1. Kinship Axioms (Partitioned)

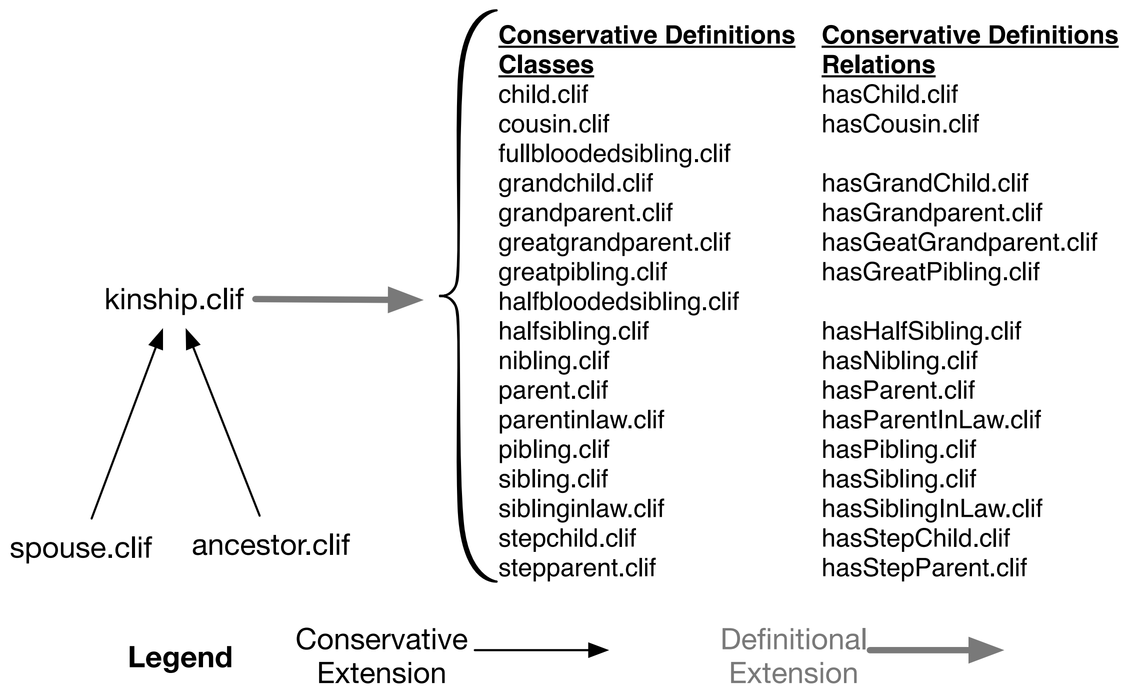

Figure 1.1: Hierarchy organization in COLORE.

1.1 $T_{ancestor}$ (ancestor.clif)

(**ANC-1**) The ancestorOf(x,y) relation is a relation over persons.

$$(\forall x \forall y\ (ancestorOf(x, y) \supset (person(x) \land person(y)))).$$

(**ANC-2**) The ancestorOf(x,y) relation is irreflexive.

$$(\forall x\ (\neg ancestorOf(x, x))).$$

(**ANC-3**) The $ancestorOf(x, y)$ relation is transitive.

$$(\forall x \forall y \forall z((ancestorOf(x, y) \wedge ancestorOf(y, z)) \supset ancestorOf(x, z))).$$

(**ANC-4**) The $ancestorOf(x, y)$ relation is asymmetric.

$$(\forall x \forall y\ (ancestorOf(x, y) \supset \neg ancestorOf(y, x))).$$

(**ANC-5**) $ancestorOf(x, y)$ is the inverse of $hasAncestor(y, x)$.

$$(\forall x \forall y(ancestorOf(x, y) \equiv hasAncestor(y, x))).$$

(**ANC-6**) The $ancestorOf(x, y)$ relation is a discrete ordering, so every ancestor has an ancestor in the ordering.

