A Mereological System for Informational Templates

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Abstract

We propose an axiomatic ontological framework for informational templates based on former works on slot-mereology. Templates and their parts can be filled by information content entities, but can exist even if unfilled. Thus, we represent templates as slots that can themselves have slots, where the "slot of" relation between slots can be interpreted as a parthood relation. Some slots of a slot are mandatory and need to be filled for the parent slot to be filled, whereas others are optional and do not have this restriction. The structure of a filler is also described by slots of a different nature. We discuss how parthood between slots can be connected with parthood between their fillers.

Keywords

Mereology, Information content entity, Informational template

1. Introduction

The ontology of informational entities has been investigated from a variety of perspectives and general ontological frameworks [1]. The kinds of informational entities that have been typically scrutinized are what we might call "substantial" informational entities, such as words, sentences or figures. For example, the Informational Artifact Ontology (IAO [2]) focuses explicitly on "information *content* entities". There is however another kind of informational entities that deserves a closer analysis, namely templates. Templates are typically filled by information content entities. But a template can exist even if unfilled: think for example of a Latex template, which is an entity in its own right.

Templates are of prime importance to characterize documents, especially documents that have a normative dimension. Consider a diploma. It typically encompasses a first name and a last name. However, we would want to be able to represent the fact that such a diploma *could* encompass a middle name. In open world systems, such facts are typically represented by closure axioms: for example, we could formally state that a diploma has as direct parts *only* the following: first name, middle name, last name, title of the grade, etc. However, such a formalization assumes that we know exactly all direct parts a diploma can have. By contrast, there might be cases where we know that a diploma *must* include a first name and a last name, *could* include a middle name in some cases, but *might* also include other unknown parts. In such situations, a closure axiom would not be adapted anymore.

An alternative, more expressive way would thus be to characterize a *template* for diplomas (rather than the diplomas themselves), stating that it has fields for last name and first name that *must* be filled in any diploma based on this template, and a field for middle names that *may* be filled or not. In such a representation, we can leave it open whether the template encompasses other unknown fields or not in an open world formalization. Thus, it is desirable to be able to represent not only filled documents but also templates, and the relations between both.

A former work [3,4] proposed a first mereology of informational entities that accounts for the fact that the very same informational entity can be part several times of another informational entity, by

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filling several of its "slots" – inspired by Bennett's foundational work [5]. For example, the very same word "cat" is part twice of the sentence "A cat is a cat.". This theory left room to templates in the form of unfilled "informational slots" which can themselves own informational slots. Thus, a "full name" slot could have three subslots for respectively a first name, a middle name and a last name. However, in this theory, the slots of a slot are identical to the slots of its filler. This is a strong restriction (cf. [3], Section 5.1) that implies that informational templates could not keep their slot structure independently on whether they are filled or not. In such a system, as soon as the full name slot is filled by a full name encompassing a first name and a last name but no middle name, it loses its middle name slot. Thus, it does not fit with a common pre-formal notion of templates: a questionnaire would for example keep its unfilled space for middle name (concretizing a middle name slot) even if the spaces for the first name and for the last name (concretizing the first name slot and the last name slot) have been filled.

To account for the fact that a document of a certain type must encompass some fields and can encompass other fields, we can introduce a distinction between slots in a template that are mandatory and others that are optional. For example, a full name slot would have as mandatory slots a first name slot and a last name slot, and as optional slot a middle name slot. It could be filled by a full name filler that would have as slots only a first name slot and a last name slot.

Therefore, we will propose an ontology of slots and fillers where the slot structure of a slot does not need to be identical to the slot structure of its filler, and where a slot can have both optional and mandatory slots. The next section will specify the methods used. A third section will propose an axiomatic representation of templates, independently of their fillers. A fourth section will axiomatize parthood between fillers. A fifth section will propose theoretical and realistic models based on clinical documents. A sixth section will discuss how this system could be extended in various directions. A conclusion will follow.

2. Methods and first axioms

2.1. Methods

In this paper, we will work in transitive closure logic, that is, FOL enriched with the operation of transitive closure TC, where the transitive closure of a predicate X will be written "^{C}X" [6–8]. We will also assume all free variables are universally quantified when writing axioms and theorems. The variable symbols "s", "t", "u", "v", "w" will be used for slots, "x", "y", "z" for fillers, and "a", "b" for entities that can be either slots or fillers.

