**BFO 2 Sanctioned Relations**

**Draft, extracted from the BFO 2.0 Specification at** [**http://bfo.googlecode.com/svn/trunk/docs/bfo2-reference/BFO2-Reference.docx**](http://bfo.googlecode.com/svn/trunk/docs/bfo2-reference/BFO2-Reference.docx) **by Leonard Jacuzzo**

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**Exists\_at**

a(exists\_at)[Elucidation: *a* **exists\_at** *t* means: *a* is an entity which exists at some temporal region *t.* [118-002] ]

a(exists\_at)[Domain: *entity*]

a(exists\_at)[Range: *temporal region*]

‘Exists’ here includes the case where *a* is occurring at *t.* ‘Temporal region’ includes both temporal instances and temporal intervals.

**Instance\_of**

The **instance\_of** relation holds between particulars and universals. It comes in two forms, for continuants (*C*, *C*1, …) and occurrents (*P*, *P*1, …) as follows [16]:

*c***instance\_of***C***at***t* means: that the particular *continuant* entity *c* **instantiates** the universal *C* **at** *t*

*p***instance\_of***P* means: that the particular *occurrent* entity *p* **instantiates** the universal *P.*

Examples are: John **instance\_of** *adult* **at** 2012, this laptop **instance\_of** *laptop* **at** 2012, 2012 **instance\_of** *temporal region*, John’s birth **instance\_of** *process.*

## *Is\_a*

The *is\_a* relation is the subtype or subuniversal relation between universals or types.

*C is\_a C*1means: for all *c*, *t*, if *c***instance\_of***C***at***t*then *c***instance\_of***C*1**at***t*

*P is\_a P*1means: for all *p*, if *p***instance\_of***P*then *p***instance\_of***P*1

where ‘*C*’*,* ‘*C*1’ stand for *continuant* types and ‘*P*’, ‘*P*1’ for *occurrent* types, respectively.

Examples are: house *is\_a* building, symphony *is\_a* musical work of art, promenade *is\_a* dance step, promise *is\_a* speech act

## Relations of parthood

As our starting point in understanding the parthood relation, we take the axioms of Minimal Extensional Mereology as defined by Simons [46, pp. 26-31], assuming, like Simons, the axioms of first order predicate calculus. The axioms (reformulations of SA1-3 and SA6 in Simons’ numbering) are:

**Antisymmetry:** If *x* part of *y*, then if *y* part of *x*, then *x = y.*

**Transitivity:** If *x* part of *y,* and *y* part\_of *z*, then *x* part\_of *z*

**Weak Supplementation:** If *x* part\_of *y* & not *x* = *y*, then there is some *z* such that (*z* part\_of *y* and *z* has no part in common with *x*)

**Unique Product:** If *x* and *y* have a part in common, then there is some unique *z* such that for all *w* (*w* is part of *z* if and only if (*w* is part of *x* and *w* is part of *y*))*.*

Where Simons takes as primitive the relation of proper parthood, we use here and in the remainder of this document parthood relations that include not only proper parthood but also identity as a special case. The corresponding proper\_part\_ofrelations are then defined in the obvious way as follows:

*x* proper\_part\_of *y* =Def. *x* part\_of *y* & not *x ­= y.*

BFO 2.0 includes two relations of parthood, namely parthood as it obtains between continuants – called **continuant\_part\_of** – and parthood as it obtains between occurrents – called **occurrent\_part\_of**, as follows.

## Continuant\_part\_of

a(continuant\_part\_of)[Elucidation: *a* **continuant\_part\_of** *b* **at** *t* =Def. *a* is a part of *b* at *t* & *t* is a time & *a* and *b* are continuants. [002-001]]

a(continuant\_part\_of)[Domain: continuant]

a(continuant\_part\_of)[Range: continuant

The range for ‘*t*’ **(as in all cases throughout this document unless otherwise specified) WHEN NOT? is**: temporal region.

