On Model Recovery

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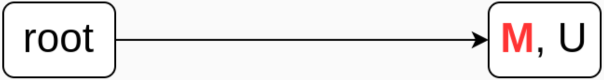
Motivation

- Edge upgrades may break the model,
- Goal: recover the model property with as little disturbance as possible,
- Preserve an invariant – **pre canonicity**.

Pre Canonicity

1. Required neighbors must be maximal to the root's type.
2. Fixing the edges, there are no smaller models (w.r.t. concept membership) sharing the same domain.

Pre canonicity



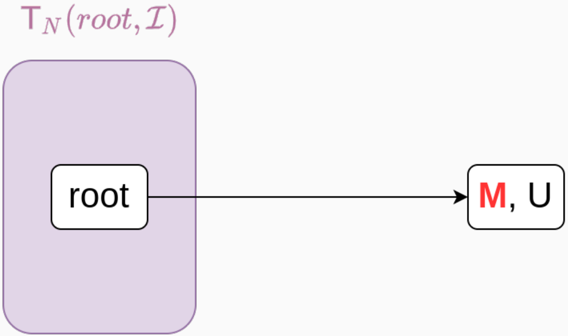
iff

$$\mathcal{T}^{\mathcal{D}} \models \mathsf{T}_N(root, \mathcal{I}) \sqsubseteq \exists r. \lceil M \rceil$$

and ***M*** is maximal.

Pre canonicity

(2) Fixing the edges, there are no smaller models (w.r.t. concept membership) sharing the same domain.

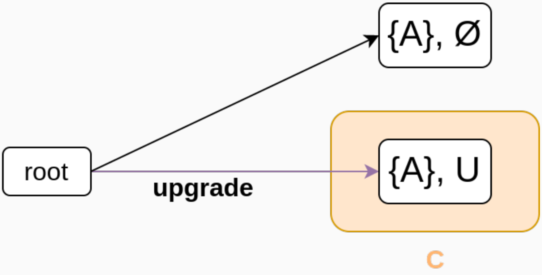


There is no way of taking out elements of the type of the root without either (i) breaking the model property or (ii) losing condition 1.

Extra condition – Building from the upgraded interpretation

- We must also ensure that the recovered model is not arbitrary, i.e., that it is a recovery over the original upgraded interpretation.
- This means that membership and edges should be preserved when possible . . .
- . . . and all edges that move should move to concepts of the same typicality (e.g., moving $(M, \mathcal{U})$ to $(N, \mathcal{U})$).

Example 1



$$C \sqsubseteq \forall r^{-} . D$$

$$D \sqsubseteq \forall r . E$$

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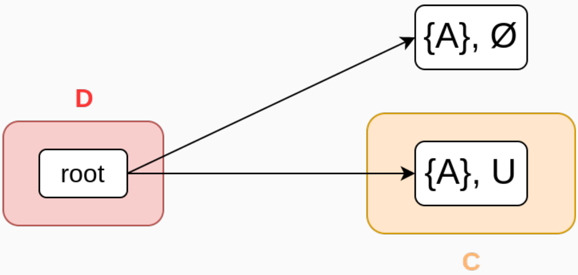

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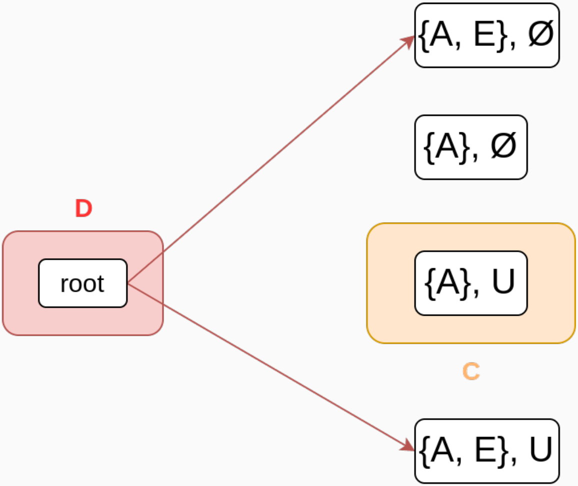