2.2. Taxonomy and domain/range axioms

All the axioms reflecting the taxonomic structure in Figure 1 will be accepted, that is, if A is a subclass of B, we accept Aa → Ba. We will introduce the following classes (unary predicates), that will be explained below:

- *Informational slot* [IS]
  - *Slot of filler* [IS^F]
  - *Slot of slot* [IS^S]
  - *Unattached slot* [IS^U]
- *Informational filler* [IF]

Figure 1: Taxonomy of entities and associated unary predicates

We consider templates as "unattached slots" or U-slots (IS^U), that are not slots of anything – that is, they do not belong to anything (we leave open here the question of whether all U-slots are templates, as well as whether all documents follow a template, at least an implicit one). Such slots can themselves have slots, which can themselves have slots, etc. This latter kind of slots is called "slot of slots" or S-slots (IS^S). Fillers also can have slots (called "slots of filler", IS^F) and can themselves fill slots (U-slots, S-slots or F-slots).

We also introduce the relations on those classes as pictured on Table 1.

Table 1
Binary relations

Name	Predicate	Domain	Range
slot of	S	IS	IS or IF
mandatory slot of	MS	IS^S	IS^S or IS^U
optional slot of	OS	IS^S	IS^S or IS^U
fills	F	IF	IS
slot of closure (C-slot of)	${}^C S$	IS	IS or IF
C-slot-overlap	${}^C SO$	IS	IS
direct proper part of	PP^D	IF	IF
proper part of	PP	IF	IF
part of	P	IF	IF

We accept the binary relations summarized in Table 1, where R has domain X and range Y is translated as: $Rab \rightarrow Xa \ \& \ Yb$.

2.3. Fillers and slots

We accept an axiom of disjointness between fillers and slots:

(A1) **Disjointness** $\neg(ISa \ \& \ IFa)$

and an axiom of covering of all entities by fillers and slots:

(A2) **Covering** $ISa \lor IFa$

That is, slots and fillers form a partition of the domain of quantification considered in this paper.

Five of the above-mentioned unary and binary predicates are primitive: IS ("is a slot"), S ("slot of"), MS ("mandatory slot of"), OS ("optional slot of") and F ("fills"). All the others will be derived from those five predicates. In particular, the four derived classes in the above taxonomy depicted in Figure 1 can be defined as follows:

- Fillers are entities filling a slot:

(D1) **Filler definition** $IFx :=_{def} \exists t \ Fxt$

- U-slots are slots belonging to nothing:

(D2) **U-slot definition** $IS^U s :=_{def} ISs \ \& \ \forall a \ \neg Ssa$

- S-slots are slots belonging to a slot:

(D3) **S-slot definition** $IS^S s :=_{def} \exists t \ Sst \ \& \ ISt$

- F-slots are slots belonging to a filler:

(D4) **F-slot definition** $IS^F s :=_{def} \exists x \ Ssx \ \& \ IFx$

Note that fillers can only exist in slots, but slots can exist independently of fillers, as argued for in former work [3]. We want to add two constraints about the owners of S-slots and F-slots. First, S-slots belong only to S-slots or U-slots:

(A3) **S-slots owner** $IS^S s \ \& \ Sst \rightarrow IS^S t \lor IS^U t$

Second, F-slots belong only to fillers:

(A4) **F-slot owner** $IS^F s \ \& \ Ssx \rightarrow IFx$

We can then deduce that slots are exactly S-slots, F-slots and U-slots:

(T1) **Covering of IS** $ISs \leftrightarrow [IS^S s \lor IS^F s \lor IS^U s]$

Proof: The right-to-left inference is trivial. For the left-to-right inference, suppose that ISs. If there is no a such that Ssa, then $IS^{U}s$. If there is some a such that Ssa, then a is either a slot or a filler by A2. If a is a filler, then $IS^{F}s$. If a is a slot, then $IS^{S}s$. QED

We can also show that the three kinds of slots are disjoint:

(T2) **S-slots, F-slots and U-slots are disjoint**

$$\neg(IS^{S}s \ \& \ IS^{F}s) \ \& \ \neg(IS^{S}s \ \& \ IS^{U}s) \ \& \ \neg(IS^{F}s \ \& \ IS^{U}s)$$

Proof: Consider s such that $IS^{F}s$, thus there is some filler x such that Ssx. By definition D2 of IS^{U}, $\neg IS^{U}s$. Thus, $\neg(IS^{F}s \ \& \ IS^{U}s)$. If $IS^{S}s$, there is some slot t such that Sst. Since $IS^{F}s$, by A4, t is a filler. Thus t is both a slot and a filler: absurd by A1. Thus $\neg(IS^{S}s \ \& \ IS^{F}s)$.
Consider now s such that $IS^{S}s$. By definition D2 of IS^{U}, we have $\neg IS^{U}s$, thus $\neg(IS^{S}s \ \& \ IS^{U}s)$. QED

Thus, S-slots, F-slots and U-slots form a partition of slots. We will now turn in the next part to the analysis of mere slot structures, independently of their fillers.