]

as(continuant\_part\_of)[Examples: Mary’s arm **continuant\_part\_of** Mary in the time of her life prior to her operation\; the Northern hemisphere of the planet Earth is a part of the planet Earth at all times at which the planet Earth exists.

a(continuant\_part\_of)[Axiom: **continuant\_part\_of** is antisymmetric. [120-001]

a(continuant\_part\_of)[Axiom: **continuant\_part\_of** is transitive. [110-001]

a(continuant\_part\_of)[Axiom: **continuant\_part\_of** satisfies weak supplementation. [121-001]

(What this means is that:

If *x* **continuant\_part\_of** *y* **at** *t* & not *x* = *y*, then there is some *z* such that (*z* **continuant\_part\_of** *y* **at** *t* & there is no *w*(*w* **continuant\_part\_of** z& *w* **continuant\_part\_of** *x* **at** *t*)),

where *z* is, as it were, some remainder that results when *x* is imagined to have been removed from *y.*)

Axiom: **continuant\_part\_of** satisfies unique product. [122-001] ]

*a(continuant\_part\_of)[*Theorem: **continuant\_part\_of** is reflexive (every continuant entity is a **continuant\_part\_of** itself). [111-002]

Wwe allow **continuant\_part\_of** to include such material-immaterial crossings, and recommend the use of the more specific relation of **material\_part\_of** where they need to be ruled out.

First we define]

a(member\_part\_of)[Definition: *a* **member\_part\_of** *b* **at** *t* =Def. *a* is an *object* **at** *t*

& there is **at** *t* a mutually exhaustive and pairwise disjoint partition of *b* into objects *x*1, …, *x*n with *a* = *xi* for some natural number *i.* [026-003]]

a(member\_part\_of)[Domain: *object*]

a(member\_part\_of)[Range: *object aggregate*]

a(member\_part\_of)[Theorem: if *a* **member\_part\_of** *b* **at** *t* then *a* **continuant\_part\_of** *b* **at** *t.* [104-001] ]

## Occurrent\_part\_ofMoM]

a(occurrent\_part\_of)[Elucidation: *a* **occurrent\_part\_of** *b* =Def. *a* is a part of *b* & *a* and *b* are occurrents. [003-002]]

a(occurrent\_part\_of)[Domain: occurrent]

a(occurrent\_part\_of)[Range: occurrent]

as(occurrent\_part\_of)[Examples: Mary’s 5th birthday **occurrent\_part\_of** Mary’s life\; the first set of the tennis match **occurrent\_part\_of** the tennis match. ]

a(continuant\_part\_of)[Axiom: **occurrent\_part\_of** is antisymmetric. [123-001]

a(continuant\_part\_of)[Axiom: **occurrent\_part\_of** is transitive. [112-001]

a(continuant\_part\_of)[Axiom: **occurrent\_part\_of** satisfies weak supplementation. [124-001]

Axiom: **occurrent\_part\_of** satisfies unique product. [125-001] ]

Theorem: occurrent\_part\_of is reflexive (every occurrent entity is an occurrent\_part\_of itself). [113-002]

Note that in all of the above every entity is, trivially, a (continuant or occurrent) part of itself. We appreciate that this is counterintuitive for some users, since it implies for example that President Obama is a part of himself – however it brings benefits in simplifying the logical formalism, and it captures an important feature of identity, namely that it is the limit case of mereological inclusion.

**Relations defined in terms of parthood**

Proper parthood relations can be easily defined, as follows:

**For continuants**:

a(proper\_continuant\_part\_of)[Definition: *a* **proper\_continuant\_part\_of** *b* **at** *t* =Def. *a* **continuant\_part\_of** *b* **at** *t* & *a* and *b* are not identical. [004-001]]

For occurrents:

a(proper\_occurrent\_part\_of)[Definition: *a* **proper\_occurrent\_part\_of** *b* =Def. *a* **occurrent\_part\_of** *b* & *a* and *b* are not identical. [005-001]]

We can also define inverse relations:

**For continuants**:

a(has\_continuant\_part)[Definition: *a* **has\_continuant\_part** *b* at *t* = Def. *b* **continuant\_part\_of** *a* **at** *t.* [006-001]]

For occurrents:

a(has\_occurrent\_part )[Definition: *a* **has\_occurrent\_part** *b* = Def. *b* **occurrent\_part\_of** *a­*. [007-001]]

## Temporal\_parthood

We introduced above the relation **occurrent\_part\_of**. We can now identify in its terms the sub-relation **temporal\_part\_of** which holds between two occurrents when the former is a phase or subprocess (a slice or segment) of the latter:

a(temporal\_part\_of)[Definition: *a* **temporal\_part\_of** *b* =Def.

