

BFO 2020 Temporal Region Axioms

Has last instant and last instant of are inverse relations [wal-1]

$$\forall a,b(\text{hasLastInstant}(a,b) \leftrightarrow \text{lastInstantOf}(b,a))$$

Has first instant and first instant of are inverse relations [bon-1]

$$\forall a,b(\text{hasFirstInstant}(a,b) \leftrightarrow \text{firstInstantOf}(b,a))$$

Temporal part of and has temporal part are inverse relations [boo-1]

$$\forall a,b(\text{temporalPartOf}(a,b) \leftrightarrow \text{hasTemporalPart}(b,a))$$

Temporal part of for occurrents implies occurrent part of [bal-1]

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

Temporal part of is reflexive [dbj-2]

$$\forall a(\text{instanceOf}(a,\text{temporalRegion},a) \rightarrow \text{temporalPartOf}(a,a))$$

Proper temporal part of and has proper temporal part are inverse relations [dbc-1]

$$\forall a,b(\text{properTemporalPartOf}(a,b) \leftrightarrow \text{hasProperTemporalPart}(b,a))$$

If something is an instance of temporal region at t, then t is part of that temporal region [njq-1]

$$\forall ti,t(\text{instanceOf}(ti,\text{temporalRegion},t) \rightarrow \text{temporalPartOf}(t,ti))$$

Temporal part of is reflexive [bvr-1]

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

Temporal part of is antisymmetric [zdq-1]

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

Proper temporal part of is asymmetric [aqu-1]

$$\forall a,b(\text{properTemporalPartOf}(a,b) \rightarrow \neg \text{properTemporalPartOf}(b,a))$$

Has last instant is functional on second argument [ogd-1]

$$\forall p,q,r(\text{hasLastInstant}(p,q) \wedge \text{hasLastInstant}(p,r) \rightarrow q=r)$$

Has first instant is functional on second argument [fwf-1]

$$\forall p,q,r(\text{hasFirstInstant}(p,q) \wedge \text{hasFirstInstant}(p,r) \rightarrow q=r)$$

A proper temporal part of b means a is a temporal part of b and b a is not the same as b [aeu-1]

$$\forall x,y(\text{properTemporalPartOf}(x,y) \leftrightarrow \text{temporalPartOf}(x,y) \wedge x \neq y)$$

The only part of a temporal instant is itself [pir-2]

$$\forall p,q(\text{instanceOf}(p,\text{temporalInstant},p) \wedge \text{hasTemporalPart}(p,q) \rightarrow p=q)$$

Instance of is disjunctive on third argument, a temporal region [qaf-1]

$$\forall p,q,r,s(\text{instanceOf}(p,q,r) \wedge \text{temporalPartOf}(s,r) \rightarrow \text{instanceOf}(p,q,s))$$

Temporal part of is transitive [bfq-1]

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

The first and last time points for an instant are the instant itself [info-1]

$$\forall i(\text{instanceOf}(i,\text{temporalInstant},i) \leftrightarrow \text{hasFirstInstant}(i,i) \wedge \text{hasLastInstant}(i,i))$$

Temporal regions are instances at themselves [tvx-2]

$$\forall a,u(\exists t(\text{instanceOf}(a,\text{temporalRegion},t) \wedge \text{instanceOf}(a,u,t)) \leftrightarrow \text{instanceOf}(a,u,a))$$

If a temporal part of b then if a is an instance of temporal region then b is an instance of temporal region, and vice versa [mjn-2]

$$\forall p,q(\text{temporalPartOf}(p,q) \rightarrow (\text{instanceOf}(p,\text{temporalRegion},p) \leftrightarrow \text{instanceOf}(q,\text{temporalRegion},q)))$$

Has last instant has domain temporal region and range temporal instant [jtk-2]

$$\forall a,b(\text{hasLastInstant}(a,b) \rightarrow \text{instanceOf}(a,\text{temporalRegion},a) \wedge \text{instanceOf}(b,\text{temporalInstant},b))$$

Proper temporal part of is transitive [mns-1]

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

Has first instant has domain temporal region and range temporal instant [fwk-2]

$$\forall a,b(\text{hasFirstInstant}(a,b) \rightarrow \text{instanceOf}(a,\text{temporalRegion},a) \wedge \text{instanceOf}(b,\text{temporalInstant},b))$$

If the last instant of a temporal region precedes the first instant of another, then the first region precedes the second [qqv-1]

$$\forall i_1,i_2,l_1,f_2(\text{hasLastInstant}(i_1,l_1) \wedge \text{hasFirstInstant}(i_2,f_2) \wedge \text{precedes}(l_1,f_2) \rightarrow \text{precedes}(i_1,i_2))$$