$$\begin{aligned}(\forall x \forall y((ancestorOf(x, y) \supset (\exists z(&ancestorOf(x, z) \wedge \\ &(ancestorOf(z, y) \vee (y = z)) \wedge \\ &\neg(\exists w((ancestorOf(x, w) \wedge \\ &ancestorOf(w, z))))))))).\end{aligned}$$

(**ANC-7**) The $ancestorOf(x, y)$ relation is a discrete ordering, so every activity has a descendant in the ordering.

$$\begin{aligned}(\forall x \forall y((ancestorOf(x, y) \supset (\exists z(&ancestorOf(x, z) \wedge \\ &(ancestorOf(z, y) \vee (y = z)) \wedge \\ &\neg(\exists w((ancestorOf(z, w) \wedge \\ &ancestorOf(w, y))))))))).\end{aligned}$$

(**ANC-8**) Prevent someone from being an ancestor in two different ways.

$$\begin{aligned}(\forall x \forall y \forall z \forall u\ ((&ancestorOf(u, y) \wedge ancestorOf(z, y) \wedge \\ &ancestorOf(x, u) \wedge ancestorOf(x, z)) \supset \\ &(ancestorOf(u, z) \vee ancestorOf(z, u) \vee (z = u))))\end{aligned}$$

1.2 T_{spouse} (spouse.clif)

(**S-1**) A spouse is a person.

$$(\forall x(spouse(x) \supset\ person(x))).$$

(**S-2**) The $hasSpouse(x, y)$ relation is between two people.

$$(\forall x \forall y(hasSpouse(x, y) \supset\ (person(x) \wedge person(y) \wedge (x \neq y)))).$$

(**S-3**) A person has at most one spouse.

$$(\forall x \forall y \forall z((hasSpouse(x, y) \land hasSpouse(x, z)) \supset (y = z))).$$

(**S-4**) The $hasSpouse(x, y)$ relation is symmetric.

$$(\forall x \forall y(hasSpouse(x, y) \supset hasSpouse(y, x))).$$

(**S-5**) A person cannot be a spouse of themselves.

$$(\forall x(\neg hasSpouse(x, x))).$$

1.3 $T_{kinship}$ (kinship.clif)

Imports:

- `cl-imports ancestor.clif`
- `cl-imports spouse.clif`
- `cl-imports definitions/hasChild.clif`

Residue Axioms:

(**RES-1**) Prevent ancestors from being related (up to third cousins). Eliminates the British Royal Family.

$$(\forall x \forall y \forall z ((hasSpouse(x, y) \land ancestorOf(z, x)) \supset \neg ancestorOf(z, y))).$$

(**RES-2**) Prevent ancestors from being spouses.

$$(\forall x \forall y \forall z ((hasSpouse(x, y) \land ancestorOf(z, x)) \supset (z \neq y))).$$

1.4 $T_{related}$ (related.clif)

Imports:

- `cl-imports kinship.clif`

(**REL-1**) The related(x,y) relation is irreflexive.

$$\forall x \, \neg related(x, x)$$

(**REL-2**) The related(x,y) relation is transitive.

$$\forall x \forall y \forall z \; related(x, y) \land related(y, z) \supset related(x, z)$$

(**REL-3**) If two people are related and there is no one in-between them, then they are the parent of one another, or the spouse of one another.

$$\forall x \forall y \; (related(x, y) \land \neg(\exists z \; related(x, z) \land related(z, y))) \supset hasChild(x, y) \lor hasChild(y, x) \lor hasSpouse(x, y)$$

1.5 T_{lemmas} (lemmas.clif)

(**LEM-1**) If someone is the child of two people, they must not be descended from a common ancestor.

$$(\forall x \forall y \forall z\ ((hasChild(y, x) \wedge hasChild(z, x) \wedge (y \neq z)) \supset \neg(\exists u(ancestorOf(u, y) \wedge ancestorOf(u, z))))).$$

