

BFO 2020 Occurrent Mereology Axioms

(1) Proper occurrent part of and has proper occurrent part are inverse relations

$$\forall a,b (\text{properOccurrentPartOf}(a,b) \leftrightarrow \text{hasProperOccurrentPart}(b,a))$$

(2) A proper occurrent part of b means a is an occurrent part of b and a is not the same as b

$$\forall x,y (\text{properOccurrentPartOf}(x,y) \leftrightarrow \text{occurrentPartOf}(x,y) \wedge x \neq y)$$

(3) Proper occurrent part of has domain occurrent and range occurrent

$$\forall a,b (\text{properOccurrentPartOf}(a,b) \rightarrow \exists t \text{instanceOf}(a,\text{occurrent},t) \wedge \exists t \text{instanceOf}(b,\text{occurrent},t))$$

(4) Every process has a process boundary

$$\forall p (\exists t \text{instanceOf}(p,\text{process},t) \rightarrow \exists pb,t (\text{instanceOf}(pb,\text{processBoundary},t) \wedge \text{occurrentPartOf}(pb,p)))$$

(5) At least one process boundary needs to be at the first or last instant of the process it bounds

$$\begin{aligned} \forall p (\exists tp \text{instanceOf}(p,\text{process},tp) \rightarrow \exists pb,tb,tp (\text{occupiesTemporalRegion}(p,tp) \wedge \text{occurrentPartOf}(pb,p) \\ \wedge \text{occupiesTemporalRegion}(pb,tb) \wedge \text{instanceOf}(pb,\text{processBoundary},tb) \\ \wedge (\exists ltp,ftp (\text{hasFirstInstant}(tp,ftp) \wedge \text{hasLastInstant}(tp,ltp) \\ \wedge (tb=ftp \vee tb=ltp)))))) \end{aligned}$$

(6) Definition of temporal part for temporal regions

$$\forall b,c (\exists t \text{instanceOf}(b,\text{temporalRegion},t) \wedge \exists t \text{instanceOf}(c,\text{temporalRegion},t) \rightarrow (\text{temporalPartOf}(b,c) \leftrightarrow \text{occurrentPartOf}(b,c)))$$

(7) Occurrent part of is transitive

$$\forall a,b,c (\text{occurrentPartOf}(a,b) \wedge \text{occurrentPartOf}(b,c) \rightarrow \text{occurrentPartOf}(a,c))$$

(8) If a occurrent part of b then if a is an instance of process boundary then b is an instance of process or process boundary

$$\begin{aligned} \forall p,q (\text{occurrentPartOf}(p,q) \rightarrow (\exists t \text{instanceOf}(p,\text{processBoundary},t) \\ \rightarrow \exists t (\text{instanceOf}(q,\text{process},t) \vee \text{instanceOf}(q,\text{processBoundary},t)))) \end{aligned}$$

(9) If one occurrent is part of another, then the temporal region on which the former projects is a part of the temporal region on which the latter projects

$$\forall o1,o2 (\text{occurrentPartOf}(o1,o2) \rightarrow \forall t (\text{existsAt}(o1,t) \rightarrow \text{existsAt}(o2,t)))$$

(10) B is a temporal part of process or process boundary c if b is occurrent part of c and b's spatiotemporal region is temporal part of c's spatiotemporal region

$$\begin{aligned} \forall b,c ((\exists t (\text{instanceOf}(b,\text{process},t) \vee \text{instanceOf}(b,\text{processBoundary},t)) \\ \wedge (\exists t (\text{instanceOf}(c,\text{process},t) \vee \text{instanceOf}(c,\text{processBoundary},t))) \\ \rightarrow (\text{temporalPartOf}(b,c) \leftrightarrow \exists bs,cs (\text{occurrentPartOf}(b,c) \wedge \text{occupiesSpatiotemporalRegion}(b,bs) \\ \wedge \text{occupiesSpatiotemporalRegion}(c,cs) \wedge \text{temporalPartOf}(bs,cs)))))) \end{aligned}$$

(11) If a occurrent part of b then if a is an instance of process then b is an instance of process

$$\forall p,q (\text{occurrentPartOf}(p,q) \rightarrow (\exists t \text{instanceOf}(p,\text{process},t) \rightarrow \exists t \text{instanceOf}(q,\text{process},t)))$$

(12) A process boundary is any temporal part of a process that has no proper temporal parts.

$$\begin{aligned} \forall pb (\exists t \text{instanceOf}(pb,\text{processBoundary},t) \leftrightarrow (\exists p (\text{temporalPartOf}(pb,p) \wedge \exists t \text{instanceOf}(p,\text{process},t)) \\ \wedge (\exists t (\text{occupiesTemporalRegion}(pb,t) \wedge \text{instanceOf}(t,\text{temporalInstant},t)))))) \end{aligned}$$

(13) If a has occurrent part b then if a is an instance of process then b is an instance of process or process boundary

$$\begin{aligned} \forall p,q (\text{hasOccurrentPart}(p,q) \rightarrow (\exists t \text{instanceOf}(p,\text{process},t) \\ \rightarrow \exists t (\text{instanceOf}(q,\text{process},t) \vee \text{instanceOf}(q,\text{processBoundary},t)))) \end{aligned}$$