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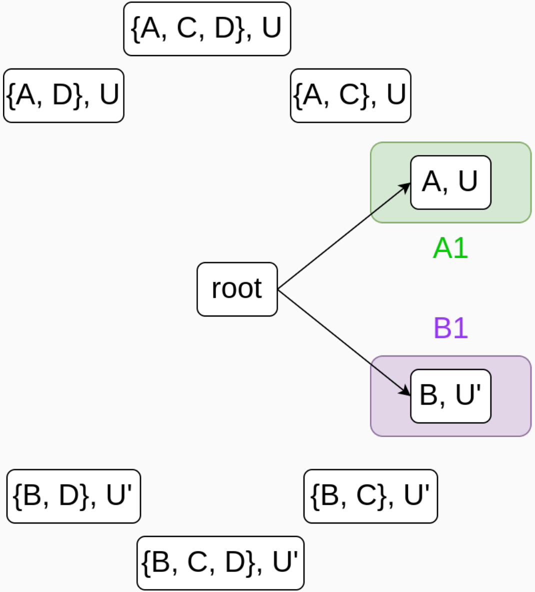
Example 2 – Multiple Recoveries

- The *root* belonging to D is a kind of *artifact* from the upgrade procedure.
- It was required because the *root* was connected to $(\{A\},\mathcal{U}) \in C$, but this edge was later erased.
- This cannot be avoided – taking D out out hurt maximality w.r.t. neighbors. Further downgrading the edge would take us back to the initial situation.