3. Templates as slot structures

3.1. "Slot of" and its transitive closure

As mentioned above, slots can themselves have slots, as represented by the relation S. Consider for example a template "complete name" that is an unattached slot 'cn_0[]', which has as slots 'fn_0[]' (for "first name") and 'ln_0[]' (for "last name"), and can exist even if it is not filled.

We define the transitive closure of the S relation: ^{C}S.

(D5) **Slot_of transitive closure** $\quad ^{C}S :=_{def} TC(S)$

We will say that s is a "C-slot" of t when ^{C}Sst. As we will see, ^{C}S will be interpreted as a relation of proper parthood between slots, and thus we want S to be irreflexive (nothing is a slot of itself). Indeed, we do not want to have cycles by the S relation such as represented on Figure 2.a.

(A5) **Slot_of closure irreflexivity** $\quad \neg{}^{C}Stt$

That is, slots are structured in directed acyclic graphs by the relation S. This implies trivially that S is irreflexive. It also implies that S is asymmetric (two slots s and t cannot own each other):

(T3) **Slot_of asymmetry** $\quad Stu \rightarrow \neg Sut$

Proof: If Stu and Sut, then ^{C}Stt by definition D5: absurd by A5. QED

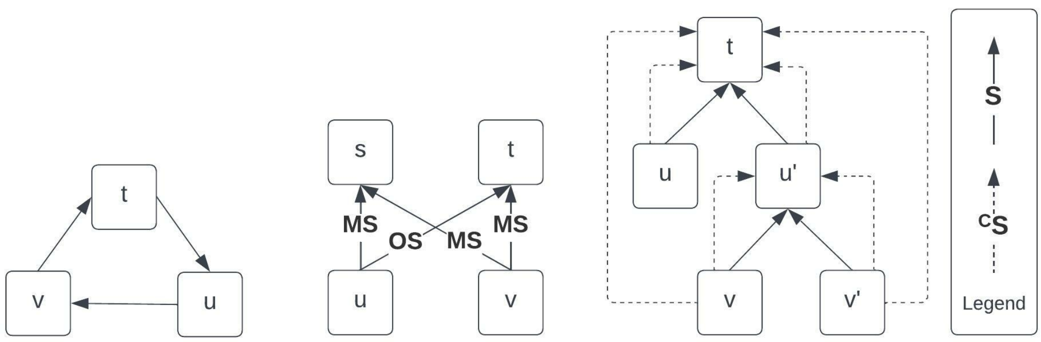

Figure 2: Models (a) Unwanted (b) Intended (c) Intended (2.b and 2.c discussed below)

3.2. Mandatory and optional slots

We can now turn to relational properties of slots of slots, namely being mandatory or optional relatively to their owner. First, slots of slots (and only those) are either mandatory or optional relatively to their owners:

(A6) **Slots of slots are mandatory or optional** $\quad (ISt \ \& \ Sst) \leftrightarrow (MSst \lor OSst)$

(in the models graphically represented in this paper, either S or MS/OS relations will be pictured, keeping in mind that if S holds between two slots, then either MS or OS holds, and vice versa; also, ^{C}S relations will not be pictured but can easily be inferred from S relations)

Second, no slot is both optional and mandatory relatively to the same owner:

(A7) **Optional and mandatory slots are disjoint** ¬(OSst & MSst)

Note however that a slot can be optional relatively to a slot, and mandatory relatively to another slot: the mandatory or optional characters of a slot are *relational* properties. On Figure 2.b, for example, u is a mandatory slot for t, but an optional slot for s. A realist model would consist of t being a slot for a name that must encompass a last name slot (v) and can – but must not – encompass a first name slot (u); and s being a slot for a name that must encompass both a first name slot and a last name slot.