(14) Two spatiotemporal regions are parts when they are temporal parts and their spatial projects are always parts

$$\begin{aligned} & \forall st1, st2 (\exists t \text{instanceOf}(st1, \text{spatiotemporalRegion}, t) \\ & \quad \wedge \exists t \text{instanceOf}(st2, \text{spatiotemporalRegion}, t) \\ & \quad \rightarrow (\text{occurrentPartOf}(st1, st2) \\ & \quad \leftrightarrow (\exists t1, t2 (\text{temporallyProjectsOnto}(st1, t1) \wedge \text{temporallyProjectsOnto}(st2, t2) \\ & \quad \quad \wedge \text{temporalPartOf}(t1, t2))) \\ & \quad \wedge (\forall t (\text{existsAt}(st1, t) \\ & \quad \quad \rightarrow \exists s1, s2, tp (\text{temporalPartOf}(tp, t) \wedge \text{spatiallyProjectsOnto}(st1, s1, tp) \\ & \quad \quad \quad \wedge \text{spatiallyProjectsOnto}(st2, s2, tp) \\ & \quad \quad \quad \wedge \text{continuantPartOf}(s1, s2, tp)))))) \end{aligned}$$

(15) Occurrent part of is antisymmetric

$$\forall a, b (\text{occurrentPartOf}(a, b) \wedge \text{occurrentPartOf}(b, a) \rightarrow a = b)$$

(16) Occurrent part of and has occurrent part are inverse relations

$$\forall a, b (\text{occurrentPartOf}(a, b) \leftrightarrow \text{hasOccurrentPart}(b, a))$$

(17) B temporal part c (both spatiotemporal regions) iff b temporal projection is part of c's temporal projection, and for all parts of b's existence, if it spatially projects onto s at that time, then so does c

$$\begin{aligned} & \forall b, c (\exists t \text{instanceOf}(b, \text{spatiotemporalRegion}, t) \wedge \exists t \text{instanceOf}(c, \text{spatiotemporalRegion}, t) \\ & \quad \rightarrow (\text{temporalPartOf}(b, c) \\ & \quad \leftrightarrow \exists tb, tc (\text{temporallyProjectsOnto}(b, tb) \wedge \text{temporallyProjectsOnto}(c, tc) \\ & \quad \quad \wedge \text{occurrentPartOf}(tb, tc) \\ & \quad \quad \wedge (\forall tp (\text{occurrentPartOf}(tp, tb) \wedge \exists s \text{spatiallyProjectsOnto}(b, s, tp) \\ & \quad \quad \quad \rightarrow \exists s (\text{spatiallyProjectsOnto}(b, s, tp) \\ & \quad \quad \quad \wedge \text{spatiallyProjectsOnto}(c, s, tp)))))) \end{aligned}$$

(18) If a occurrent part of b then if a is an instance of temporal region then b is an instance of temporal region, and vice versa

$$\begin{aligned} & \forall p, q (\text{occurrentPartOf}(p, q) \\ & \quad \rightarrow (\exists t \text{instanceOf}(p, \text{temporalRegion}, t) \leftrightarrow \exists t \text{instanceOf}(q, \text{temporalRegion}, t))) \end{aligned}$$

(19) If a has occurrent part b then if a is an instance of process boundary then b is an instance of process boundary

$$\begin{aligned} & \forall p, q (\text{hasOccurrentPart}(p, q) \\ & \quad \rightarrow (\exists t \text{instanceOf}(p, \text{processBoundary}, t) \rightarrow \exists t \text{instanceOf}(q, \text{processBoundary}, t))) \end{aligned}$$

(20) Occurrent part of has a unique product

$$\begin{aligned} & \forall x, y (\exists t (\text{instanceOf}(x, \text{occurrent}, t) \wedge \text{instanceOf}(y, \text{occurrent}, t) \\ & \quad \wedge \text{instanceOf}(t, \text{temporalRegion}, t)) \\ & \quad \rightarrow (\exists w (\text{occurrentPartOf}(w, x) \wedge \text{occurrentPartOf}(w, y)) \\ & \quad \rightarrow \exists z (\forall w (\text{occurrentPartOf}(w, z) \leftrightarrow \text{occurrentPartOf}(w, x) \wedge \text{occurrentPartOf}(w, y)))) \end{aligned}$$

(21) Occurrent part of has domain occurrent and range occurrent

$$\forall a, b (\text{occurrentPartOf}(a, b) \rightarrow \exists t \text{instanceOf}(a, \text{occurrent}, t) \wedge \exists t \text{instanceOf}(b, \text{occurrent}, t))$$

(22) If a occurrent part of b then if a is an instance of spatiotemporal region then b is an instance of spatiotemporal region, and vice versa

$$\begin{aligned} & \forall p, q (\text{occurrentPartOf}(p, q) \\ & \quad \rightarrow (\exists t \text{instanceOf}(p, \text{spatiotemporalRegion}, t) \\ & \quad \quad \leftrightarrow \exists t \text{instanceOf}(q, \text{spatiotemporalRegion}, t))) \end{aligned}$$

(23) Occurrent part of is reflexive

$$\forall a (\exists t \text{instanceOf}(a, \text{occurrent}, t) \rightarrow \text{occurrentPartOf}(a, a))$$

(24) Proper temporal part of has domain occurrent and range occurrent

$$\begin{aligned} & \forall a, b (\text{properTemporalPartOf}(a, b) \\ & \quad \rightarrow \exists t \text{instanceOf}(a, \text{occurrent}, t) \wedge \exists t \text{instanceOf}(b, \text{occurrent}, t)) \end{aligned}$$