1.6 Conservative Definition Modules

Imports (for all modules):

- `cl-imports kinship.clif`

1.6.1 hasChild

(Covering Axiom) If someone has a child, the parent is the ancestor of the child and there does not exist a person in-between them.

$$(\forall x \forall y(hasChild(x, y) \equiv (ancestorOf(x, y) \wedge \neg(\exists z(ancestorOf(x, z) \wedge ancestorOf(z, y)))))).$$

1.6.2 Child (T_{child})

A child is a person who has at least one parent.

$$(\forall x(child(x) \equiv\ (\exists y(hasChild(y, x) \wedge (x \neq y))))).$$

1.6.3 Parent

A parent is a person who has a child.

$$(\forall x(parent(x) \equiv\ (\exists c(person(c) \wedge hasChild(x, c) \wedge (x \neq c))))).$$

1.6.4 Sibling (Brother, Sister)

A sibling is a person who has a *same* parent of another person.

$$(\forall x(sibling(x) \equiv (\exists y \exists z(person(x) \wedge hasChild(z, y) \wedge hasChild(z, x) \wedge (x \neq y) \wedge (x \neq z) \wedge (y \neq z))))).$$

For children who have the same parent, they are siblings.

$$(\forall x \forall y(hasSibling(x, y) \equiv (\exists z(hasChild(z, x) \wedge hasChild(z, y) \wedge (x \neq y))))).$$

1.6.5 Grandparent (Grandfather, Grandmother)

A grandparent is a person who is the parent of a parent.

$$(\forall x(grandparent(x) \equiv (\exists y \exists z(hasChild(x, y) \wedge hasChild(y, z) \wedge (x \neq y) \wedge (y \neq z) \wedge (x \neq z))))).$$

A person has a grandparent if their parent has a parent.

$$(\forall x \forall z(hasGrandparent(z, x) \equiv (\exists y(hasChild(x, y) \wedge hasChild(y, z) \wedge (x \neq y) \wedge (x \neq z) \wedge (y \neq z))))).$$

1.6.6 Grandchild (Grandson, Granddaughter)

The child of a child is a grandchild.

$$(\forall x(grandchild(x) \equiv (\exists y \exists z(hasChild(z, y) \wedge hasChild(y, x) \wedge (x \neq y) \wedge (y \neq z) \wedge (x \neq z))))).$$

A person has a grandchild if their child has a child.

$$(\forall x \forall z(hasGrandchild(x, z) \equiv (\exists y(hasChild(x, y) \wedge hasChild(y, z) \wedge (x \neq y) \wedge (x \neq z) \wedge (y \neq z))))).$$

1.6.7 Great-Grandparent (Great-Grandfather, Great-Grandmother)

A great-grandparent is a parent of a parent of a parent.

$$(\forall x(greatgrandparent(x) \equiv (\exists w \exists y \exists z(hasChild(x, w) \wedge hasChild(w, y) \wedge hasChild(y, z) \wedge (w \neq x) \wedge (w \neq y) \wedge (w \neq z) \wedge (x \neq y) \wedge (y \neq z) \wedge (x \neq z))))).$$

A person has a great-grandparent if they have a parent who has a parent who has a parent.

$$(\forall z \forall w(hasGreatGrandparent(z, w) \equiv (\exists x \exists y(hasChild(w, x) \wedge hasChild(x, y) \wedge hasChild(y, z) \wedge (w \neq x) \wedge (w \neq y) \wedge (w \neq z) \wedge (x \neq y) \wedge (x \neq z) \wedge (y \neq z))))).$$

Also logically equivalent:

$$(\forall z \forall w(hasGreatGrandparent(z, w) \equiv (\exists x(hasGrandparent(z, x) \wedge hasParent(x, w) \wedge (z \neq x) \wedge (z \neq w) \wedge (x \neq w))))).$$

1.6.8 Cousin

The child of the sibling of a person's parent is their cousin.