3.3. Unwanted properties: Transitivity, Anti-transitivity and Functionality

Contrarily to what was assumed in former work [3], S is not a strict order relation: it is not transitive. Instead, what corresponds to the transitive "slot_of" relation in this former work is here the transitive closure ^{C}S (for reasons that will be discussed in Section 6). Thus, the model pictured on Figure 2.c is intended. Note that in this model, u' is a slot of t and v is a slot of u', but v is *not* a slot of t (we do not have Svt): however, v is a C-slot of t (that is, ^{C}Svt). This means intuitively that the template t does not have v as a *direct* part, but as an *indirect* part (we will indeed justify later that ^{C}S can be interpreted as a parthood relation).

To take a clinical example inspired by an ontology of drug prescriptions [9], t could be a drug prescription template, u' a posology slot (the posology is the part of the drug prescription that explains when and under which condition to take a dose) and v a dose specification slot (where the dose specification states which quantity of which drug to take): the dose specification is not a direct part of the drug prescription template, but only indirectly through the posology slot.

Note that we do not want to impose the functionality of S here, that is, that slots would have only one owner. Indeed, it would exclude slot-overlap as presented on Figure 3.a, which might be acceptable. A realistic model of Figure 3.a would be e.g. having u being a slot for a day number (between 1 and 31, e.g. 24), v a slot for a month (e.g. October), and w a slot for a year (e.g. 1981) (t being a slot for a day in a month without specifying the year, e.g. October 24, t' a slot for a month of a specific year, e.g. October 1981, and s a slot for a specific day of a specific month of a specific year, e.g. October 24 1981). Another example of slot-overlap, this time in the clinical domain, would be a template for a drug prescription of several drugs (suppose here there are only two) made by the same prescriber: such a document is composed by two slots t and t' that should each be filled by the information about the prescriber and the prescription of a single drug, and where t and t' overlap on the prescriber slot v (u being the slot for the prescription of the first drug, and w the slot for the prescription of the second drug).

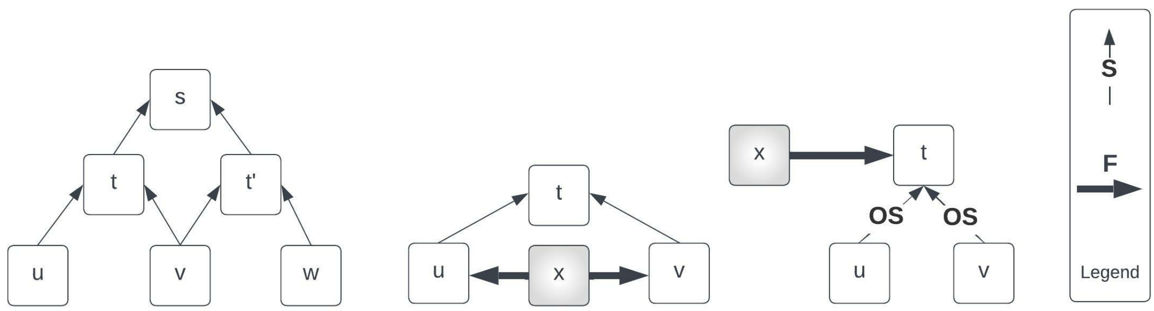

Figure 3: Models (a) Intended (b) Unwanted (c) Unwanted (3.b and 3.c discussed below)

3.4. Supplementation

${}^{C}S$ can be seen as a proper parthood relation on the domain $IS^{U} \lor IS^{S}$. It already satisfies axioms of strict partial order: it is irreflexive, asymmetric and transitive. Arguably, for it to be an authentic proper parthood relation, it must also satisfy some supplementation axiom [10]. For this, we can define C-slot-overlap ${}^{C}SO$ as follows: two slots C-slot-overlap if they have a C-slot in common, if one is a C-slot of the other, or if they are identical:

(D6) **C-slot overlap**

$${}^{C}SOst :=_{def} (ISs \ \& \ ISt) \ \& \ (s{=}t \lor {}^{C}Sst \lor {}^{C}Sts \lor \exists u \, ({}^{C}Sus \ \& \ {}^{C}Sut))$$

An axiom of C-slot weak supplementation would be the following: if t is a C-slot of s, there is a C-slot of s that does not C-slot-overlap t:

(A8) **C-slot weak supplementation** $\quad {}^{C}Sts \rightarrow \exists u \, ({}^{C}Sus \ \& \ \neg {}^{C}SOut)$

Note that we do not want a stronger axiom of slot weak supplementation on S as follows (where SO would be defined like ${}^{C}SO$, replacing ${}^{C}S$ by S): $Sts \rightarrow \exists u \, (Sus \ \& \ \neg SOut)$. Indeed, the model presented above in Figure 3.a is intended, but does not satisfy the slot weak supplementation. As a matter of fact, in this model, Sts holds, but there is no slot a such that Sas and ¬SOta (since the two only slots of s do S-overlap). However, the model does satisfy the C-slot weak supplementation.