*a* **occurrent\_part\_of** *b* &

& for some *temporal region r*, *a* **occupies** *r*

& for all occurrents *c*, *r*′ (if *c* **occupies** *r*′ & *r* **occurrent\_part\_of***r*

then (*c* **occurrent\_part\_of** *a* iff *c* **occurrent\_part\_of** *b*)). [078-001]]

Thus *a* is exactly the restriction of *b* to *r*. The process of a footballer’s heart beating once is an **occurrent part** but not a **temporal part** of a game of football.

as(temporal\_part\_of)[Examples: your heart beating from 4pm to 5pm today is a **temporal part** of the *process* of your heart beating\; the 4th year of your life is a **temporal part** of your life\. The first quarter of a game of football is a **temporal part**ofthe whole game. ]

a(temporal\_part\_of)[Definition: *a* **proper\_temporal\_part\_of** *b* =Def. *a* **temporal\_part\_of** *b* & not (*a* = *b*). [116-001]]

a(temporal\_part\_of)[Axiom: if *a* **proper\_temporal\_part\_of** *b*, then there is some *c* which is a**proper\_temporal\_part\_of** *b*and which shares no parts with *a.* [117-001]]

[117-001] may be provable as theorem.

Temporal parts are often referred to as stages or phases of an occurrent.

a(occurrent)[Axiom: *a* is an *occurrent* entity iff *a* is an entity that has **temporal parts**. [079-001]]

**Temporally\_projects\_onto**

a(projects\_onto)[Elucidation: To say that each spatiotemporal region *r* **temporally\_projects\_onto** some temporal region *t* is to say that *t* serves as the temporal extension of *r.* [080-002]]

**Spatially\_projects\_onto**

a(projects\_onto)[Elucidation: To say that spatiotemporal region *r* **spatially\_projects\_onto** spatial region *s* **at** *t* is to say that *s* serves as the spatial extent of *r* **at** *t.* [081-002]]

## Every spatiotemporal region projects onto some time region, and at every time instant within its extent onto some spatial region (all of this relative to some frame)

## Specific\_dependence

Specific dependence (henceforth: **s-dependence**) is a relation that obtains between one entity and another when the first entity cannot exist unless the second entity exists also. This relation can be either one-sided, in the sense that *a* s-depends on *b*, but not (*b* s-depends on *a*), or reciprocal where *a* and *b* s-depend on each other. There are cases where a single entity is s-dependent on multiple other entities in either or both senses of ‘s-dependence’. As a purely terminological matter, only dependence relations involving at least one specifically dependent entity are cases of s-dependence. Thus the relation between a boundary and that which it bounds, or between a site and its host, are not examples of s-dependence. (The nature of boundary dependence will be addressed in a later version of BFO.)

a(s-dependence)[Elucidation: To say that *a* **s**-**depends on** *b* **at** *t* is to say that

*a*and *b* do not share common parts

*&* *a* is of its nature such that it cannot exist unless *b* exists

*& a* is not a boundary of *b* and *a* is not a site of which *b* is the host [64]. [012-002]]

as(s-dependence)[Domain: *dependent continuant*\; *process*; *process boundary*]

Range:

**range(s-dependence)[for one-sided s-dependence**: *independent continuant*;]

**range(s-dependence)[for reciprocal s-dependence:** *dependent continuant*\; *process*]

as(s-dependence)[Examples: The **s-dependence** of a pain on the organism that is experiencing the pain\, the dependence of a shape on the shaped object\, the dependence of a gait on the walking object.]

**Types of s-dependence**

Examples of **one-sided s-dependence** of a *dependent continuant* on an *independent continuant*:

an **instance** of *headache* **s-depends** on an **instance** of *head*

an **instance** of *temperature* **s-depends** on some organism

an **instance** of *seeing* (a relational process) **s-depends** on some organism and on some seen entity, which may be an occurrent or a continuant

a process of cell death **s-depends** on a cell

Examples of **reciprocal s-dependence** between *dependent continuants*:

the two-sided reciprocal **s-dependence** of the *roles* of husband and wife [20]

the three-sided reciprocal **s-dependence** of the hue, saturation and brightness of a color [45]

the three-sided reciprocal **s-dependence** of the pitch, timbre and volume of a tone [45]

Note that reciprocally dependent entities are in every case also one-sidedly dependent on some relevant bearers. This is why you can’t change a smile, for example, without changing the face upon which the smile depends.