$$(\forall x(cousin(x) \equiv (\exists k \exists w \exists z \exists y(hasChild(k, z) \wedge hasChild(k, w) \wedge hasChild(z, x) \wedge hasChild(w, y) \wedge (k \neq z) \wedge (k \neq w) \wedge (k \neq x) \wedge (k \neq y) \wedge (z \neq w) \wedge (z \neq x) \wedge (z \neq y) \wedge (w \neq x) \wedge (w \neq y) \wedge (x \neq y))))).$$

A person has a cousin if their parent's sibling has a child.

$$(\forall x \forall y(hasCousin(x, y) \equiv (\exists k \exists w \exists z(hasChild(k, z) \wedge hasChild(k, w) \wedge hasChild(z, x) \wedge hasChild(w, y) \wedge (k \neq z) \wedge (k \neq w) \wedge (k \neq x) \wedge (k \neq y) \wedge (z \neq w) \wedge (z \neq x) \wedge (z \neq y) \wedge (w \neq x) \wedge (w \neq y) \wedge (x \neq y))))).$$

1.6.9 Pibling (Aunt, Uncle)

A sibling of a parent is a person's pibling (aunt or uncle).

$$(\forall x(pibling(x) \equiv \ (\exists y \exists z \exists w(hasSibling(x, y) \wedge hasChild(y, z))))).$$

A person has a pibling (aunt/uncle) if their parent has a sibling.

$$(\forall x \forall z(hasPibling(x, z) \equiv (\exists y(hasParent(x, y) \wedge hasSibling(y, z))))).$$

1.6.10 Great-Pibling (Great-Aunt, Great-Uncle)

A sibling of someone's grandparent is their great-pibling (great-aunt or great-uncle).

$$(\forall x(greatpibling(x) \equiv (\exists w \exists y \exists z(hasChild(w, y) \wedge hasChild(y, z) \wedge hasSibling(w, x))))).$$

A person has a great-pibling (great-aunt or great-uncle) if their grandparent has a sibling.

$$(\forall x \forall w(hasGreatPibling(x, w) \equiv (\exists z(hasGrandparent(x, z) \wedge hasSibling(z, w))))).$$

1.6.11 Nibling (Nephew, Niece)

A nibling is the child of someone's sibling. Nibling is the gender-neutral term in place of niece or nephew.

$$(\forall x(nibling(x) \equiv \ (\exists y \exists z(hasChild(y, x) \wedge hasSibling(y, z))))).$$

The child of one person's sibling is their nibling.

$$(\forall x \forall z(hasNibling(x, z) \equiv \ (\exists y(hasSibling(x, y) \wedge hasChild(y, z))))).$$

1.6.12 Parent-in-Law (Father-in-Law, Mother-in-Law)

The parent of a person's spouse is their parent-in-law.

$$(\forall x(parentinlaw(x) \equiv (\exists y \exists z(hasSpouse(y, z) \wedge hasParent(z, x) \wedge (y \neq z))))).$$

A person has a parent-in-law if their spouse has a parent.

$$(\forall x \forall z(hasParentInLaw(x, z) \equiv (\exists y(hasSpouse(x, y) \wedge hasParent(y, z) \wedge (x \neq z) \wedge \neg hasParent(x, z))))).$$

1.6.13 Sibling-in-Law (Brother-in-Law, Sister-in-Law)

The sibling of a person's spouse is their sibling-in-law.

$$
\begin{aligned}
(\forall x(siblinginlaw(x) \equiv (\exists y \exists z(&hasSpouse(y,z) \wedge \\
&hasSibling(z,x))))).
\end{aligned}
$$

A person has a sibling-in-law if their spouse has a sibling.

$$
\begin{aligned}
(\forall x \forall z(hasSiblingInLaw(x,z) \equiv (\exists y(&hasSpouse(x,y) \wedge \\
&hasSibling(y,z))))).
\end{aligned}
$$

