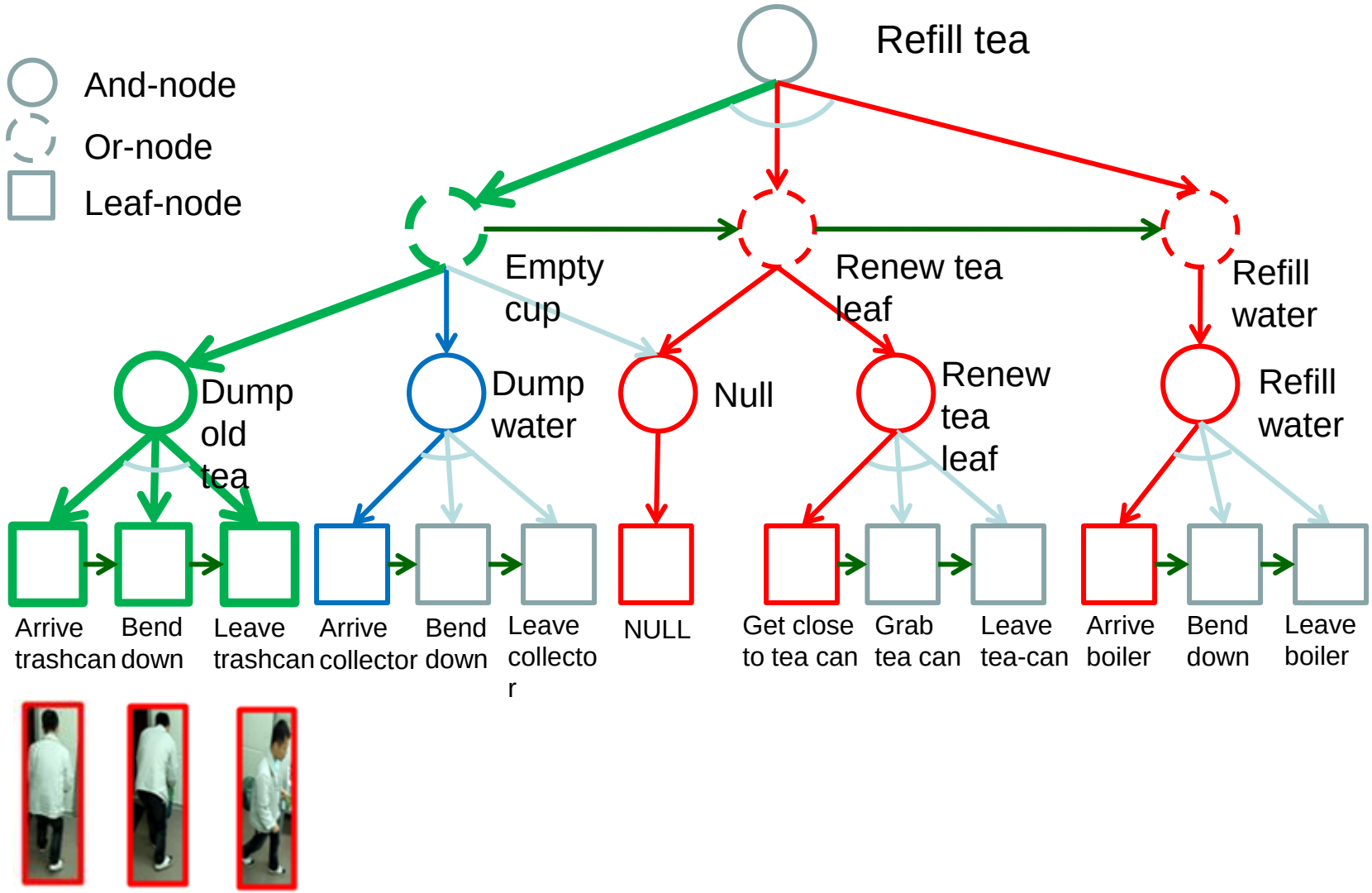
Parsing process (Earley Parser [Earley 1970])



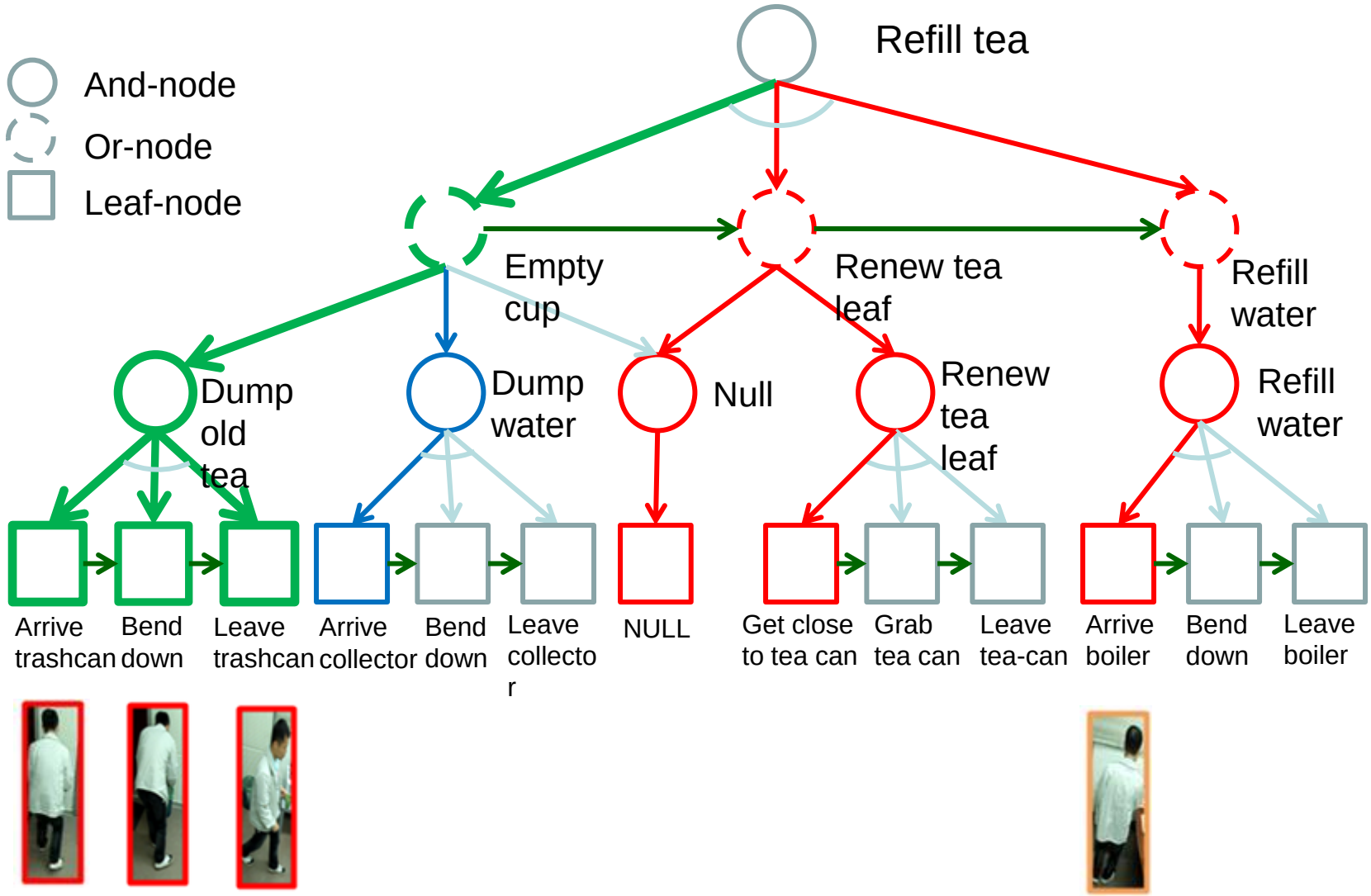
Parsing process (Earley Parser [Earley 1970])



