Does branching explain flow of time or is it the other way around?

Petr Švarný

Logic and Relativity, 2012

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Outline

1. Setup
   - Problem
   - Flow of time and branching models
2. The formalized interactions
   - FoT gives BCont a valuation
   - Example
   - Branches make FoT natural

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B-MODELS & FoT

The venture point

- Generalized flow of time can be formalized in Branching continuations and it adds the possibility of semantics to it.
- Generalized flow of time uses the term ontological definiteness as a basic notion.

B-MODELS & FoT

The interaction of branching models and flow of time

- (Does the framework of Branching Continuations entail the notion of a generalized flow of time?
- - OR -
- Does a generalized flow of time lead to a branching structure?)
- - AND -
- Does it help to solve the problem of now?

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GENERALIZED FLOW OF TIME

A generalized flow of time must have:

- worldlines with linear order of now-points
- ontological definiteness of past and present (!)
- a set of now-points on worldlines respecting the ontological definiteness

D. Dieks: Special relativity and the flow of time, 1988

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BRANCHING MODELS

Main ideas of Branching Continuations

- $(W, \leq)$
- Continuations, l-events
- $e_C, e/A$
- Branching Time+*Instants*-like models

T. Placek: Possibilities Without Possible Worlds/Histories, 2009

BCONT MODEL

1. $\mathcal{W}$ is a non-empty partially ordered set;
2. the ordering $\leq$ is dense on W;
3. W has no maximal elements;
4. every lower bounded chain $C \subseteq W$ has an infimum;
5. if a chain $C \subseteq W$ is upper bounded and $C \leq b$ then there is a unique minimum in $\{e \in W | C \leq e \wedge e \leq b\}$;
6. for every $x, y, e \in W$, if $e \not< x$ and $e \not< y$ then x and y are snake-linked in the subset $W_{\not> e} := \{e' \in W | e \not< e'\}$ of W;
7. if $x, y \in W$ and $W_{\leq xy} := \{e \in W | e \leq x \wedge e \leq y\} \neq \emptyset$ then $W_{\leq xy}$ has a maximal element;
8. for every $x_1, x_2 \in W$, if $\forall c : c \in CE \to c \not< x_i$ then x_1, x_2 are snake-linked in the subset $W_{\not> CE} := \{e \in W | \forall c \in CEe \not> c\}$ of W.

BT+I MODEL

A model $\langle W, \leq, S\rangle$ is said to be *(BT+Instants)-like* if it satisfies the following conditions:

- downward directedness,
- no backward forks,
- $\forall e, e' \in W$: if e, e' are incomparable by $\leq$, then there are $H_1, H_2 \in \Pi_m$ such that $H_1 \neq H_2$, $e \in H_1$ and $e' \in H_2$, where m is a maximal element of $W_{\leq ee'} = \{y | y \leq e \wedge y \leq e'\}$;

GFOT IN BCONT

- **Formalization of general FoT:**
  - worldline as chains of events
  - settings of now-points
  - ontological definiteness via valuation

P. Švarný: Flow of Time in BST/BCont Models and Related Semantical Observations, LOGICA 2012

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Outline

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PFF

For given $e_C, e/A$ and the model $\mathfrak{M} = \langle \mathfrak{G}, \mathcal{I} \rangle$, then:

- if ψ is $P_x\varphi$ for $x > 0 : \mathfrak{M}, e_C, e/A, X_{WI_{(e_C)},A} \Vdash \psi$ iff there is $e' \in \bigcup X_{WI_{(e_C)},A}$ such that $e' \cup A \in$ I-events and $int(e', e, WI_{(e)}, x)$ and $\mathfrak{M}, e_C, e'/A \Vdash \varphi$;
- if ψ is $Sett : \varphi : \mathfrak{M}, e_C, e/A, X_{WI_{(e_C)},A} \Vdash \psi$ iff for every evaluation point e/A' from fan $\mathcal{F}_{e/A} : \mathfrak{M}, e_C, e/A', X_{WI_{(e_C)},A} \Vdash \varphi$;
- if ψ is Now $: \varphi : \mathfrak{M}, e_C, e/A, X_{WI_{(e_C)},A} \Vdash \psi$ iff there is $e' \in X_{e_C,A}$ such that $e' \cup A \in$ I-events and $\mathfrak{M}, e_C, e'/A, X_{WI_{(e_C)},A} \Vdash \varphi$.

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Outline

SETTLEDNESS OF THE FUTURE

Formulation of the problem

Is there a difference between necessary future events and future events?

$$\mathfrak{M}, e_C, e_C/A, X_{Wl_{(e_C)},A} \models F_1\psi$$

vs

$$\mathfrak{M}, e_C, e_C/A, X_{Wl_{(e_C)},A} \models Sett : F_1\psi$$

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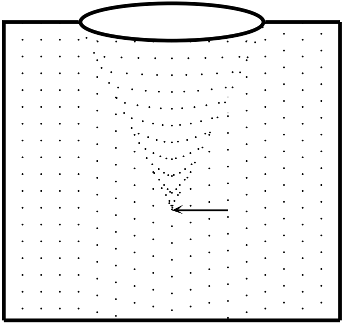
SETTLEDNESS OF THE FUTURE I

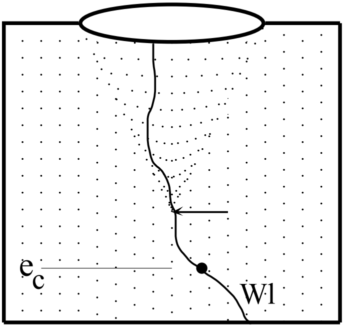
Choice event in BCont+FoT



A 2D BCont model with a CE.