Do we also want an axiom of strong supplementation by ${}^{C}S$ as follows: $\neg {}^{C}Sst \rightarrow \exists u \, ({}^{C}Sus \ \& \ \neg {}^{C}SOut)$? The answer is negative, as this would imply extensionality, and thus prohibit models such as the one presented on Figure 2.b. Note that we could even accept a model like on Figure 2.b but where u and v would be mandatory slots of both s and t. Indeed, templates might have the exact same slots but with different additional relations holding between those slots. For example, we might want to accept two templates for complete names ‘$cn[]_1$’ and ‘$cn[]_2$’ which would have the same two mandatory slots ‘first_name[]’ and ‘last_name[]’, but in different orders (where such order relations would be ternary: ‘first_name[]’ is before ‘last_name[]’ in ‘$cn[]_1$’, and ‘last_name[]’ is before ‘first_name[]’ in ‘$cn[]_2$’).

4. Fillers

The slot structure of fillers is typically different from the slot structure of slots. Indeed, since a slot of a filler cannot itself have slots (by A3 and T2), on fillers, ${}^{C}S$ collapses to S. On F-slots, S and ${}^{C}S$ never apply and ${}^{C}SO$ collapses to identity. This implies that on fillers, C-slot weak supplementation collapses to the following theorem of “company” (reusing the vocabulary of Varzi [11]):

(T4) **Company on fillers** $\quad IFx \ \& \ Stx \rightarrow \exists u \, (Sux \ \& \ \neg u{=}t)$

Also, on F-slots, C-slot weak supplementation is vacuously true, since its premise never applies (as F-slots do not have slots).

However, a slot of a filler can be filled by another filler that has itself slots: this is how a filler can have a mereological structure spanning several levels, and how the slot structure of a template can be mirrored in a filler of this template (as will be discussed in Section 6). Let us now turn to more substantial statements on fillers.

4.1. First axiom

We adapt a first axiom former works [3,5]: there is at most one filler in a given slot:

(A9) **Maximum one occupant** $\quad Fyt \ \& \ Fzt \rightarrow y{=}z$

This implies that when we informally say that the “same” template is used for several documents constituted by different fillers, according to this theory, we are actually referring to *different* U-slots that are *similar* by being instances of a same class of templates. Indeed, a slot can have at most one filler. On the other hand, a filler can occupy several slots: an entity can “have a part twice over”, as Bennett claims.

4.2. Definition of parthood

Like in traditional slot mereology [3,5,12–14], parthood is linked with filling a slot. But instead of defining parthood or proper parthood as filling a slot of a filler, it is the notion of *direct* proper parthood that is defined as such:

(D7) **Direct proper parthood** $PP^{D}xy :=_{def} IFy \,\&\, \exists t\, (Sty \,\&\, Fxt)$

We then define proper parthood as the transitive closure of direct proper parthood:

(D8) **Proper parthood** $PP :=_{def} TC(PP^{D})$

We can define regular parthood on fillers as usual, on the basis of proper parthood:

(D9) **Parthood** $Pxy :=_{def} PPxy \lor (IFx \,\&\, x=y)$

4.3. Parthood as a partial order

Former work [3] endorsed an axiom (named AX8) that identified the slots of fillers with the slots of the filled slot: $Fxt \rightarrow (Sux \leftrightarrow Sut)$. As explained in Section 1, we reject such an axiom, as we want slots to have their own intrinsic slot structure, independently of their fillers. In the former theory, AX8 was used to show slot inheritance (from which could be derived proper parthood asymmetry): $Stx \,\&\, Pxy \rightarrow Sty$. Here, we also reject slot inheritance that created a counting problem (see [12] and Section 6.2 of this paper). We must thus adapt the axioms.