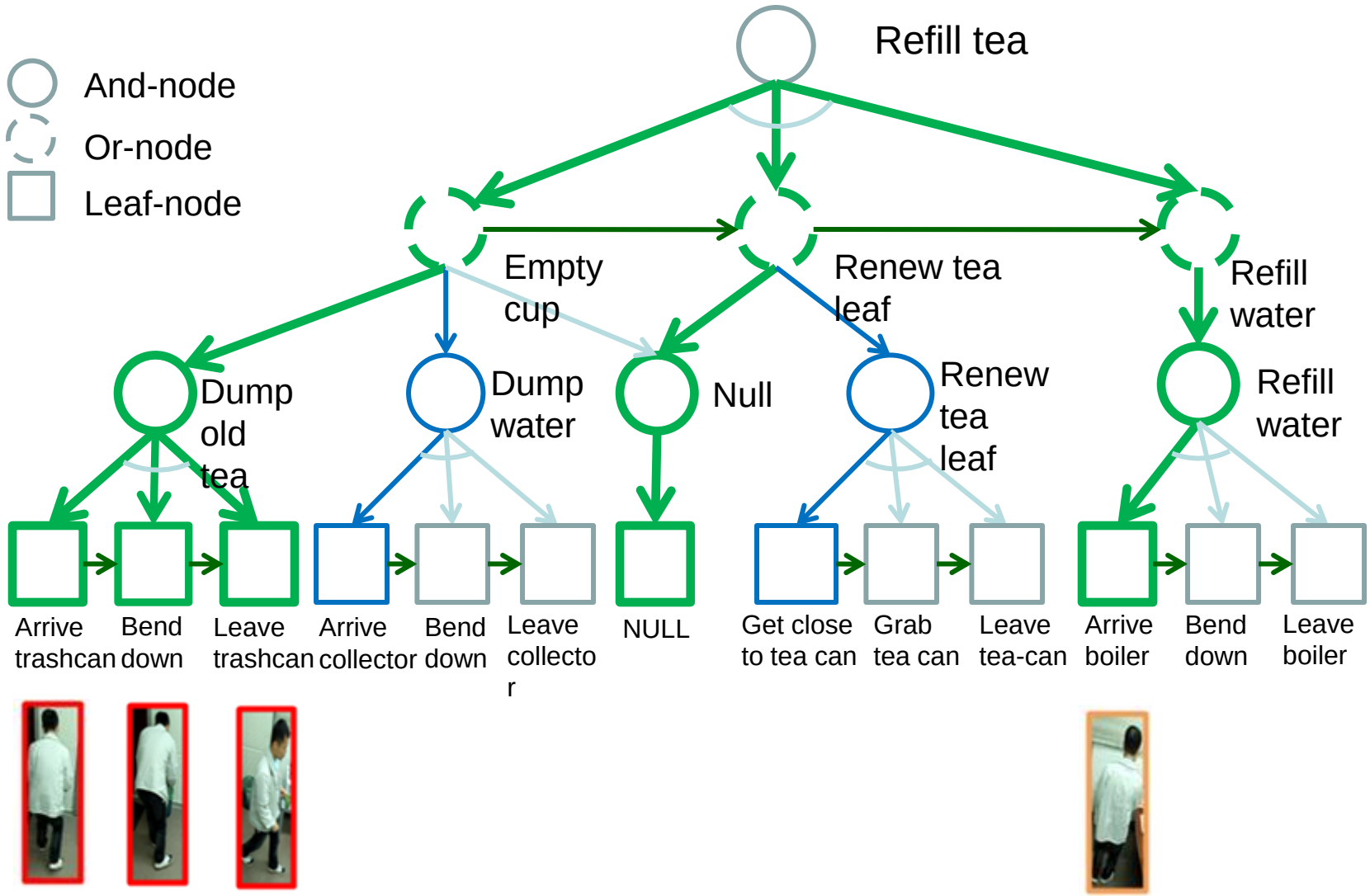
Parsing process (Earley Parser [Earley 1970])