SETTLEDNESS OF THE FUTURE II

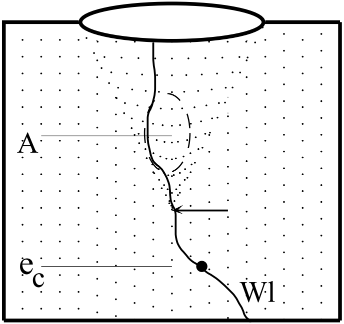
Worldlines in BCont+gFoT



Model with a worldline and moment of use.

SETTLEDNESS OF THE FUTURE III

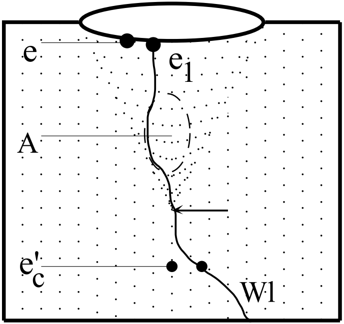
Continuations in BCont+gFoT



Adding the continuation *A*.

SETTLEDNESS OF THE FUTURE IV

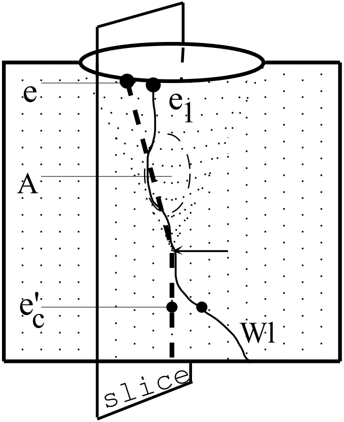
Continuations in BCont+gFoT



Adding the reference point e_1 and the point e that belongs to e_1's setting of now-points and where ψ holds.

SETTLEDNESS OF THE FUTURE V

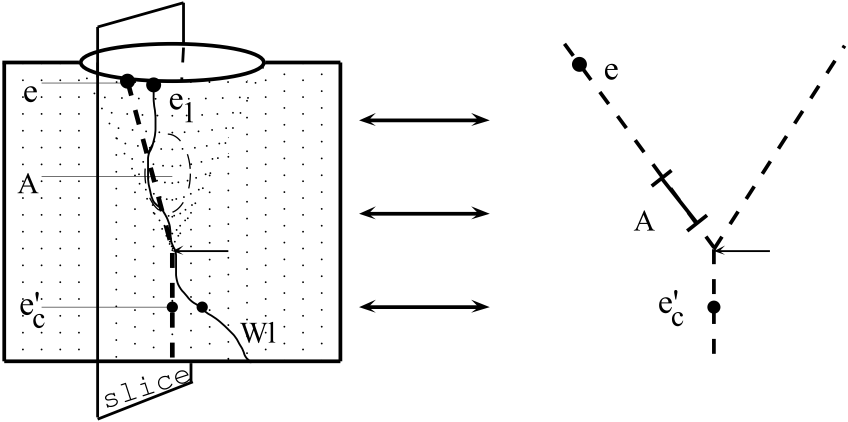
Continuations in BCont+gFoT



Preparing a slice going through point *e*.

SETTLEDNESS OF THE FUTURE VI

Continuations in BCont+gFoT



The final figure for *Sett* : $F_1\psi \not\equiv F_1\psi$.

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GFOT IN BCONT

GFoT with respect to BCont has the following properties:

- is a definition away from basic BCont structures;
- allows for a valuation on BCont structures.

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GFOT DEMANDS

Let *gFoT* a structure based on gFoT demands:

- structure is not necessarily BCont model (already ax. 2, nor BST).
- does not have to be any branching structure.
- difference of past and future given by now-points.

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TRIVIAL BCONT

Let $\mathfrak{M} = \langle \mathfrak{G}, \mathcal{I} \rangle$ BCont model without CE:

- GFoT demands are met.
- Future is Peircean.
- Past/future has no significant difference.

FULL BCONT

Let $\mathfrak{M} = \langle \mathfrak{G}, \mathcal{I} \rangle$ BCont model without CE:

- GFoT demands are met.
- Future is not Peircean.
- Past/Future are structurally different.

BCONT FOR GFOT

- GFoT does not need in any way BCont.
- BCont without choice events also fulfils gFoT's demands, but ontologically definite future.
- BCont with branches allows for a structural difference F/P and non-Peircean future.

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SUMMARY

- GFoT is part of BCont structures and allows to construct valuation.
- GFoT does not need a branching structure. However, branching does make it non-trivial.

- Outlook:
  - analysis of temporal Copernican principle (Now).

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Thank you for your attention.

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