Since we defined proper parthood as the transitive closure of direct proper parthood, proper parthood is trivially transitive:

(T5) **Proper parthood transitivity** $PPxy \,\&\, PPyz \rightarrow PPxz$

From this, we derive trivially parthood transitivity:

(T6) **Parthood transitivity** $Pxy \,\&\, Pyz \rightarrow Pxz$

Former works [3,5] introduced an axiom stating that no filler occupies any of its slot ($\neg(Stx \,\&\, Fxt)$; that is, there is no improper slot) – which translates here as $\neg PP^{D}xx$ (the irreflexivity of direct proper parthood). However, we need here a stronger axiom, namely the irreflexivity of proper parthood:

(A10) **Proper parthood irreflexivity** $\neg PPxx$

Finally, parthood reflexivity is a trivial consequence of the definition of parthood:

(T7) **Parthood reflexivity** $IFx \rightarrow Pxx$

This implies proper parthood asymmetry:

(T8) **Proper parthood asymmetry** $PPxy \rightarrow \neg PPyx$

Proof: If PPxy and PPyx, then PPxx by transitivity of PP: absurd by A10. QED

From this, we derive parthood anti-symmetry trivially as usual:

(T9) **Parthood anti-symmetry** $Pxy \,\&\, Pyx \rightarrow x=y$

Proof: Suppose that Pxy and Pyx. By T8, either ¬PPxy or ¬PPyx. Thus, we have x=y. QED

4.4. Filling axioms

Like in [3], we accept that a slot of a filler is filled.

(A11) **Slot of a filler is filled** $IFx \,\&\, Stx \rightarrow \exists y\, Fyt$

We can deduce trivially from this axiom that a slot of a filler is always filled by a proper part of the filler:

(T10) **Slot of a filler is filled by a proper part** $IFx \,\&\, Stx \rightarrow \exists y\, (Fyt \,\&\, PPyx)$

For example, the filler 'John Doe' has a slot for the first name 'fn_{JD}[]' filled by 'John'. As in former work [3], we accept an "ascending" filling axiom: if all slots of a slot that has slots are filled, then this slot is also filled.

(A12) **A slot with filled slots is filled**

$$ISt \,\&\, (\exists s\, Sst) \,\&\, [\forall u\, (Sut \rightarrow \exists x\, Fxu)] \;\rightarrow\; \exists y\, Fyt$$

Note that we need the condition "(∃s Sst)" in A12, otherwise the condition ∀u (Sut → ∃xFxu) would be trivially true for any slot that does not have any slot, and thus such slots would always be filled. This axiom excludes models such as represented on Figure 3.b, where t is not filled, despite all its sub-slots u and v being filled.

However, the reciprocal is not true: a filled slot does not need to have all its slots filled. Indeed, a slot can be filled while some of its optional slots are not filled – this is, as a matter of fact, the motivation for introducing optional slots. Moreover, a slot that has all its mandatory slots filled is not always filled. For example, if someone named 'John D. Brown' fills the mandatory slots for the first name and for the last name of a full name slot, but does not fill the optional slot for the middle name – that is, if he writes only 'John Brown', then he has not filled the full name slot.

However, we claim that if a slot is filled, then all its *mandatory* slots are also filled[2]:

(A13) **Mandatory slots of a filled slot are also filled**

∃y Fyt → ∀u (MSut → ∃x Fxu)

We also impose that if a slot that has slots is filled, then at least one of its slots is filled.

(A14) **Some slot of a filled slot with slots is filled**

(∃t Sts) & Fxs → ∃u,y (Sus & Fyu)

(note the importance of the proviso ∃s Sts, as otherwise a slot that has no slot could never be filled)

This excludes models in which a slot that would have only optional slots could be filled without any of its slots being filled, such as pictured on Figure 3.c. For example, in an informal registry of a small classroom, there could be a slot "name" with two optional slots "first name" and "last name" (that is, people could be referred either by their first name or by their last name). However, it is not possible in such a registry that a name would be indicated without indicating either the first name or the last name. A14 ensures that this constraint is satisfied.

It enables also to represent a situation where either a first name and last name (or both) must be specified, and a middle name can (but must not) be specified: this can be represented with the templates having a first mandatory slot that has two optional slots, one for the first name and one for the last name, and a second optional slot for the middle name.