1.6.14 Half-Sibling (Half-Brother, Half-Sister)

A half-sibling is someone who has a parent who is not the biological parent of their sibling.

$$
\begin{aligned}
(\forall x(halfsibling(x) \equiv (\exists w \exists y \exists z(&hasChild(w,x) \wedge hasChild(y,z) \wedge \\
&\neg hasChild(w,z) \wedge \neg hasChild(y,x) \wedge (x \neq z) \wedge \\
&hasSpouse(w,y) \wedge (w \neq z) \wedge (w \neq y) \wedge \\
&(w \neq x) \wedge (x \neq y))))).
\end{aligned}
$$

A person has a half-sibling if they have a sibling born to one parent, but not both.

$$
\begin{aligned}
(\forall x \forall w(hasHalfSibling(x,w) \equiv (\exists y \exists z(&hasParent(x,y) \wedge \\
&hasParent(x,z) \wedge \\
&hasParent(w,y) \wedge \\
&\neg hasParent(w,z) \wedge \\
&hasSpouse(y,z))))).
\end{aligned}
$$

1.6.15 Step-Child (Step-Son, Step-Daughter)

A step-child is a child born to a person z's spouse, but is not the child of z.

$$
\begin{aligned}
(\forall x(stepchild(x) \equiv (\exists y \exists z(&hasParent(x,y) \wedge hasSpouse(y,z) \wedge \\
&\neg hasParent(x,z))))).
\end{aligned}
$$

A person has a step-child if the child is born to their spouse, but not their own.

$$
\begin{aligned}
(\forall x \forall z(hasStepChild(x,z) \equiv (\exists y(&hasParent(z,y) \wedge \\
&\neg hasParent(z,x) \wedge \\
&hasSpouse(y,x))))).
\end{aligned}
$$

1.6.16 Step-Parent (Step-Father, Step-Daughter)

A step-parent is someone who marries someone else who has a child.

$$
\begin{aligned}
(\forall x(stepparent(x) \equiv (\exists w \exists y \exists z(&hasChild(y,z) \wedge \neg hasSpouse(x,w) \wedge \\
&hasSpouse(x,y) \wedge (w \neq y))))).
\end{aligned}
$$

A person has a step-parent if one of their parents remarries another person (who is not a blood relation).

$$(\forall x \forall z(hasStepParent(x, z) \equiv (\exists y \exists w(hasParent(x, y) \wedge \\ \neg hasParent(x, z) \wedge \\ hasSpouse(y, z))))).$$

1.6.17 Full-Blooded Siblings

Full-blooded siblings have both parents in common.

$$\forall x\ fullBloodedSibling(x) \equiv \exists w \exists y \exists z\ hasParent(x, y) \wedge \\ hasParent(x, z) \wedge hasParent(w, y) \wedge \\ hasParent(w, z) \wedge hasSpouse(y, z) \wedge \\ (x \neq w) \wedge (y \neq z)$$

1.6.18 Half-Blooded Siblings

Half-siblings have one parent in common.

$$\forall x\ halfSibling(x) \equiv \exists w \exists y \exists z\ hasParent(x, y) \wedge \\ hasParent(x, z) \wedge hasParent(w, y) \wedge \\ hasSpouse(y, z) \wedge (x \neq w) \wedge (y \neq z)$$

1.7 Entailed Axioms

1.7.1 Spouse

(**S-ENT-1**) The $hasSpouse(x, y)$ relation is disjoint with $hasChild(x, y)$.

$$(\forall x \forall y(hasSpouse(x, y) \supset \neg hasChild(x, y))).$$

1.7.2 Child

(**C-ENT-1**) A child is a person.

$$(\forall x(child(x) \supset person(x))).$$

(**C-ENT-2**) A child is not the parent of themselves.

$$(\forall x(\neg hasChild(x, x))).$$

(**C-ENT-3**) A parent is not a child of themselves.