Examples of **one-sided s-dependence** of an *occurrent* on an *independent continuant*:

the one-sided dependence of a hand wave on a hand

the one-sided dependence of a football match on the players, the ground, the ball

Examples of **one-sided s-dependence** of one *occurrent* on multiple *independent continuants*:

a relational *process* of hitting a ball with a cricket bat

a relational *process* of paying cash to a merchant in exchange for a bag of figs

Examples of **one-sided s-dependence** of one *occurrent* on another

a *process* of answering a question is dependent on a prior *process* of asking a question

a *process* of obeying a command is dependent on a prior *process* of issuing a command

Examples of **reciprocal s-dependence** between *occurrents*:

in a game of chess the process of playing with the white pieces is reciprocally dependent on the process of playing with the black pieces

a process of buying and the associated process of selling

a process of increasing the volume of a portion of gas while temperature remains constant and the associated process of decreasing the pressure exerted by the gas

**No s-dependence of higher order**

BFO does not recognize **s-dependence** of higher order. Thus there are no **s-dependence** structures of this sort:

**Inherence**

**Inherence** is a subrelation of **s-dependence** which holds between a *dependent continuant* and an *independent continuant*. Since dependent continuants cannot migrate from one independent continuant bearer to another, it follows that if *a* **s-depends on** independent continuant*b* at some time, then *a* **s-depends on** *b* at all times at which *a* exists. Inherence is in this sense redundantly time-indexed.

a(inheres\_in)[Definition: *a* **inheres\_in** *b* **at** *t* =Def. *a* is a *dependent continuant* & *b* is an *independent continuant* & *a* **s-depends on** *b* **at** *t*. [051-001]]

a(inheres\_in)[Domain: *specifically dependent continuant*]

a(inheres\_in)[Range: *independent continuant*

For example, consider the particular instance of openness inhering in my mouth at *t* as I prepare to take a bite out of a donut, followed by a closedness at *t*+1 when I bite the donut and start chewing. The openness instance is then shortlived, and to say that **s-depends** on my mouth at all times at which it exists, means: at all times during this short life. Every time you make a fist, you make a new (instance of the universal) fist.(Every time your hand has the fist-shaped quality, there is created a new instance of the universal fist-shaped quality.)

Intuitively inherenceholds only where the **s-dependent** entity or entities have no material parts. The accused in a court of law has an **s-dependent** role, but he himself is a human being, and thus not an **s-dependent** entity

a(s-dependence)[Axiom: If *a* is**s-dependent** on something at some time, then *a* is not a *material entity.* [052-001]]

**Bearer\_of**

**Bearer\_of** in contrast to inherence, is non-redundantly time-indexed, since if *a* is a bearer of some *b* only at some time during which *a* exists, but *b* cannot similarly inhere in *a* only at some times during which *b* exists.

a(bearer\_of)[Definition: *a* **bearer\_of** *b* **at** *t =*Def. *b* **s-depends on** *a* **at** *t* & *a* is an *independent continuant* & *b* exists at *t.* [053-002]]

a(bearer\_of)[Domain: *independent continuant*]

a(bearer\_of)[Range: *specifically dependent continuant*]

See also the discussion of **has\_material\_basis\_in** below.