Example 2



$A1 \sqsubseteq \forall r^{-}.\, A2$
$A2 \sqsubseteq \forall r.\, C$

$B1 \sqsubseteq \forall r^{-}.\, B2$
$B2 \sqsubseteq \forall r.\, D$

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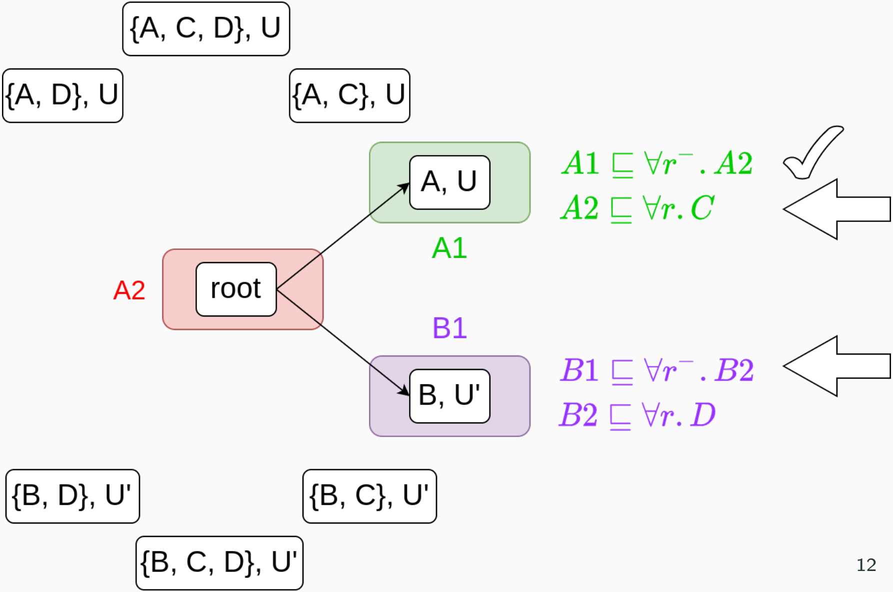
{A, C, D}, U
{A, D}, U
{A, C}, U
A, U
A1
A2
root
B1
B, U'
{B, D}, U'
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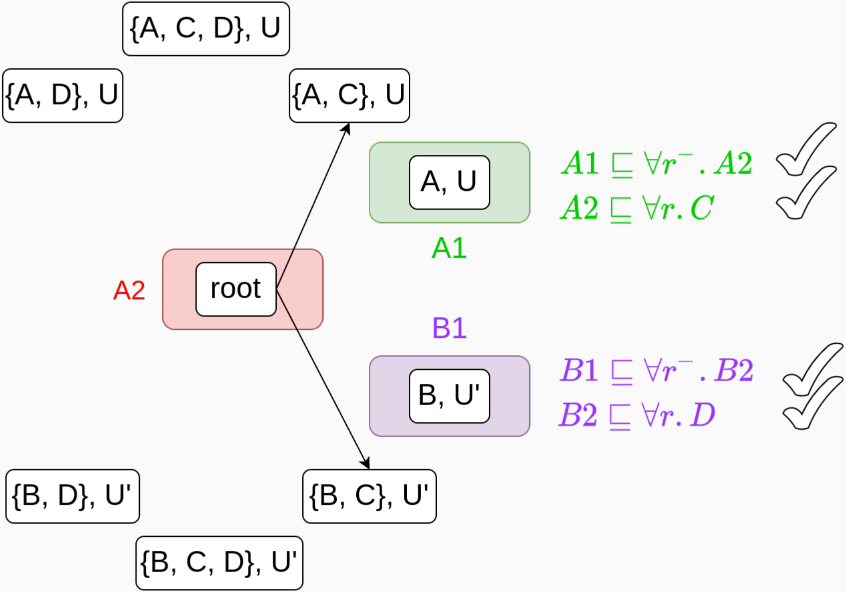
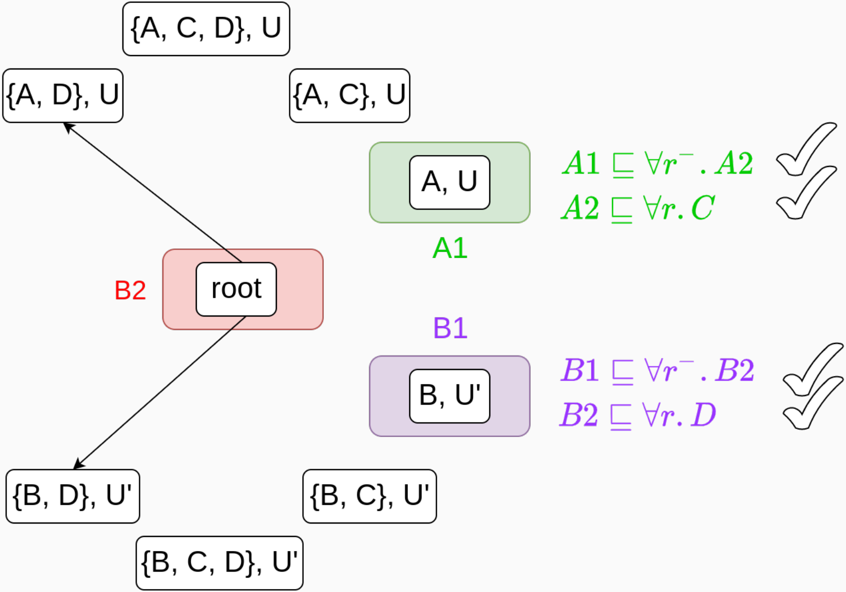
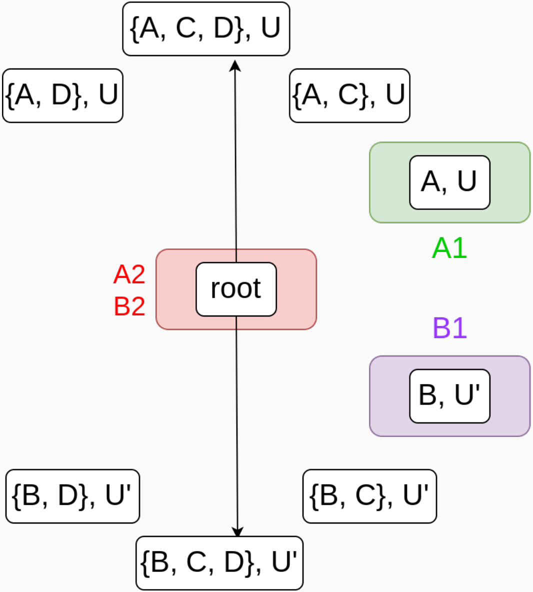
Example 2 – Solution 1