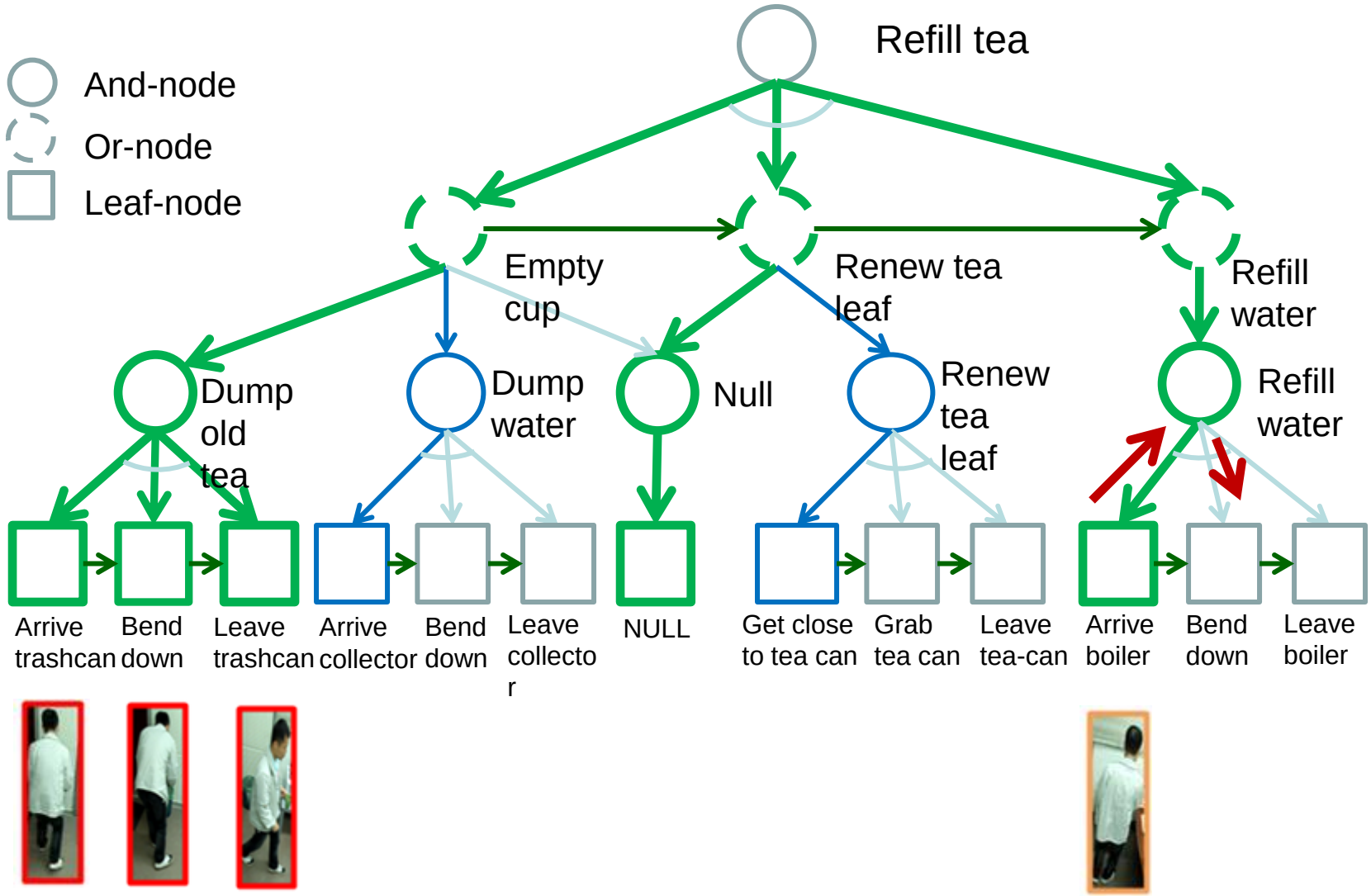
Parsing process (Earley Parser [Earley 1970])



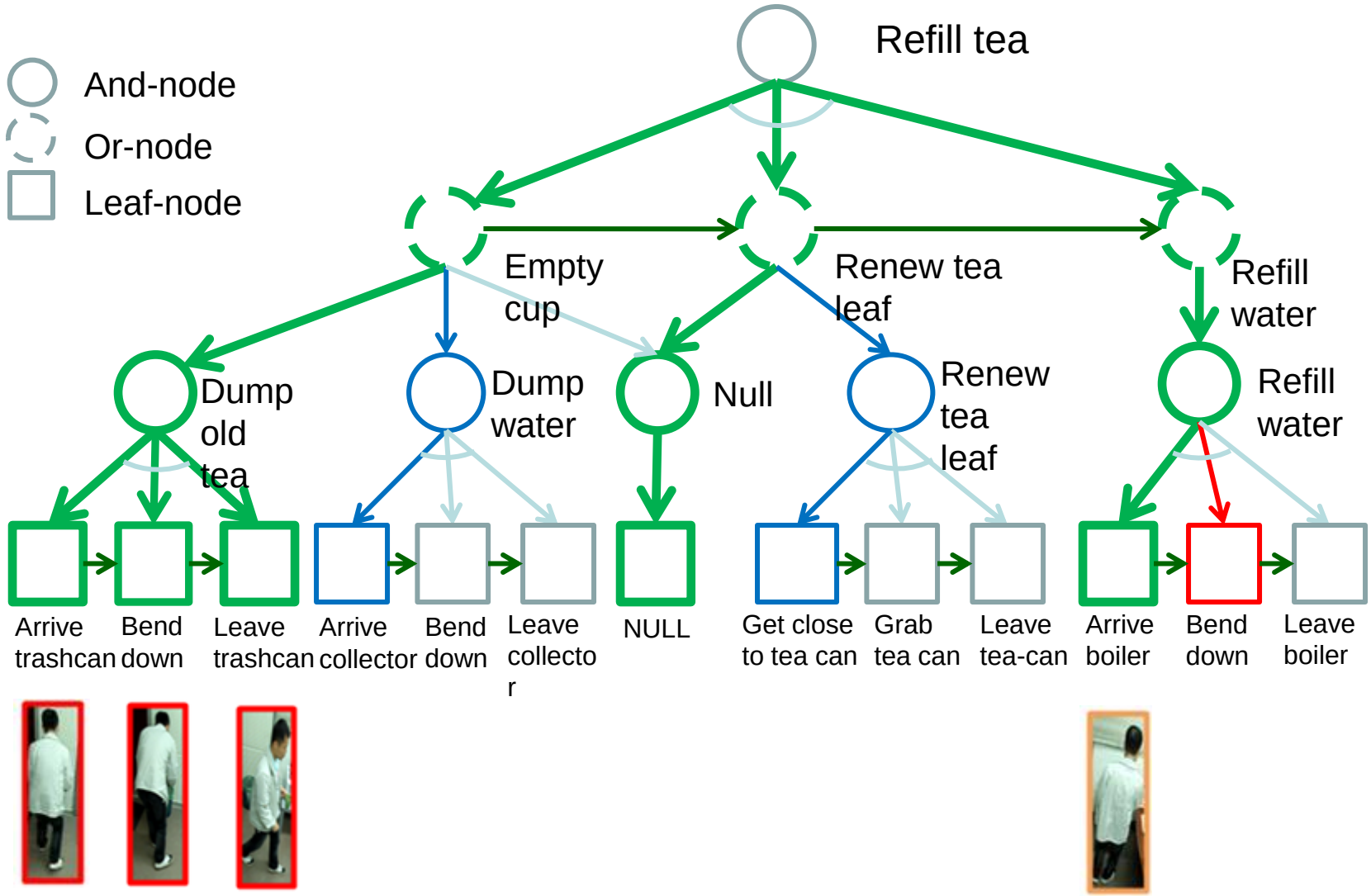
Parsing process (Earley Parser [Earley 1970])