**]****The located\_at relation**

a(located\_at)[Elucidation: a **located\_at** r **at** t means that r is a spatial region in which independent continuant a is exactly located [041-002]]

a(located\_at)[Domain: independent continuant]

a(located\_at)[Range: spatial region]

This is a primitive relation between an *independent continuant*, a spatial region which it occupies, and a time. This is a relation of exact location; the size, shape, orientation and location of *a* fit exactly to the size, shape and location of *r.* Thus for example if there are cavities in the interior of *a* then there are corresponding holes in the interior of *r.*

Clearly, normal usage will involve not assertions of exact location, but rather more liberal statements for example: John is in London, Mary is in her hotel room, Carlo is in his mother’s womb, which will involve assertions of which are formulated using the located\_in relation as defined below.

a(located\_at)[Axiom: every region *r* is located\_at *r* at all times. [042-002]

a(located\_at)[Axiom: if *a* located at *r* at *t* & *a′* continuant\_part\_of *a* at *t*, then there is some *r′* which is continuant\_part\_of *r* at ***t***& such that *a′* located\_at *r′* at *t*. [043-001]]

## The located\_in relation

The **located\_in** relation links independent continuants which are not spatial regions..

a(located\_in)[Definition: a **located\_in** b **at** t = Def. a and b are independent continuants, and the region **at** which a is **located at** t is a (proper or improper) **continuant\_part\_of** the region **at** which b is **located at** t. [045-001] ]

a(located\_in)[Domain: independent continuant]

a(located\_in)[Range: independent continuant]

as(located\_in)[Examples: your arm **located\_in** your body\; this stem cell **located\_in** this portion of bone marrow\; this portion of cocaine **located\_in** this portion of blood\; Mary **located\_in** Salzburg\; the Empire State Building **located\_in** New York. ]

a(located\_in)[Axiom: **Located\_in** is transitive. [046-001]

*a* **located\_in** *b* at *t* and *b* **located\_in** *c* at *t*, then *a* **located\_in** *c*]

Axiom: For all material entities *a* and *b*, parthood implies location:

if *a* **continuant\_part\_of** *b* **at** *t*, then *a* is **located\_in** *b* **at** *t.* [047-001]

Sites and boundaries, too, may stand in the **located\_in** relation, as for example when we say that 5th Avenue is **located in** New York, or that a portion of the Franco-German boundary is **located in** the Rhein valley. Notethat *object aggregates*, *aggregate of sites* can also stand in the **located\_in** relation.

**Problem cases for the located\_in relation**

As pointed out in [52] there are problem cases for this account, in that, for example an insect located near the stem of a wine glass would be counted as **located\_in** the wine glass; similarly crumbs placed in the hole of a donut would be counted as **located\_in** the donut. Briefly, users of **located\_in** should use an intuitive test to the effect that: if *a* is not in the interior of *b* but is rather in some hole or cavity attached to *b*’s outer boundary, then *a* **located­\_in** *b* will obtain only if this hole is a fillable hole in the sense defined by Casati and Varzi [52]. The cup-shaped hole in the wine glass is fillable in this sense; not however the concave spaces around the stem.

**Chaining rules**

a(located\_in)[Axiom: for all independent continuants *a*, *b*, and *c*: if *a* **continuant\_part\_of** *b* **at** *t* & *b* **located\_in** *c* **at** *t*, then *a* **located\_in** *c* **at** *t*. [048-001]]

a(located\_in)[Axiom: for all independent continuants *a*, *b*, and *c*: if *a* **located\_in** *b* **at** *t* & *b* **continuant\_part\_of** *c* **at** *t*, then *a* **located\_in** *c* **at** *t*. [049-001]]

**Relation of realization**

a(realization)[Elucidation: to say that *a* **realizes** *b* **at** *t* is to assert that

there is some *material entity* *c*

& *a* is a *process* in which **has participant** *c* **at** temporal interval *t*

& *b* is a disposition or role of which *c* is **bearer at** *t*

& the type instantiated by *a* is correlated with the type instantiated by *b*. [059-002]]

a(realization)[Theorem: if a realizable entity *a* is realized in a process *p*, then *p* stands in the **has\_participant** relation to the bearer of *a*. [106-002] ]

a(realization)[Axiom: All *realizable dependent continuants* have *material entities* or *sites* as their **bearers**. [060-001] ]