Example 2 – Solution 2



Example 2 – Solution 3



$A1 \sqsubseteq \forall r^{-}.\, A2$ ✓

$A2 \sqsubseteq \forall r.\, C$ ✓

$B1 \sqsubseteq \forall r^{-}.\, B2$ ✓

$B2 \sqsubseteq \forall r.\, D$ ✓

Comments on Example 2

- Procedurally, recovering the model property is applying several **conflict resolution rules** to address **violations**.
- Solving one violation can dissolve others indirectly (by taking away edges that caused them).
- Essentially, the order in which one apply the conflict resolution rules may affect the outcome, and there is no way to circumvent this.

Two ways of capturing this idea

- A **semantic approach** captures how the models look like.
- A **procedural approach** captures a (non-deterministic) procedure to get from $\mathcal{I}$ to some $\mathcal{J}$.

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    - We only deal with the level of typicality of neighbors during the upgrade step, not during the recovery.
4. It should be the (one of the) smallest model(s) to satisfy the properties.
    - This should prevent spurious, non-necessary membership.

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Formally we say...

$$\mathcal{J} \models \mathcal{K}$$

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Formally we say...

$$t_{N_{\mathcal{K}}}(e, \mathcal{I}) \subseteq t_{N_{\mathcal{K}}}(e, \mathcal{J}) \text{for every } e \in \Delta^{\mathcal{I}}$$

Additionally, we may postulate that the change needs to be kept within the **dependency set** of the root (i.e., whatever element outside of this set must remain the same).

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If $\mathcal{T}^{\mathcal{D}} \models \lceil t_{N_{\mathcal{K}}}(M_{\mathcal{U}}, \mathcal{J}) \rceil \sqcap \widehat{\mathcal{U}} \sqsubseteq \exists r. \lceil N \rceil$ for a maximal N, then

(a) $(M_{\mathcal{U}}, N_{\mathcal{U}'}) \in r^{\mathcal{J}}$ $\forall N_{\mathcal{U}'} s.t.$ $\exists N' \subseteq N.(M_{\mathcal{U}}, N'_{\mathcal{U}'}) \in r^{\mathcal{I}}$, and

(b) $(M_{\mathcal{U}}, N_{\emptyset}) \in r^{\mathcal{J}}$

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Formally we say...

If $(M_{\mathcal{U}}, N_{\mathcal{U}'}) \in r^{\mathcal{I}}$, then

$\mathcal{T}^{\mathcal{D}} \models t_{N_{\mathcal{K}}}(M_{\mathcal{U}}, \mathcal{J}) \sqcap \widehat{\mathcal{U}} \sqsubseteq \exists r.\lceil N \rceil$ for a maximal M, and

$\exists N' \sqsubseteq N$ *s.t.* $(M_{\mathcal{U}}, N'_{\mathcal{U}'}) \in r^{\mathcal{I}}$ or

$\mathcal{U}' = \emptyset$

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$$
\begin{aligned}
\nexists \mathcal{J}' = (\Delta^{\mathcal{I}}, \cdot^{\mathcal{I}}) \ \mathit{s.t.} \\
r^{\mathcal{J}'} = r^{\mathcal{J}} \text{ and} \\
\forall e \in \Delta^{\mathcal{I}}. t_{N_{\mathcal{K}}}(e, \mathcal{J}') \subseteq t_{N_{\mathcal{K}}}(e, \mathcal{J})
\end{aligned}
$$

The procedural approach – Intuition

A set of rules to deal with *violations*. Those violations are not only axiom violations, but also deal with interpretations that do not conform to the properties outlined in the semantic approach.

$\mathcal{J}$ is an *improvement over* $\mathcal{I}$ iff it is generated by applying one of the rules to $\mathcal{I}$.

A series $\mathcal{I}_1, \ldots, \mathcal{I}_k$ fixes $\mathcal{I}_1$ iff $\mathcal{I}^i$ is an improvement over $\mathcal{I}^{i+1}$ and $\mathcal{I}^k$ contains no violation.