Any temporal region has a first and last instant [daf-1]

$$\forall i(\text{instanceOf}(i,\text{temporalRegion},i) \rightarrow \exists t_1,t_2(\text{hasFirstInstant}(i,t_1) \wedge \text{hasLastInstant}(i,t_2)))$$

All temporal regions are part of a temporal interval [mvd-1]

$$\forall t(\text{instanceOf}(t,\text{temporalRegion},t) \rightarrow \exists i(\text{instanceOf}(i,\text{temporalInterval},i) \wedge \text{temporalPartOf}(t,i)))$$

Temporal part of has domain occurrent and range occurrent [ruj-1]

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

First instant of a temporal region that is not an instant precedes last instant [rzv-1]

$$\forall t,ft,lt(\neg \text{instanceOf}(t,\text{temporalInstant},t) \wedge \text{hasFirstInstant}(t,ft) \wedge \text{hasLastInstant}(t,lt) \rightarrow \text{precedes}(ft,lt))$$

If one temporal region precedes another then the first last time point precedes the second first time point [miz-1]

$$\forall t_1,t_2,l_1,f_2(\text{precedes}(t_1,t_2) \wedge \text{hasLastInstant}(t_1,l_1) \wedge \text{hasFirstInstant}(t_2,f_2) \wedge l_1 \neq f_2 \rightarrow \text{precedes}(l_1,f_2))$$

If a temporal part of b then if a is an instance of one dimensional temporal region then b is an instance of one dimensional temporal region [mei-2]

$$\forall p,q(\text{temporalPartOf}(p,q) \rightarrow (\text{instanceOf}(p,\text{oneDimensionalTemporalRegion},p) \rightarrow \text{instanceOf}(q,\text{oneDimensionalTemporalRegion},q)))$$

A one dimensional temporal region has at least one interval as part [jhe-1]

$$\forall t(\text{instanceOf}(t,\text{oneDimensionalTemporalRegion},t) \rightarrow \exists p(\text{temporalPartOf}(p,t) \wedge \text{instanceOf}(p,\text{temporalInterval},p)))$$

If a has temporal part b then if a is an instance of zero dimensional temporal region then b is an instance of zero dimensional temporal region [bnt-2]

$$\forall p,q(\text{hasTemporalPart}(p,q) \rightarrow (\text{instanceOf}(p,\text{zeroDimensionalTemporalRegion},p) \rightarrow \text{instanceOf}(q,\text{zeroDimensionalTemporalRegion},q)))$$

Temporal instants are totally ordered [qnf-1]

$$\forall t_1,t_2(\text{instanceOf}(t_1,\text{temporalInstant},t_1) \wedge \text{instanceOf}(t_2,\text{temporalInstant},t_2) \rightarrow \text{precedes}(t_1,t_2) \vee \text{precedes}(t_2,t_1) \vee t_1=t_2)$$

Temporal region is the union of zero dimensional temporal region and one dimensional temporal region [hgs-1]

$$\forall i,t(\text{instanceOf}(i,\text{temporalRegion},t) \rightarrow (\text{instanceOf}(i,\text{zeroDimensionalTemporalRegion},t) \vee \text{instanceOf}(i,\text{oneDimensionalTemporalRegion},t)))$$

If the last instant of a temporal region is the first instant of another, the first region precedes the second [suk-1]

$$\begin{aligned} &\forall i1,i2,l1,f2 (\neg \text{instanceOf}(i1,\text{temporalInstant},i1) \wedge \neg \text{instanceOf}(i2,\text{temporalInstant},i2) \\ &\quad \wedge \text{hasLastInstant}(i1,l1) \wedge \text{hasFirstInstant}(i2,f2) \wedge l1=f2 \\ &\quad \rightarrow \text{precedes}(i1,i2)) \end{aligned}$$

If a has temporal part b then if a is an instance of one dimensional temporal region then b is an instance of one dimensional temporal region or zero dimensional temporal region [eeg-2]

$$\begin{aligned} &\forall p,q (\text{hasTemporalPart}(p,q) \\ &\quad \rightarrow (\text{instanceOf}(p,\text{oneDimensionalTemporalRegion},p) \\ &\quad \rightarrow \text{instanceOf}(q,\text{oneDimensionalTemporalRegion},q) \\ &\quad \vee \text{instanceOf}(q,\text{zeroDimensionalTemporalRegion},q))) \end{aligned}$$

A last instant is either part of an extended region or is preceded by it [acg-1]

$$\begin{aligned} &\forall l,i (\text{instanceOf}(l,\text{temporalInstant},l) \wedge \text{instanceOf}(i,\text{temporalRegion},i) \\ &\quad \wedge \neg \text{instanceOf}(i,\text{temporalInstant},i) \wedge \text{hasLastInstant}(i,l) \\ &\quad \rightarrow (\neg \text{temporalPartOf}(l,i) \leftrightarrow \text{precedes}(i,l))) \end{aligned}$$

