Conflict Resolution in CHR

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Incremental general conflict resolution (I)

Choose rule to be applied among applicable rules. Implementable for arbitrary CHR rules under refined semantics.

Definition (Rule scheme for CHR rule with given property)

Generalised simpagation rule (with property \( P \))

\[ H_1 \setminus H_2 \Leftrightarrow \text{Guard} \mid B : P \]

translates to CHR rules

\[
\begin{align*}
\text{delay } & @ H_1 \land H_2 \Rightarrow \text{Guard} \mid \text{conflictset}([\text{rule}(P,H_1,H_2,B)]) \\
\text{apply } & @ H_1 \setminus H_2 \land \text{apply}(\text{rule}(P,H_1,H_2,B)) \Leftrightarrow B
\end{align*}
\]

- **Constraint conflictset:** collects all applicable rules
- **Rule apply:** executes chosen rule
- **Rule delay:** finds applicable rules
Incremental general conflict resolution (II)

Additional generic rules for rule choice

### Rules to resolve conflict

- **empty-cs** @ conflictset([]) \(\iff\) true

- collect @ conflictset(L1) \(\land\) conflictset(L2) \(\iff\) append(L2,L1,L3) \(\land\) conflictset(L3)

- choose @ fire \(\land\) conflictset(L) \(\iff\) choose(L,R,L1) \(\land\) conflictset(L1) \(\land\) apply(R) \(\land\) fire

### Phase constraint

**fire** should be present (at end of query)

- **Rules** delay, collect **collect applicable rules in** conflictset

- **Constraint** **fire present**: rule choose selects rule **R**
  - Rule **R** applied by rule apply
  - Updated conflictset **without** applied rule added then **fire** is called again
Incremental general conflict resolution (III)

Rule choice depends on the property of the initial rule. Property $P$ could be:

- **bfs**: selects a rule from set to ensure breadth first traversal of rules
- **random**: randomly selects a rule from the conflict set
- **$N$ (a number)**: for weighted rules, selects rule with highest priority
- **$neg(C, G)$**: negation as absence; rule is applied if there are no CHR constraints $C$ for which guard $G$ holds. A rule is written to extract an applicable rule $R$ from the conflict-set $L$, and leaving the rest of the rules in $L_1$. 
Some possible choice rules

**bfs**
@ choose(L,R,L1) <=> L = [rule(bfs,_,_,_)|_]
  | L = [R|L1].

**random**
@ choose(L,R,L1) <=> L = [rule(random,_,_,_)|_]
  | random_select(R,L,L1).

**priority**
@ choose(L,R,L1) <=> L = [rule(N,_,_,_)|_], number(N)
  | sort(L,SL), SL = [R|L1].
Example - Coin flip

Example (CHR with Random choice)

\[ h @ \text{coin} \iff \text{head} : \text{random.} \]
\[ t @ \text{coin} \iff \text{tail} : \text{random.} \]

Example (CHR with Conflict Resolution)

\[ \text{delay-h} @ \text{coin} \implies \text{true} \mid \text{conflictset([rule(random,coin,head)])}. \]
\[ \text{apply-h} @ \text{coin}, \text{apply}(\text{rule(random,coin,head)}) \iff \text{true} \mid \text{head}. \]

\[ \text{delay-t} @ \text{coin} \implies \text{true} \mid \text{conflictset([rule(random,coin,tail)])}. \]
\[ \text{apply-t} @ \text{coin}, \text{apply}(\text{rule(random,coin,tail)}) \iff \text{true} \mid \text{tail}. \]
### Example (Dijkstra - shortest path)

\[dl \ @ \ \text{dist}(X,N) \ \backslash \ \text{dist}(X,M) \iff N<M \ | \ \text{true} : 1.\]

\[dn \ @ \ \text{dist}(X,N), \ \text{edge}(X,Y,M) \implies \ \text{dist}(Y,N+M) : N+2.\]

### Example (CHR with Priority)

\[\text{delay-d1} \ @ \ \text{dist}(X,N), \ \text{dist}(X,M) \implies X<M\]
\[\quad | \ \text{conflictset}([\text{rule}(1,\text{dist}(X,N),\text{dist}(X,M))]).\]

\[\text{apply-d1} \ @ \ \text{dist}(X,N) \ \backslash \ \text{dist}(X,M),\]
\[\quad \text{apply}(\text{rule}(1,\text{dist}(X,N),\text{dist}(X,M))) \implies \text{true}.\]

\[\text{delay-dn} \ @ \ \text{dist}(X,N), \ \text{edge}(X,Y,M) \implies \]
\[\quad \text{conflictset}([\text{rule}(N+2,\text{dist}(X,N),\text{edge}(X,Y,M),\text{dist}(Y,N+M))]).\]

\[\text{apply-dn} \ @ \ \text{dist}(X,N), \ \text{edge}(X,Y,M) \ \backslash \ \text{apply}(\text{rule}(E,\text{dist}(X,N),\text{edge}(X,Y,M),\text{dist}(Y,N+M))) \iff \text{dist}(Y,N+M).\]
Choose rule to be applied among applicable rules. Implementable for arbitrary CHR rules under refined semantics.

**Definition (Rule scheme for CHR rule with given property)**

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translates to CHR rules

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\begin{align*}
\text{delay} & @ H_1 \land H_2 \Rightarrow \text{Guard} | \text{conflictset}([\text{rule}(P,H_1,H_2,B)]) \\
\text{apply} & @ H_1 \setminus H_2 \land \text{apply} (\text{rule}(P,H_1,H_2,B)) \Leftrightarrow B
\end{align*}
\]

- **Constraint** \text{conflictset}: collects all applicable rules
- **Rule** \text{apply}: executes chosen rule
- **Rule** \text{delay}: finds applicable rules
Negation-as-Absence using Conflict resolution

Definition (Rule scheme for CHR rule with negation)

Generalised simpagation rule (with applies if NH constraints are not present and NG does not hold)

\[ H_1 \setminus H_2 \Leftrightarrow \text{Guard} \mid B : \text{neg}(NH,NG) \]

translates to CHR rules

\[ \text{delay} \ @ \ H_1 \land H_2 \Rightarrow \text{Guard} \]
\[ \quad \mid \text{conflictset([rule(neg(NH,NG),H_1,H_2,B)])} \]
\[ \text{apply} \ @ \ H_1 \setminus H_2 \land \text{apply(rule(neg(NH,NG),H_1,H_2,B))} \Leftrightarrow B \]
\[ \text{remove} \ @ \ NH \setminus \text{choose([rule(neg(_,_),H_1,H_2,B)|L],R,L_1)} \]
\[ \Leftrightarrow \text{NG} \mid \text{choose(L,R,L_1)} \]

- Same delay and apply rules as previous
- Additional remove rule, that deletes the negated rule from the conflict-set if NH is present and NG holds
Example (CHR with Negation)

\[ \text{person}(X) \implies \text{single}(X) : \neg(\text{married}(X), \text{true}) \].

Example (CHR with Conflict Resolution)

\[ \text{delay @} \text{person}(A) \implies \text{conflictset}([\text{rule}(\neg(\text{married}(A), \text{true}), \text{person}(A), \text{single}(A))]). \]

\[ \text{apply @} \text{person}(A) \setminus \text{apply}(\text{rule}(\neg(\text{married}(A), \text{true}), \text{person}(A), \text{single}(A))) \iff \text{single}(A). \]

\[ \text{remove @} \text{married}(A) \setminus \text{choose}([\text{rule}(\neg(\_, \_), \text{person}(A), \text{single}(A)) | P, Q, R]) \iff \text{choose}(P, Q, R). \]