$$(\forall x(parent(x) \supset \neg hasChild(x, x))).$$

(**C-ENT-4**) The $hasChild(x, y)$ relation between two different people.

$$(\forall x \forall y(hasChild(x, y) \supset (person(x) \wedge person(y) \wedge (x \neq y)))).$$

(**C-ENT-5**) The $hasChild(x, y)$ relation is not symmetric.

$$(\forall x \forall y(hasChild(x, y) \supset \neg hasChild(y, x))).$$

(**C-ENT-6**) A child cannot be a child of themselves.

$$(\forall x(\neg hasChild(x, x))).$$

(**C-ENT-7**) The $hasChild(x, y)$ relation is not transitive.

$$(\forall x \forall y \forall z((hasChild(x, y) \wedge hasChild(y, z) \wedge (x \neq y) \wedge (x \neq z) \wedge (y \neq z)) \supset \neg hasChild(x, z))).$$

1.7.3 Parent

(**P-ENT-1**) A parent is a person.

$$(\forall x(parent(x) \supset person(x))).$$

(**P-ENT-2**) A parent is a person who has a child.

$$(\forall x(parent(x) \equiv (\exists c(person(c) \wedge hasChild(x, c) \wedge (x \neq c))))).$$

(**P-ENT-3**) $hasParent(x, y)$ is the inverse of $hasChild(y, x)$.

$$(\forall x \forall y(hasParent(x, y) \equiv hasChild(y, x))).$$

(**P-ENT-4**) A person cannot be a parent of themselves.

$$(\forall x(\neg hasParent(x, x))).$$

(**P-ENT-5**) The hasParent(x,y) relation is not symmetric.

$$(\forall x \forall y(hasParent(x, y) \supset \neg hasParent(y, x))).$$

1.7.4 Sibling

(**SIB-ENT-1**) If a person has a sibling, they are also a sibling of that person.

$$(\forall x \forall y(hasSibling(x, y) \supset hasSibling(y, x))).$$

(**SIB-ENT-2**) A person is not a sibling of themselves.

$$(\forall x(\neg hasSibling(x, x))).$$

(**SIB-ENT-3**) Two siblings cannot be spouses.

$$(\forall x \forall y(hasSibling(x, y) \supset \neg hasSpouse(x, y))).$$

1.7.5 Grandparent (Grandfather, Grandmother)

(**GP-ENT-1**) The spouse of a someone's grandparent is also that person's grandparent.

$$(\forall x \forall y \forall z\ ((hasSpouse(x, y) \wedge hasGrandchild(x, z)) \supset hasGrandchild(x, y))).$$

(**GP-ENT-2**) A person cannot be a grandparent of themselves.

$$(\forall x(\neg hasGrandparent(x, x))).$$

(**GP-ENT-3**) The hasGrandparent(x,y) relation is not transitive.

$$(\forall x \forall y \forall z\ ((hasGrandparent(x, y) \wedge hasGrandparent(y, z)) \supset \neg hasGrandparent(x, z))).$$

(**GP-ENT-4**) The hasGrandparent(x,y) relation is not symmetric.

$$(\forall x \forall y(hasGrandparent(x, y) \supset \neg hasGrandparent(y, x))).$$

1.7.6 Grandchild (Grandson, Granddaughter)

(**GC-ENT-1**) A person cannot be a grandchild of themselves.

$$(\forall x(\neg hasGrandchild(x, x))).$$

(**GC-ENT-2**) The $hasGrandchild(x, y)$ relation is not transitive.

$$(\forall x \forall y \forall z((hasGrandchild(x, y) \wedge hasGrandchild(y, z)) \supset \neg hasGrandchild(x, z))).$$

(**GC-ENT-3**) The $hasGrandchild(x, y)$ relation is not symmetric.