A first instant is either part of an extended region or precedes it [qga-1]

$$\begin{aligned} &\forall f,i (\text{instanceOf}(f,\text{temporalInstant},f) \wedge \text{instanceOf}(i,\text{temporalRegion},i) \\ &\quad \wedge \neg \text{instanceOf}(i,\text{temporalInstant},i) \wedge \text{hasFirstInstant}(i,f) \\ &\quad \rightarrow (\neg \text{temporalPartOf}(f,i) \leftrightarrow \text{precedes}(f,i))) \end{aligned}$$

If two temporal intervals do not overlap then one of them precedes the other [owb-1]

$$\begin{aligned} &\forall t1,t2 (\text{instanceOf}(t1,\text{temporalInterval},t1) \wedge \text{instanceOf}(t2,\text{temporalInterval},t2) \\ &\quad \wedge \neg (\exists \text{part} (\text{temporalPartOf}(\text{part},t1) \wedge \text{temporalPartOf}(\text{part},t2))) \\ &\quad \rightarrow \text{precedes}(t1,t2) \vee \text{precedes}(t2,t1)) \end{aligned}$$

The first temporal instant is such that it precedes every part of the interval that doesn't have the first instant as part [ixz-1]

$$\begin{aligned} &\forall fi,i (\text{instanceOf}(fi,\text{temporalInstant},fi) \wedge \text{instanceOf}(i,\text{temporalRegion},i) \\ &\quad \wedge \neg \text{instanceOf}(i,\text{temporalInstant},i) \\ &\quad \rightarrow (\text{hasFirstInstant}(i,fi) \\ &\quad \rightarrow \forall ip (\text{temporalPartOf}(ip,i) \wedge \neg \text{temporalPartOf}(fi,ip) \rightarrow \text{precedes}(fi,ip)))) \end{aligned}$$

The last temporal instant is such that every part of the interval that doesn't have the last instant as part precedes it [nhd-1]

$$\begin{aligned} &\forall li,i (\text{instanceOf}(li,\text{temporalInstant},li) \wedge \text{instanceOf}(i,\text{temporalRegion},i) \\ &\quad \wedge \neg \text{instanceOf}(i,\text{temporalInstant},i) \\ &\quad \rightarrow (\text{hasLastInstant}(i,li) \\ &\quad \rightarrow (\forall ip (\text{temporalPartOf}(ip,i) \wedge \neg \text{temporalPartOf}(li,ip) \rightarrow \text{precedes}(ip,li)))))) \end{aligned}$$

Intervals have no internal gaps [ekm-1]

$$\begin{aligned} &\forall i,\text{start},\text{end} (\text{instanceOf}(i,\text{temporalInterval},i) \wedge \text{hasFirstInstant}(i,\text{start}) \\ &\quad \wedge \text{hasLastInstant}(i,\text{end}) \\ &\quad \rightarrow \neg (\exists \text{gap},\text{gapStart},\text{gapEnd} (\text{hasFirstInstant}(\text{gap},\text{gapStart}) \\ &\quad \wedge \text{hasLastInstant}(\text{gap},\text{gapEnd}) \\ &\quad \wedge \text{precedes}(\text{gapEnd},\text{end}) \wedge \text{precedes}(\text{start},\text{gapStart}) \\ &\quad \wedge \neg \text{temporalPartOf}(\text{gap},i)))) \end{aligned}$$

Temporal part of has weak supplementation [vbw-1]

$$\begin{aligned} &\forall x,y (\text{instanceOf}(x,\text{temporalRegion},x) \wedge \text{instanceOf}(y,\text{temporalRegion},y) \\ &\quad \rightarrow (\text{properTemporalPartOf}(x,y) \\ &\quad \rightarrow \exists z (\text{properTemporalPartOf}(z,y) \\ &\quad \wedge \neg (\exists \text{overlap} (\text{instanceOf}(\text{overlap},\text{temporalRegion},\text{overlap}) \\ &\quad \wedge \text{temporalPartOf}(\text{overlap},x) \wedge \text{temporalPartOf}(\text{overlap},z)))))) \end{aligned}$$

