We have developed a resolution calculus $R_{at}^S$ for CTL.

We have implemented $R_{at}^S$ in a theorem prover called CTL-RP.

We have compared CTL-RP with the only other CTL theorem prover we know of, a CTL module for Tableau Workbench (TWB).

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**Overview**

- The algorithm to detect loop clauses of ERES1 and ERES2 is given below.

```plaintext
1. procedure eflb(T, C, l)
2. S := C is a set of clauses
3. if C is an atomic clause C = $\langle t, \sigma \rangle$ or $C = \neg t$
4. then
5. if l is an A-step clause then
6. for each $(i, j) \in T$ in a global or step clause in $T$
7. else if l is an E-step clause then
8. for each $(i, j) \in T$ in a global, A-step, or E-step clause with the index of in T
9. end if
10. l := $\neg t$
11. end if
12. B := true
13. for each $(i, j) \in C$ do
14. if $C = \neg t$
15. then
16. if b is equivalent to true then
17. return $\langle t, \sigma \rangle$
18. else
19. return $\langle t, \sigma \rangle$
20. end if
21. end if
22. end for
23. end if
24. end if
25. end if
26. end procedure
```

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**Resolution rules of $R_{at}^S$ (1)**

- We emulate all step resolution rules using ordered first-order resolution. For this part of the implementation CTL-RP is using the theorem prover SPASS. For example, an application of SRES2

```plaintext
p \rightarrow E \langle [y, z], x \rangle
q \rightarrow A \langle y, z \rangle
\rightarrow \langle x, \sigma \rangle
\rightarrow \langle \neg q_1, \neg q_2 \rangle
```

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**Comparison to TWB (1)**

<table>
<thead>
<tr>
<th>CTL equivalence</th>
<th>CTL-RP</th>
<th>TWB</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A \Box \neg t$</td>
<td>0.008s</td>
<td>0.005s</td>
</tr>
<tr>
<td>$A \Diamond \neg t$</td>
<td>0.008s</td>
<td>0.004s</td>
</tr>
<tr>
<td>$E \Box \neg t$</td>
<td>0.005s</td>
<td>0.005s</td>
</tr>
<tr>
<td>$A \Box t$</td>
<td>0.004s</td>
<td>0.006s</td>
</tr>
<tr>
<td>$E \Box \neg t$</td>
<td>0.004s</td>
<td>0.006s</td>
</tr>
<tr>
<td>$A \Box t$</td>
<td>0.004s</td>
<td>0.006s</td>
</tr>
<tr>
<td>$E \Box t$</td>
<td>0.009s</td>
<td>0.009s</td>
</tr>
<tr>
<td>$A \Box t$</td>
<td>0.009s</td>
<td>0.009s</td>
</tr>
</tbody>
</table>

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**Comparison to TWB (2)**

1. The first set of benchmark formulae consists of eight well-known equivalences between temporal formulae.
2. The table shows the eight equivalence and the CPU time in seconds required by TWB and CTL-RP to establish the validity of each benchmark formula.
3. The second set of benchmark formulae consists of one hundred formulae such that each formula specifies a randomly generated state transition system plus properties of it.
4. The graph indicates the CPU time in seconds required by TWB and CTL-RP to establish the satisfiability or unsatisfiability of each benchmark formula.