5. Models and applications

5.1. Theoretical models

The theory was implemented in Alloy4 [6] and the model presented on Figure 4 was found, proving its consistency. In this model, s is a template (U-slot) with two S-slots (one optional and one mandatory), where s is filled by x, which has itself two F-slots filled by y. Thus, y is a proper part of x twice. We will discuss in 6.1 below how models should be further constrained.

[2] An alternative formalization would be to introduce a neutral element ∅ such that all slots of a filled slot are filled, but its optional slot can be filled by this neutral element. However, the ontological status of such a neutral element would raise complex issues. For example, we might not want to endorse that optional slots are pre-filled with the neutral element, since we want slots to be able to exist even if unfilled. But then, does it imply that when someone fills a template, she fills each optional slot with a filler (either the neutral element or something else)? Then, how do we account for situations where the author of the filler did not realize the existence of such slots?

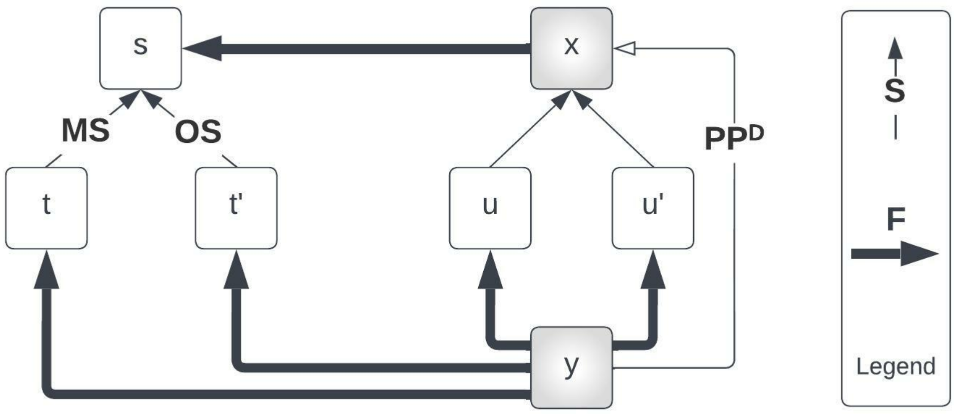

Figure 4: Model of the theory (P and PP relations omitted)

5.2. Clinical information models

Such a system might be applied to clinical documents. For example, every drug prescription specifies a drug product; however, some drug prescription specify a route of administration, but other do not [9]. This would translate by stating that a drug prescription template has a mandatory slot for a drug product specification, and an *optional* slot for a route of administration specification.

Another example would concern stays at a healthcare institution. A (simplistic) template t for such documents could have three slots: s_1 for the unit of care, s_2 for the starting date and s_3 for the end date. One could have t owning s_1 and s_2 as mandatory slots and s_3 as optional slot, such that s_3 would be filled for terminated stays and would be left unfilled for ongoing stays. An alternative template structure would be to introduce two intermediate optional slots of t, t_1 for terminated stays and t_2 for ongoing stays, such that t_1 has as mandatory slots s_1, s_2 and s_3 (as described above) and t_2 has as mandatory slots s_1' (also for the unit of care) and s_2' (also for the starting date). The second template might be more desirable to make sure that no user would leave an end date slot unfilled when entering the information for a terminated stay.

6. Discussion

This work can be completed in several directions that will be described now.

6.1. How a template structure constrains the structure of its filler

This theory would need to be further developed to avoid all unwanted models. In particular, this work would need to be completed with an analysis of how the intrinsic structure of a slot constrains the structure of its filler. For example, if a template has as mandatory slots a first name slot and a last name slot, then any filler of this template must encompass two parts that respectively fill those slots. On the other hand, a filler can have some slot structure that is not reflected in the template. For example, in a document template, there could be a slot for names that has no slot itself; it could be completed by a filler "John Brown" which has itself one F-slot for the first name "John" and one F-slot for the last name "Brown", even if there is no equivalent in the template.

We could for this introduce a relation of mirroring between the slots of a slot and the slots of a filler. For example, if s is a slot filled by f, and s has two mandatory slots, then f would have two mirrored slot that are filled. A slot and its mirror slot would be always filled by the same filler. Thus, the mandatory structure of the slot would be found in its filler. This is one motivation for focusing the formal system on a non-transitive "slot of" relation rather than on its transitive closure (as was done in

[3]), even if both systems are equivalent, as a first investigation showed us that the former would lead to mirroring axioms whose expression is more complex.