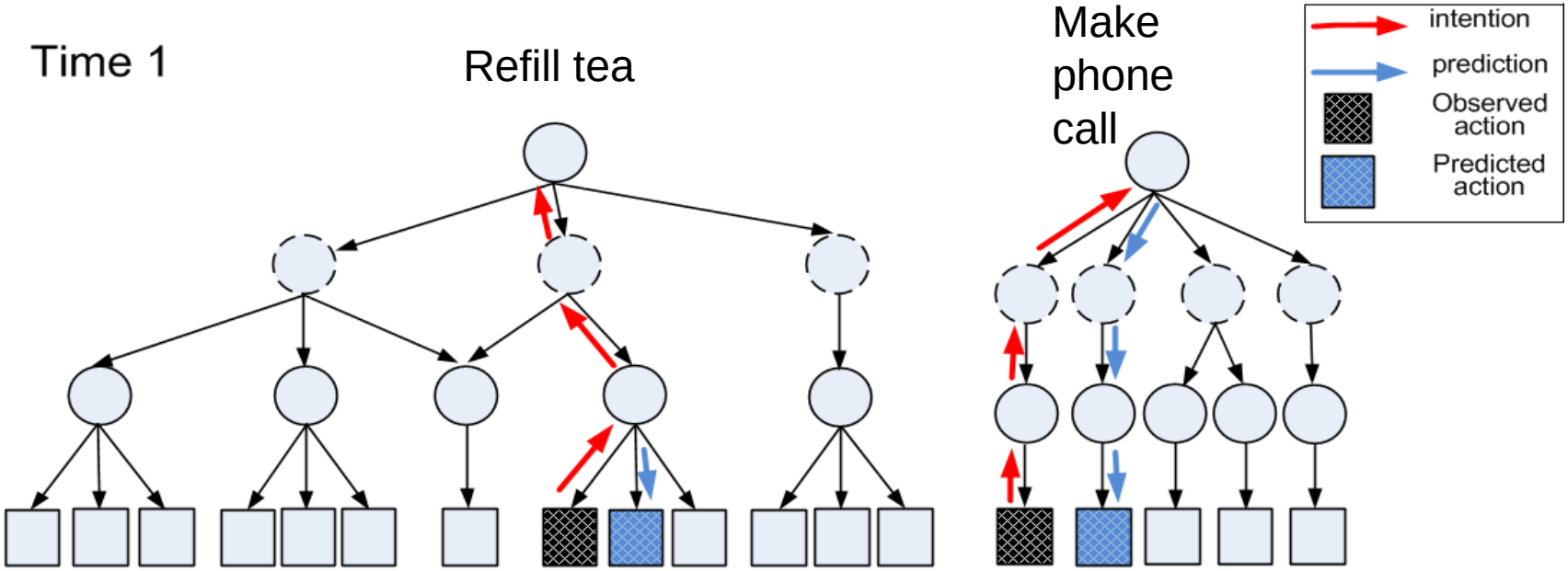
Parsing process (Earley Parser [Earley 1970])



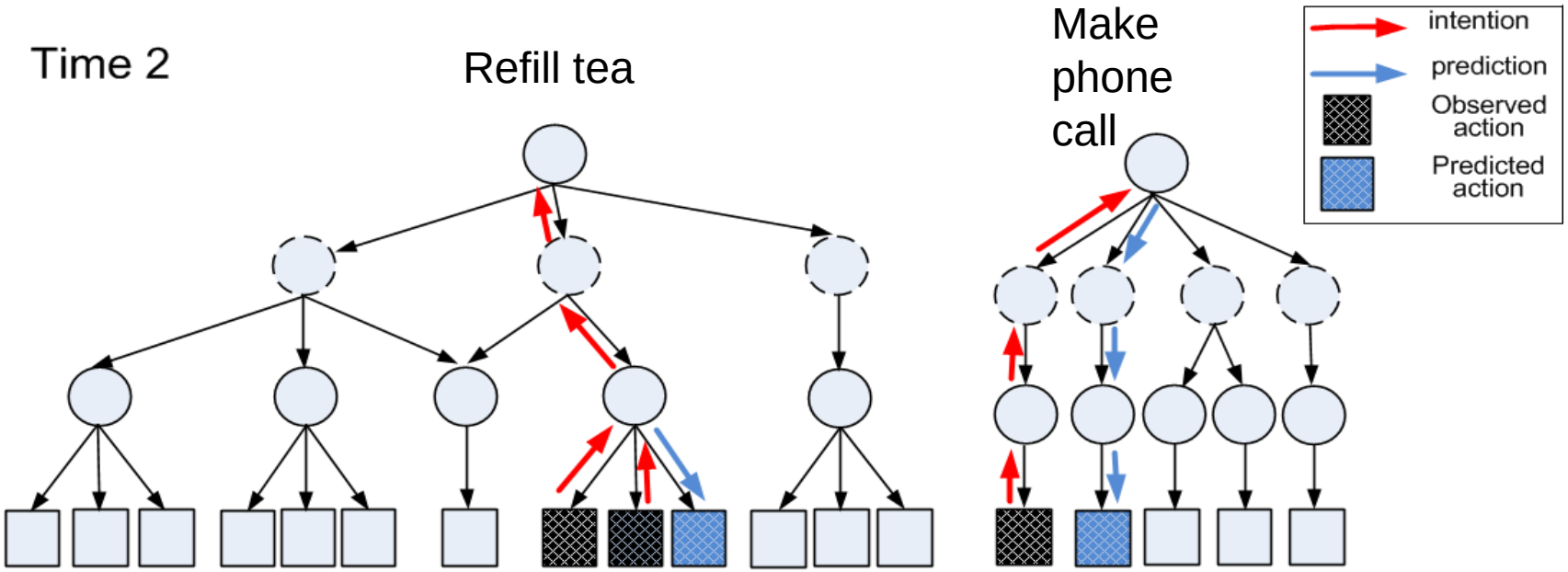
Parsing process (Earley Parser [Earley 1970])