**]Defined relations**

a(role\_of)[Definition: *a* **role\_of** *b* **at** *t =*Def. *a* is a *role* and *a* **inheres\_in** *b* **at** *t*. [065-001]]

a(disposition\_of)[Definition: *a* **disposition\_of** *b* **at** *t =*Def. *a* is a *disposition* and *a* **inheres\_in** *b* **at** *t*. [066-001] ]

a(function\_of)[Definition: *a* **function\_of** *b* **at** *t =*Def. *a* is a *function* and *a* **inheres\_in** *b* **at** *t*. [067-001] ]

a(has\_role)[Definition: *a* **has\_role** *b* **at** *t =*Def. *b* **role\_of** *a* **at** *t*. [068-001] ]

a(has\_disposition)[Definition: *a* **has\_disposition** *b* **at** *t =*Def. *b* **disposition\_of** *a* **at** *t*. [069-001] ]

a(has\_function)[Definition: *a* **has\_function** *b* **at** *t =*Def. *b* **function\_of** *a* **at** *t*. [070-001] ]

**Material\_basis**

Dispositions (and thus also functions) are introduced into BFO in order to provide a means for referring to what we can think of as the potentials or powers of things in the world without the need to quantify over putative ‘possible worlds’ or ‘possible objects’. Whenever a disposition exists, then it is a disposition of some thing, namely its material bearer. Dispositions exist in every case because there is some corresponding portion of reality that is non-dispositional in nature, which we call the material basis of the disposition. This portion of reality is not in every case identical with the bearer of the disposition. The relevant relation can be elucidated as follows:

a(has\_material\_basis)[Elucidation: *a* **has\_material\_basis** *b* **at** *t* means:

*a* is a *disposition*

& *b* is a *material entity*

& there is some *c* **bearer\_of** *a* **at** *t*

& *b* **continuant\_part\_of** *c* **at** *t*

& *c* **has\_disposition** *d* **at** *t* because *b* **continuant\_part\_of** *c* at *t*. [071-001] ]

as(has\_material\_basis)[Examples: the material basis of John’s disposition to cough is the viral infection in John’s upper respiratory tract\; the material basis of the disposition to wear unevenly of John’s tires is the worn suspension of his car. ]

### 

### Generic\_Dependence

a(g-depends on)[Elucidation: *a* **g-depends on** *b* **at** *t*1 means: *a* exists **at** *t*1 and *b* exists **at** *t*1

& for some type *B* it holds that (*b* **instantiates** *B* at *t*1)

& necessarily, for all *t* (if *a* exists **at *t*** then some **instance\_of** *B* exists **at** *t*)

& not (*a* **s-depends\_on** *b* **at** *t*1). [072-002]]

a(g-depends on)[Domain: *generically dependent continuant*]

a(g-depends on)[Range: *independent continuant*]

a(g-depends on)[Axiom: if *a* **g-depends\_on** *b* at some time *t*, then *a* **g-depends**\_on something at all times at which it exists. [073-001] ]

a(concretization)[Elucidation: *a* **concretizes** *b* **at** *t* means*:* *a* is a *specifically dependent continuant* & *b* is a *generically dependent continuant* & for some *material entity c, a* **s-depends** on *c* **at** *t* and *b* **g-depends** on *c* **at** *t*, and if *b* migrates from bearer *c* to another bearer *d* than a copy of *a* will be created in *d.* [075-001]]

The data in your database are patterns instantiated as *quality* instances in your hard drive. The database itself is an aggregate of such patterns. When you create the database you create a particular instance of the *generically dependent continuant* type *database*. Each entry in the database is an instance of the *generically dependent continuant* type *datum*.

Data, databases, pdf files, novels, and other information artifacts are thus analogous to other created artifacts such as paintings or sculptures. They differ from the latter, however, in that, once they have been created, they can exist in many copies. These many copies exist because of a templating process. Only where such a templating process exists do we have the sorts of patterns which are *generically dependent* continuants.