$$(\forall x \forall y(hasGrandchild(x, y) \supset \neg hasGrandchild(y, x))).$$

1.7.7 Great-Grandparent (Great-Grandfather, Great-Grandmother)

(**GGP-ENT-1**) A person cannot be a great-grandparent of themselves.

$$(\forall x(\neg hasGreatGrandparent(x, x))).$$

(**GGP-ENT-2**) The $hasGreatGrandparent(x, y)$ relation is not transitive.

$$(\forall x \forall y \forall z((hasGreatGrandparent(x, y) \wedge hasGreatGrandparent(y, z)) \supset \neg hasGreatGrandparent(x, z))).$$

(**GGP-ENT-3**) The $hasGreatGrandparent(x, y)$ relation is not symmetric.

$$(\forall x \forall y(hasGreatGrandparent(x, y) \supset \neg hasGreatGrandparent(y, x))).$$

1.7.8 Cousin

(**CS-ENT-1**) A person cannot be a cousin of themselves.

$$(\forall x(\neg hasCousin(x, x))).$$

(**CS-ENT-2**) The hasCousin(x,y) relation is symmetric.

$$(\forall x \forall y(hasCousin(x, y) \supset hasCousin(y, x))).$$

(**CS-ENT-3**) A person has a cousin if the sibling of their parent has a child.

$$(\forall x \forall y \forall z((hasPibling(x, y) \land hasChild(y, z)) \supset hasCousin(x, z))).$$

1.7.9 Pibling (Aunt, Uncle)

(**PIB-ENT-1**) A person cannot be a pibling of themselves.

$$(\forall x(\neg hasPibling(x, x))).$$

(**PIB-ENT-2**) The hasPibling(x,y) relation is not transitive.

$$(\forall x \forall y \forall z((hasPibling(x, y) \land hasPibling(y, z)) \supset \neg hasPibling(x, z))).$$

(**PIB-ENT-3**) The hasPibling(x,y) relation is not symmetric.

$$(\forall x \forall y(hasPibling(x, y) \supset \neg hasPibling(y, x))).$$

1.7.10 Great-Pibling (Great-Aunt, Great-Uncle)

(**PIB-ENT-1**) A person cannot be a great-pibling of themselves.

$$(\forall x(\neg hasGreatPibling(x, x))).$$

(**PIB-ENT-2**) The hasGreatPibling(x,y) relation is not transitive.

$$(\forall x \forall y \forall z((hasGreatPibling(x, y) \land hasGreatPibling(y, z)) \supset \neg hasGreatPibling(x, z))).$$

(**PIB-ENT-3**) The hasPibling(x,y) relation is not symmetric.

$$(\forall x \forall y(hasGreatPibling(x, y) \supset \neg hasGreatPibling(y, x))).$$

1.7.11 Nibling (Nephew, Niece)

(**NIB-ENT-1**) A person cannot be a nibling of themselves.

$$(\forall x(\neg hasNibling(x, x))).$$

(**NIB-ENT-2**) The $hasNibling(x, y)$ relation is not transitive.

$$(\forall x \forall y \forall z((hasNibling(x, y) \land hasNibling(y, z)) \supset \neg hasNibling(x, z))).$$

(**NIB-ENT-3**) The hasNibling(x,y) relation is not symmetric.

$$(\forall x \forall y(hasNibling(x, y) \supset \neg hasNibling(y, x))).$$

(**NIB-ENT-4**) The $hasNibling(x, y)$ relation is the inverse of $hasPibling(y, x)$.

$$(\forall x \forall y(hasNibling(x, y) \equiv hasPibling(y, x))).$$

1.7.12 Parent-in-Law (Father-in-Law, Mother-in-Law)

(**PIL-ENT-1**) A person cannot be a parent-in-law of themselves.

$$(\forall x(\neg hasParentInLaw(x, x))).$$

(**PIL-ENT-2**) The hasParentInLaw(x,y) relation is not transitive.