Any temporal instant that precedes the last instant of an interval and which is preceded by the first instant is part of the interval [zlp-1]

$$\begin{aligned} &\forall t,r (\text{instanceOf}(t,\text{temporalInstant},t) \wedge \text{instanceOf}(r,\text{temporalInterval},r) \\ &\quad \rightarrow \text{hasFirstInstant}(r,t) \vee \text{hasLastInstant}(r,t) \\ &\quad \vee (\exists f,l (\text{instanceOf}(r,\text{temporalInterval},r) \wedge \text{hasFirstInstant}(r,f) \\ &\quad \wedge \text{hasLastInstant}(r,l) \wedge \text{precedes}(t,l) \wedge \text{precedes}(f,t)) \\ &\quad \leftrightarrow \text{properTemporalPartOf}(t,r))) \end{aligned}$$

Two intervals are identical if their first and last instants are the same and if an instant is part of one of the intervals it is also part of the other [xkl-1]

$$\begin{aligned} &\forall i1,i2 (\text{instanceOf}(i1,\text{temporalInterval},i1) \wedge \text{instanceOf}(i2,\text{temporalInterval},i2) \\ &\quad \rightarrow (\exists f,l (\text{hasFirstInstant}(i1,f) \wedge \text{hasFirstInstant}(i2,f) \wedge \text{hasLastInstant}(i1,l) \\ &\quad \wedge \text{hasLastInstant}(i2,l) \wedge (\text{temporalPartOf}(l,i1) \leftrightarrow \text{temporalPartOf}(l,i2)) \\ &\quad \wedge (\text{temporalPartOf}(f,i1) \leftrightarrow \text{temporalPartOf}(f,i2))) \\ &\quad \rightarrow i1=i2)) \end{aligned}$$

Temporal part of has unique product [wsg-2]

$$\begin{aligned} & \forall x,y (\text{instanceOf}(x,\text{temporalRegion},x) \wedge \text{instanceOf}(y,\text{temporalRegion},y) \\ & \rightarrow (\exists o (\text{temporalPartOf}(o,x) \wedge \text{temporalPartOf}(o,y)) \\ & \rightarrow \exists z (\text{instanceOf}(z,\text{temporalRegion},z) \\ & \wedge (\forall w (\text{instanceOf}(w,\text{temporalRegion},w) \wedge \text{instanceOf}(z,\text{temporalRegion},z) \\ & \rightarrow (\text{temporalPartOf}(w,z) \\ & \leftrightarrow \text{temporalPartOf}(w,x) \wedge \text{temporalPartOf}(w,y)))))) \end{aligned}$$

An interval has no gaps [nui-1]

$$\begin{aligned} & \forall i,\text{start},\text{end} (\text{instanceOf}(i,\text{temporalInterval},i) \wedge \text{hasFirstInstant}(i,\text{start}) \\ & \wedge \text{hasLastInstant}(i,\text{end}) \\ & \rightarrow \neg (\exists \text{gap},\text{gapStart},\text{gapEnd} (\neg \text{instanceOf}(\text{gap},\text{temporalInstant},\text{gap}) \\ & \wedge \text{hasFirstInstant}(\text{gap},\text{gapStart}) \\ & \wedge \text{hasLastInstant}(\text{gap},\text{gapEnd}) \\ & \wedge (\text{precedes}(\text{gapEnd},\text{end}) \\ & \vee (\text{temporalPartOf}(\text{end},i) \wedge \text{gapEnd}=\text{end})) \\ & \wedge (\text{precedes}(\text{start},\text{gapStart}) \\ & \vee (\text{temporalPartOf}(\text{start},i) \wedge \text{gapStart}=\text{start})) \\ & \wedge \neg \text{temporalPartOf}(\text{gap},i)))) \end{aligned}$$

Intervals have no gaps strong version every two instants without another in between bound an interval [cop-1]

$$\begin{aligned} & \forall i,\text{start},\text{end} (\text{instanceOf}(i,\text{temporalInterval},i) \wedge \text{hasFirstInstant}(i,\text{start}) \\ & \wedge \text{hasLastInstant}(i,\text{end}) \\ & \rightarrow \forall t1,t2 (\text{temporalPartOf}(t1,i) \wedge \text{temporalPartOf}(t2,i) \\ & \wedge \text{instanceOf}(t1,\text{temporalInstant},t1) \\ & \wedge \text{instanceOf}(t2,\text{temporalInstant},t2) \wedge \text{precedes}(t1,t2) \\ & \wedge \neg (\exists t3 (\text{instanceOf}(t3,\text{temporalInstant},t3) \wedge \text{precedes}(t1,t3) \\ & \wedge \text{precedes}(t3,t2))) \\ & \rightarrow \exists \text{fill} (\text{instanceOf}(\text{fill},\text{temporalInterval},\text{fill}) \\ & \wedge \text{hasFirstInstant}(\text{fill},t1) \wedge \text{hasLastInstant}(\text{fill},t2) \\ & \wedge \text{temporalPartOf}(\text{fill},i)))) \end{aligned}$$