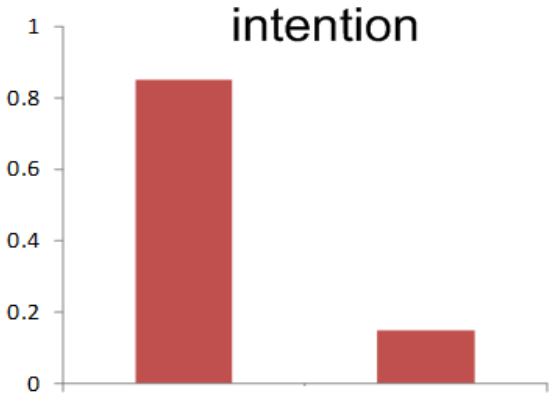


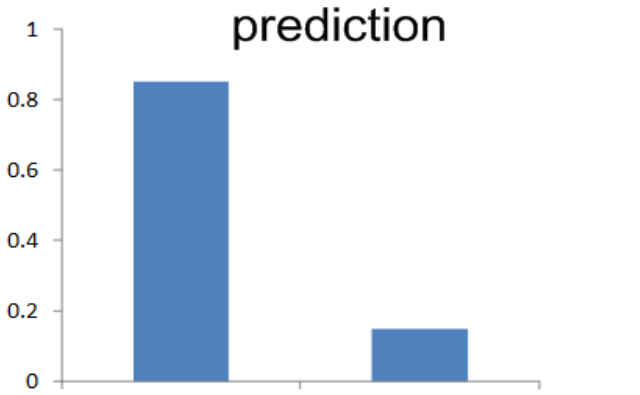
Intention and prediction



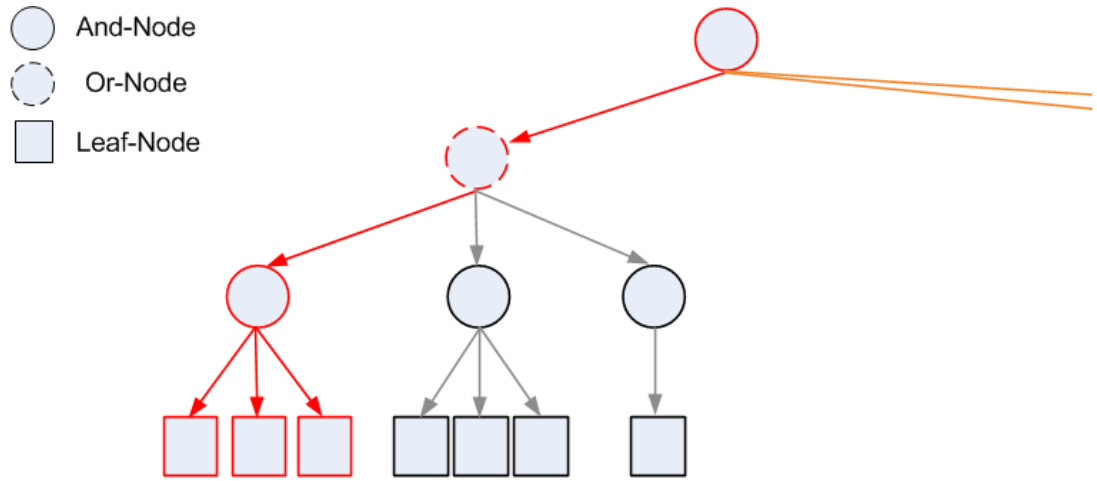
Intention and prediction







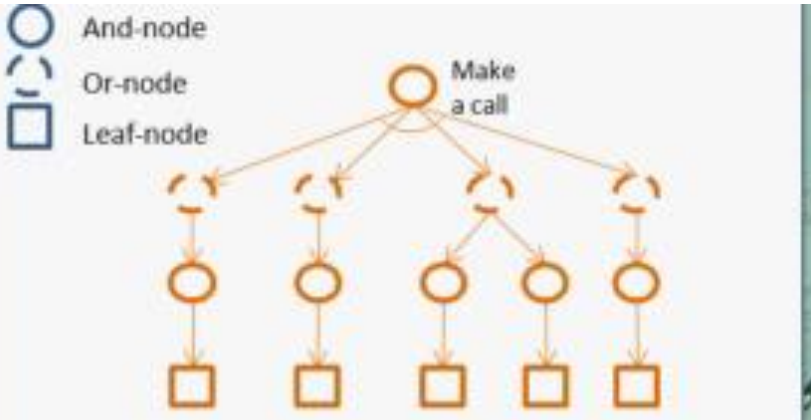
Handle event interruption

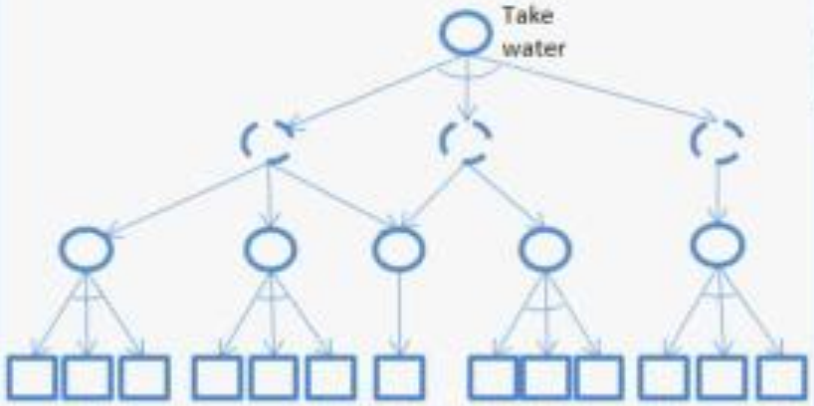


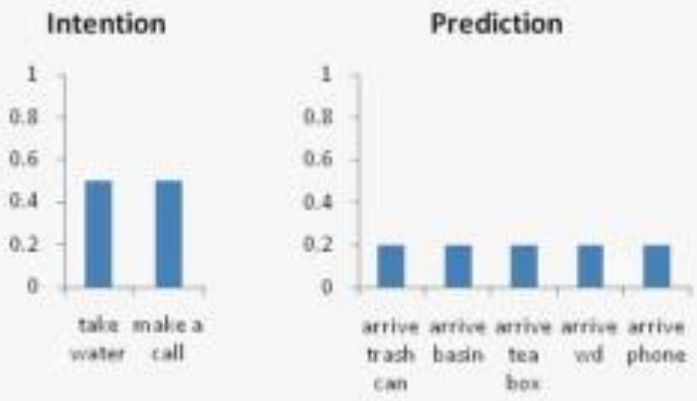
First Partial parse tree of take water

Parse tree of take a phone