$$(\forall x \forall y \forall z((hasParentInLaw(x, y) \wedge hasParentInLaw(y, z)) \supset \neg hasParentInLaw(x, z))).$$

(**PIL-ENT-3**) The hasParentInLaw(x,y) relation is not symmetric.

$$(\forall x \forall y(hasParentInLaw(x, y) \supset \neg hasParentInLaw(y, x))).$$

(**PIL-ENT-4**) The $hasParentInLaw(x, y)$ relation is the inverse of $hasChildInLaw(y, x)$.

$$(\forall x \forall y(hasParentInLaw(x, y) \equiv hasChildInLaw(y, x))).$$

1.7.13 Sibling-in-Law (Brother-in-Law, Sister-in-Law)

(**SIL-ENT-1**) A person cannot be a sibling-in-law of themselves.

$$(\forall x(\neg hasSiblingInLaw(x, x))).$$

(**SIL-ENT-2**) The hasSiblingInLaw(x,y) relation is not transitive.

$$(\forall x \forall y \forall z((hasSiblingInLaw(x, y) \wedge hasSiblingInLaw(y, z)) \supset \neg hasSiblingInLaw(x, z))).$$

(**SIL-ENT-3**) The hasSiblingInLaw(x,y) relation is symmetric.

$$(\forall x \forall y(hasSiblingInLaw(x, y) \supset hasSiblingInLaw(y, x))).$$

1.7.14 Half-Sibling (Half-Brother, Half-Sister)

(**HS-ENT-1**) A person cannot be a half-sibling of themselves.

$$(\forall x(\neg hasHalfSibling(x, x))).$$

(**HS-ENT-2**) The hasHalfSibling(x,y) relation is not transitive.

$$(\forall x \forall y \forall z((hasHalfSibling(x, y) \wedge hasHalfSibling(y, z)) \supset \neg hasHalfSibling(x, z))).$$

(**HS-ENT-3**) The $hasHalfSibling(x, y)$ relation is symmetric.

$$(\forall x \forall y(hasHalfSibling(x, y) \supset hasHalfSibling(y, x))).$$

1.7.15 Step-Child (Step-Son, Step-Daughter)

(**SC-ENT-1**) A person cannot be a step-child of themselves.

$$(\forall x(\neg hasStepChild(x, x))).$$

(**SC-ENT-2**) The $hasHalfSibling(x, y)$ relation is not transitive.

$$(\forall x \forall y \forall z\ ((hasStepChild(x, y) \wedge hasStepChild(y, z)) \supset \neg hasStepChild(x, z))).$$

(**SC-ENT-3**) The $hasStepChild(x, y)$ relation is not symmetric.

$$(\forall x \forall y(hasStepChild(x, y) \supset \neg hasStepChild(y, x))).$$

(**SC-ENT-4**) The hasStepParent(x,y) relation is the inverse of hasStepChild(y,x).

$$(\forall x \forall y(hasStepParent(x, y) \equiv hasStepChild(y, x))).$$

1.7.16 Step-Parent (Step-Father, Step-Daughter)

(**SP-ENT-1**) A person cannot be a step-parent of themselves.

$$(\forall x(\neg hasStepParent(x, x))).$$

(**SP-ENT-2**) The $hasStepParent(x, y)$ relation is not transitive.

$$(\forall x \forall y \forall z\ ((hasStepParent(x, y) \wedge hasStepParent(y, z)) \supset \neg hasStepParent(x, z))).$$

(**SP-ENT-3**) The hasStepParent(x,y) relation is not symmetric.

$$(\forall x \forall y(hasStepParent(x, y) \supset \neg hasStepParent(y, x))).$$

1.8 Not Included / Unnecessary Axioms

(**DNI-1**) A person has a parent who is a person. (For every person, there is another person who is their parent.)
Reason for not including: causes *infinite* models.

$$(\forall x(person(x) \supset (\exists y(person(y) \wedge hasParent(x, y) \wedge (x \neq y))))).$$