6.2. Solving the counting problem

In this framework, we can propose a solution to the counting problem different from the one proposed by Tarbouriech et al. [12] (this paper actually presented two counting problems, but the first one does not apply here, as it relied on the existence of improper slots, which are excluded here). In the present theory, being a part is not equivalent to filling a slot: rather, being a *direct* proper part is equivalent to filling a slot. As for being a proper part (simpliciter), it amounts to either filling a slot of a filler, or filling a slot of a filler of a slot of a filler, etc.

Thus, if x is part of y, we cannot count the number of times that x is part of y by counting the number of slots of y that x fills. Instead, we propose the following: the mereological structure of a filler can be represented by a directed acyclic graph (whose edges are constituted by the relations S and F), and to know how many times y is part of x, we count the number of paths that link y to x.

For example, in Figure 5, y is part of x twice as it fills two slots (s and t) of x. y has as parts z and w, each of which is part of x twice, as there are two chains by S and F that link z to x and w to x. In Bennett's mereology, y would also be part of x twice as it fills two slots of x; however, z (respectively w) would be (incorrectly) part of x only once, as the slot u (respectively v) would be inherited only once by x (as explained by Tarbouriech et al. [12]). This is another motivation for focusing on a non-transitive "slot of" relation and counting parts by the number of S/F paths rather than by the number of slots filled.

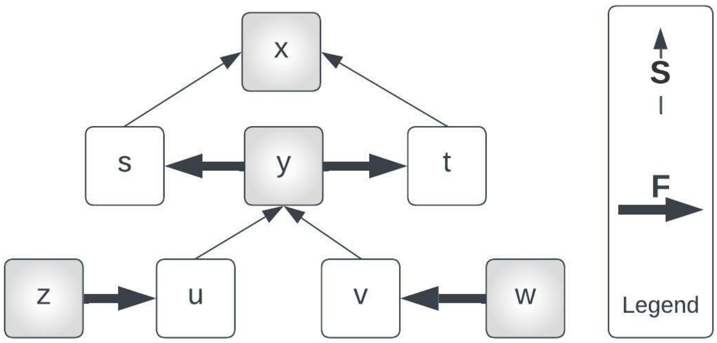

Figure 5: Counting parts (only S and F relations pictured)

6.3. Text Encoding Initiative

The topic at hand can be related with the work on documents and their structures in the digital document traditions, among which the most well-known is the Text-Encoding Initiative standards. The Text-Encoding Initiative offers a variety of slot-like tags such as <speaker> (to tag the mention of the speaker in a theater play), <quote> or <note>. However, the TEI is geared mostly at the analysis of texts, whereas our formalism aims first and foremost at representing templates that might be filled or not. Also, our focus here was on the mereological axiomatization of such a system, something which is, as far as we know, absent from the TEI; and indeed, inside a tag, not all parts of a texts need to be further tagged (whereas all parts of a text need to fill a slot in our system). There is thus a potential to strengthen the foundations of TEI thanks to the theory proposed above.

6.4. The semantic of slots

Slot could also enable to add a semantic layer to fillers. For example, the same filler "diabetes" could be used in several clinical documents: a first time as a diagnostic for a given patient, another time as a diagnosis of a family member of the patient, and a third time as a possible diagnosis that should be ruled out by a test. The filler "diabetes" refers to the disease in all the situations, but the slots in which it can be found can add this semantic layer to each occurrence of the term.

7. Conclusion

We have proposed a mereological system for informational templates. The relation S (slot of) defines a mereology on templates. It also applies on fillers and enables to define direct proper parthood between fillers as filling a slot. This system eschews the limit of a former system [3] by enabling a template and its filler to have different structures. It also avoids a problem in Bennett's mereology, namely the counting problem [12]. Future work is required to introduce axioms constraining the structure of a filler by the structure of the templates it fills, as well as how mereological sums can be defined on slots and fillers. The analysis of the structure of a filler presented here might be contrasted with Koslicki's account of "formal part" [15]. Other properties of the current theory, such as the functionality of S, should be discussed in more details. The existential conditions of templates and their connection with document acts [16] should be investigated, as well as how this theory can account for sentence structure. Finally, some fringe cases of "filling" a template would need to be analyzed: for example, when a user enters a piece of information of the requested kind in a template, but does not know that he did so, did he indeed fill the template? Answering such questions in detail will require articulating an ontology of mental states with the ontology of informational entities.

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