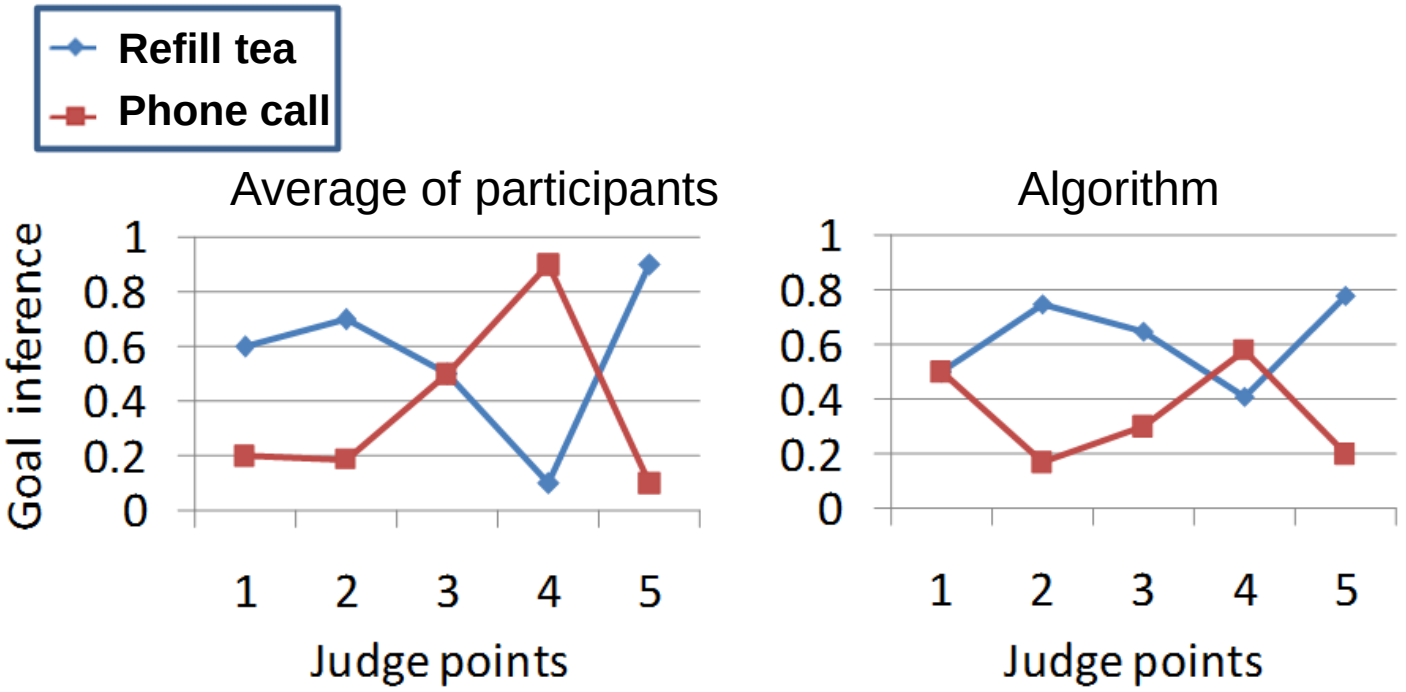
Second Partial parse tree of take water


And-node
Or-node
Leaf-node
Make a call


Take water

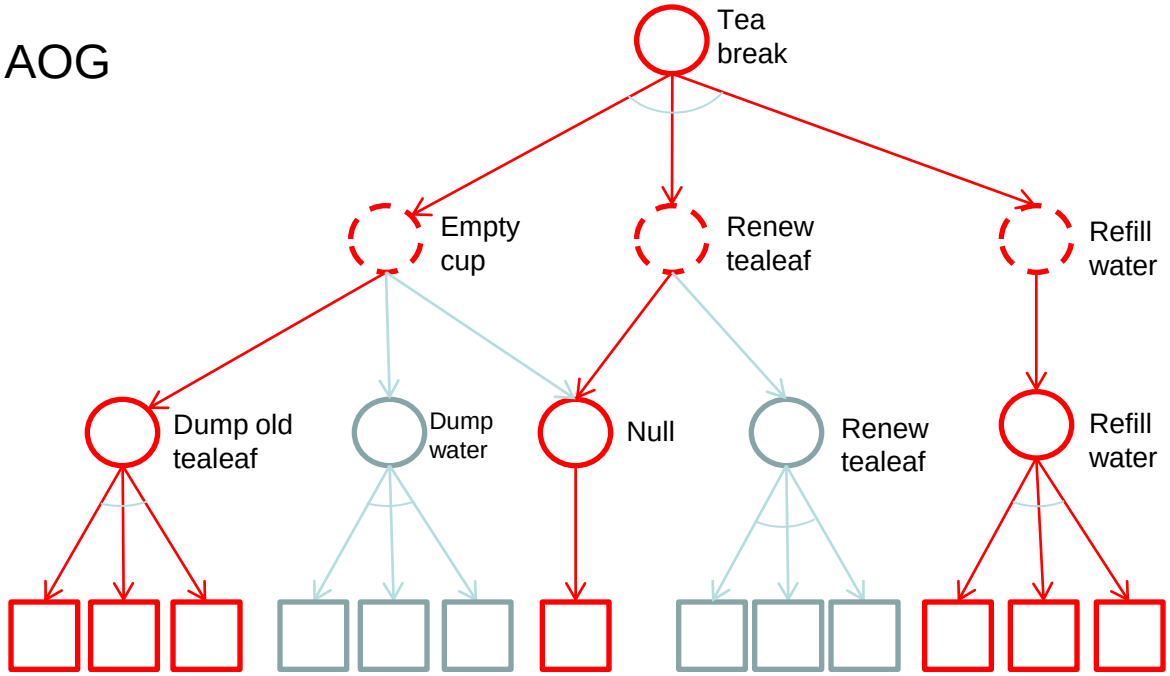

Intention
1
0.8
0.6
0.4
0.2
0
take water
make a call
Prediction
1
0.8
0.6
0.4
0.2
0
arrive trash can
arrive basin
arrive tea box
arrive vd
arrive phone

Comparison with human prediction [Baker, Saxe and Tenenbaum 2009]