*Generically dependent continuants* can be **concretized** in multiple ways; you may concretize a poem as a pattern of memory traces in your head. You may concretize a piece of software by installing it in your computer. You may concretize a recipe which you find in a cookbook by turning it into a plan which exists as a *realizable dependent continuant* in your head.

a(concretization)[Axiom: if *a* **g-depends** on *b* at some time *t*, then there is some *c*,which isa **concretization** of *a* and which **s-depends** on *b* **at** *t.* [076-001]]

## Occupies

a(occupies)[Elucidation: a **occupies** r. This is a primitive relation between an *occurrent* and the *spatiotemporal region* which is its spatiotemporal extent. [082-002]]

Domain: *occurrent*

Range: *spatiotemporal region*

The **occupies** relation is the counterpart, on the *occurrent* side, of the relation **located\_at.**

Spatiotemporal regions are such that they can be **occupied\_by** processes.

as(spatiotemporal region)[Examples: the *spatiotemporal region* **occupied** by a human life\, the *spatiotemporal region* **occupied** by the development of a cancer tumor\, the *spatiotemporal region* **occupied** by a *process* of cellular meiosis. ]

a(temporal region)[Axiom: Every *temporal region* *r* is such that *r* occupies *r.* [119-001] ]

a(temporal region)[Axiom: All parts of temporal regions are temporal regions. [101-001] ]

**Spans**

a(occupies)[Elucidation: a **spans** r. This is a primitive relation between an *occurrent* and the *temporal* *region* upon which the *spatiotemporal region* it occupies projects. [132-001]]

Domain: *occurrent*

Range: *temporal region*

**]****Participation**

a(has\_participant)[Elucidation**: has\_participant is an** instance-level relation between a process, a continuant, and a time at which the continuant participates in some way in the occurrent. [086-002]]

a(has\_participant)[Domain**:** process]

a(has\_participant)[Range**:** *independent continuant*, *specifically dependent continuant*, *generically dependent continuant*]

a(has\_participant)[Axiom: if *a* **has\_participant** *b***at** *t* then *a* is an *occurrent*. [087-001] ]

a(has\_participant)[Axiom: if *a* **has\_participant** *b***at** *t* then *b* is a *continuant*. [088-001] ]

a(has\_participant)[Axiom: if *a* **has\_participant** *b***at** *t* then *b* exists **at** *t*. [089-001] ]

Participation always involves some material entity

a(has\_participant)[Axiom: if *a* **has\_participant** *b***at** *t* & *b* is a *specifically* *dependent continuant*, then

there is some *material entity c*, *b* **s-depends on** *c* **at** *t* & *a* **s-depends on** *c* **at** *t*. [090-002] ]

a(has\_participant)[Axiom: if *a* **has\_participant** *b***at** *t* & *b* is a *generically dependent continuant*, then

there is some *material entity c*, *b* **g-depends on** *c* **at** *t* & *a* **s-depends on** *c* **at** *t.* [091-002] ]

Thus both specifically and generically dependent entities participate in processes – for example when a file is copied from one hard drive to another – but only *via* the bearers of their specifically dependent concretizations. The underlying idea is that when something changes, then a material entity changes. All change supervenes in this sense on material change.

**process\_profile­\_of**

We introduce the relation process\_profile­\_ofbetween one process and another surrounding process, as a special of occurrent parthood relation, which we elucidate as follows:

Elucidation: *a* **process\_profile\_of** *b* holds when

*a* **proper\_continuant\_part\_of** *b*

& there is some **proper\_continuant\_part** *c* of *b* which has no parts in common with *a* and which is reciprocally dependent on *a*

& *a*, *b* and *c* occupythe same temporal region [094-004]

**]****The precedes relation NOT SURE WHAT TO DO HERE>**

Preceded\_by, defined in RO, is not defined in the BFO2 Reference, except by citation to a paper. That paper does not provide axioms on the relation. The RO definition from<http://obofoundry.org/ro/> is given below.

As there is an open issue regarding the OWL rendering this should be fixed in the reference.

The RO page definition is suboptimal as the quantification and type of t (instant, interval) isn't stated. <http://krr.meraka.org.za/~aow2010/Trentelman-etal.pdf> offers:

Using this theory we can define relations such as preceded by and immediately preceded by, whereby a process p� ispreceded by a process p   if and only if the last temporal instant of p is earlier than the first temporal instant of p�, and a process p� is immediately preceded by a process p if and only if there exists a temporal instant which is both the first instant of p� and the last instant of p.

This is better in that it is clear that time instants are used, and because it more clearly expresses the intent of the relation, but needs the relations 'first temporal instant' and 'last temporal instant' are needed (process->time instant) are needed.

Please see <http://code.google.com/p/bfo/issues/detail?id=15> which discussed changing the domain/range of the relation to occurrent.