Synthesize new events by sampling the AoG

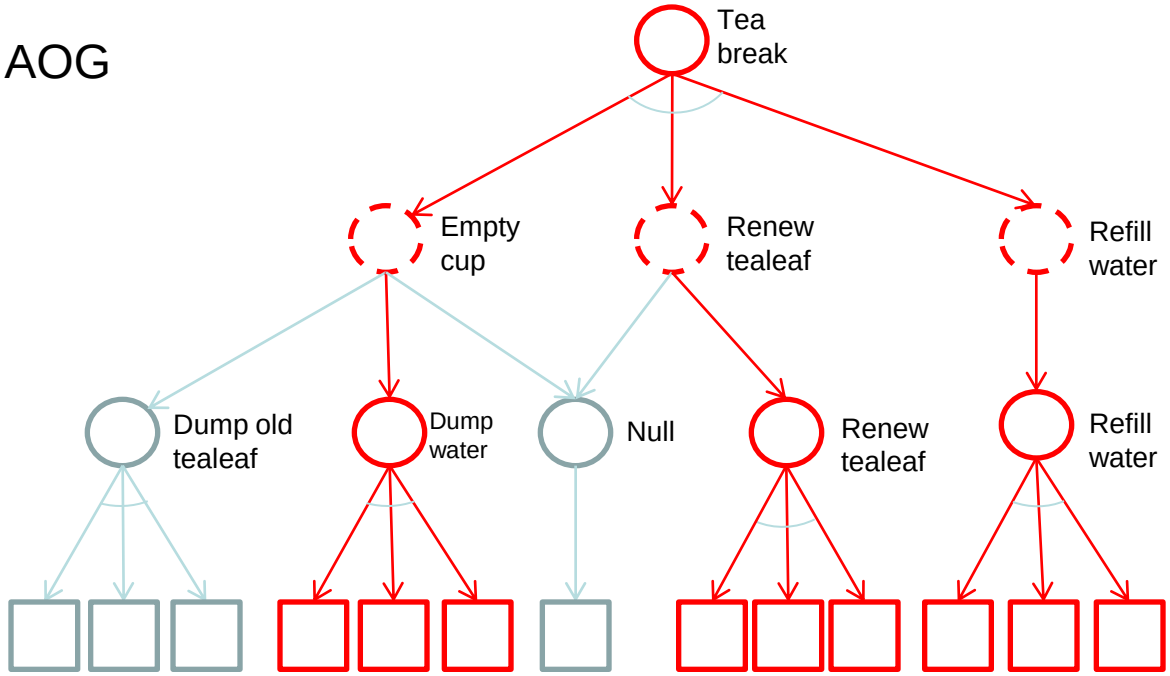
Sample from AOG



Synthesized Event

Event synthesis

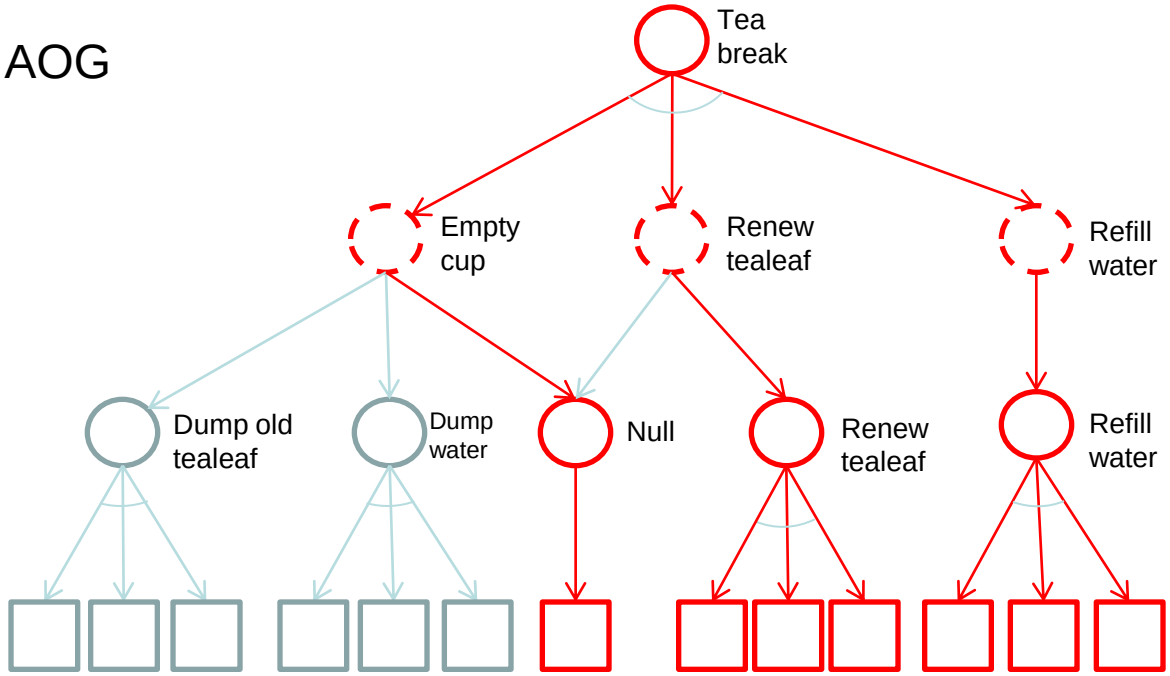
Sample from AOG



Synthesized Event

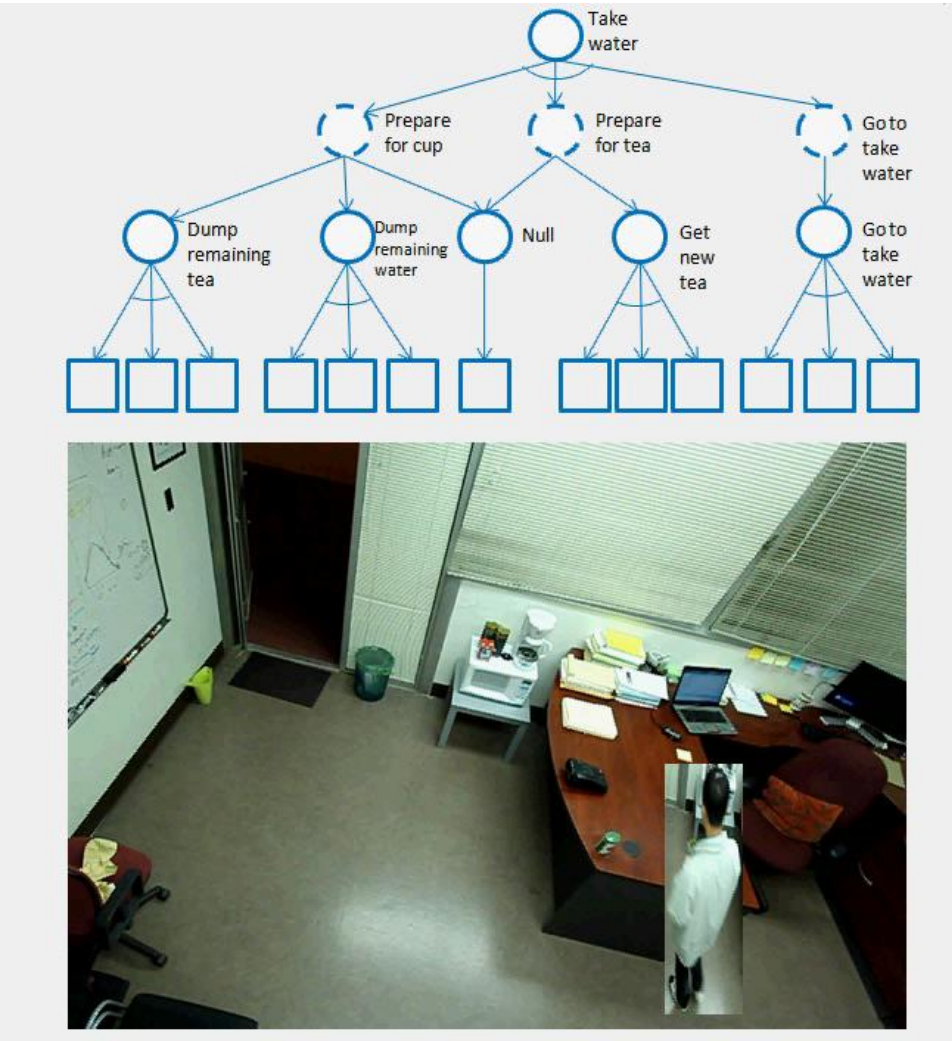
Event synthesis

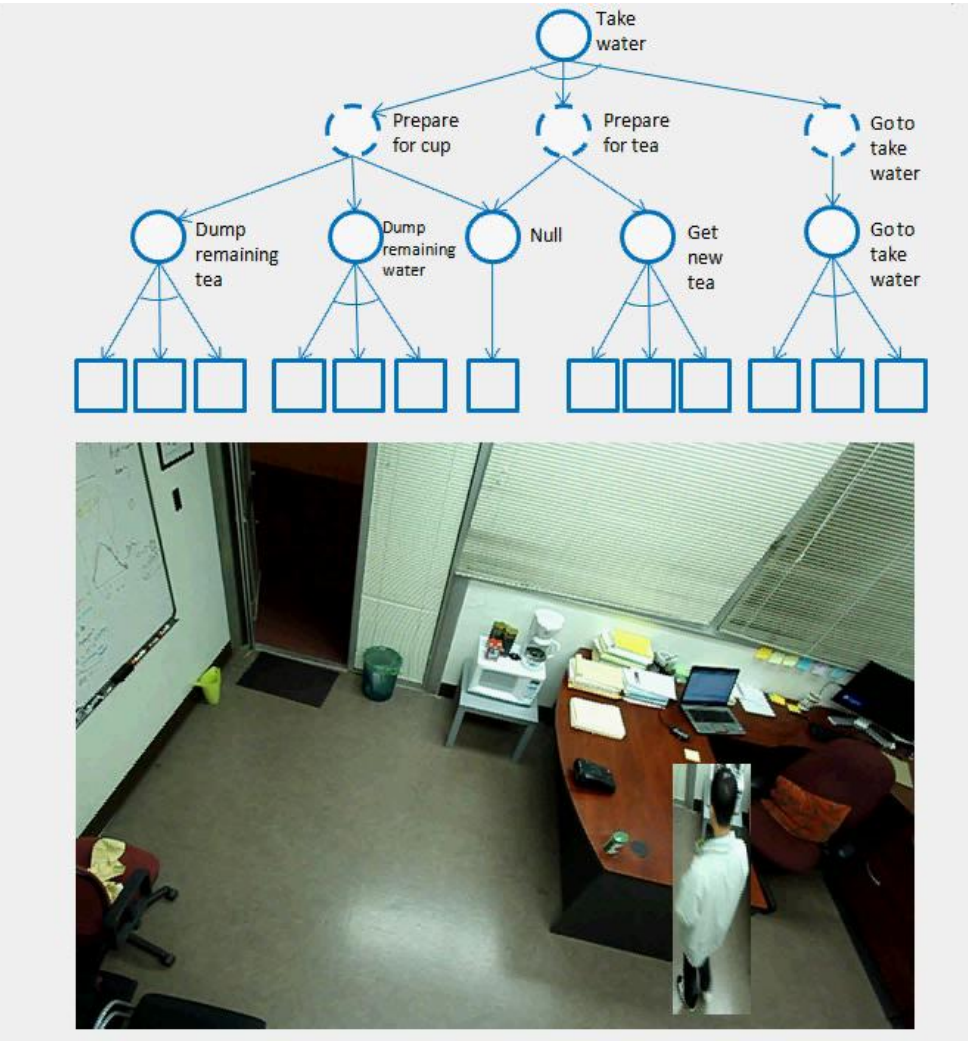
Sample from AOG



Synthesized Event

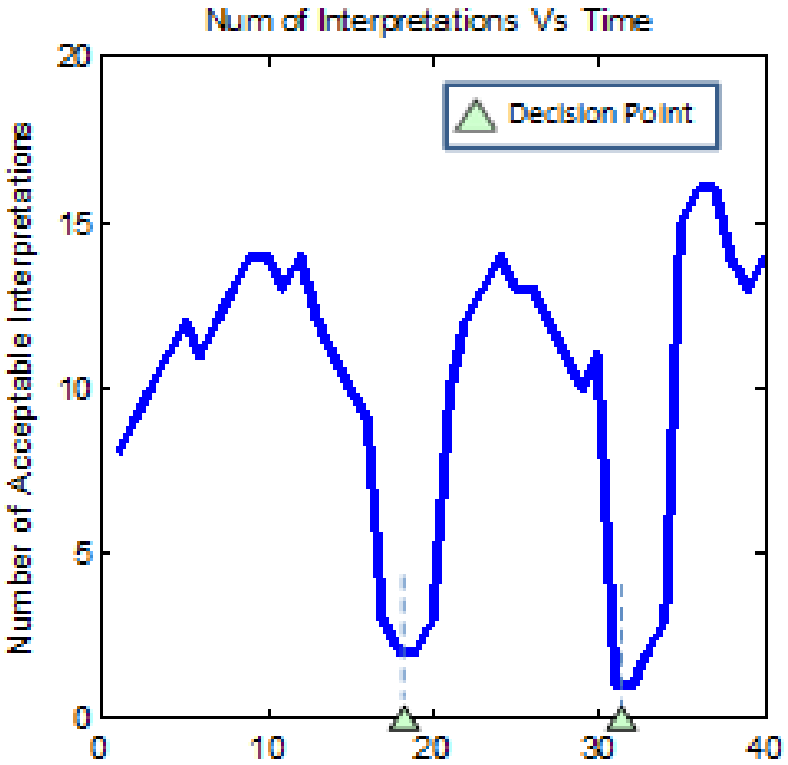
Event synthesize examples*





* We use stored foreground windows and a background frame to synthesize new videos

Computation complexity of parsing



Pickup phone

Reach water boiler

- Initially the number of interpretations above a threshold grows rapidly over time.
- At certain decisive moments, i.e. when informative actions are observed, large number of unlikely interpretation drops below the threshold and hence is pruned.