Deciding Impossible Futures

Maurice Laveaux and Tim Willemse
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Motivation

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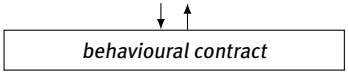

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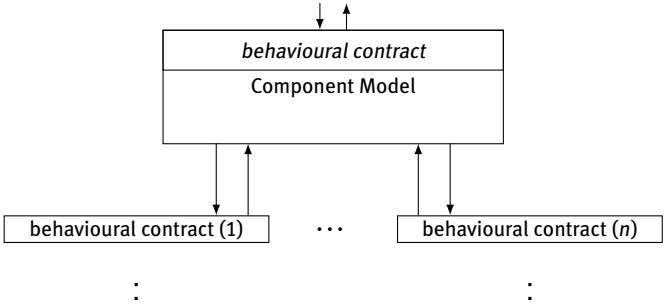

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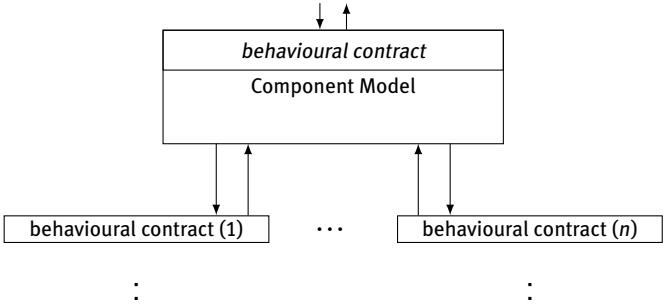

- System is designed by specifying its behavioural contract
- Contract is refined into component and other contracts and proven correct
- Generate executable code that is behaviourally equivalent to component model

Mauw's Three Stages of Maturity in Arts and Sciences

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Ideation

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Prototyping

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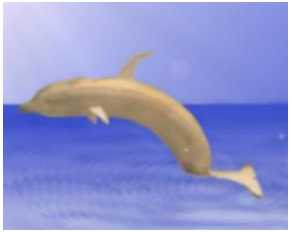
Consolidation



Impossible Futures

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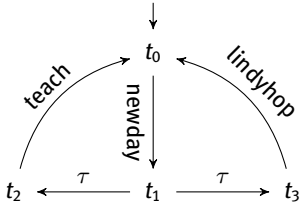

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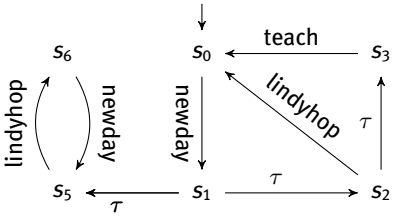

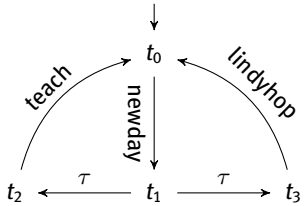

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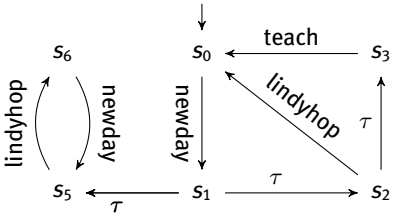
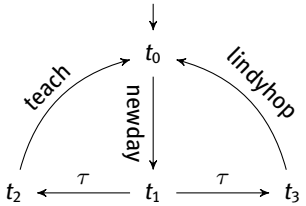


$\stackrel{?}{\sqsubseteq_{wt}}$



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- Impossible Future inclusion: $s \sqsubseteq_{if} t$ iff $\mathrm{IF}(s) \subseteq \mathrm{IF}(t)$ *(Voorhoeve&Mauw)*

  $\mathrm{IF}(s) = \{(w, X) \in \mathrm{Act}^* \times 2^{\mathrm{Act}^*} \mid \exists s' : s \stackrel{w}{\Longrightarrow} s' \text{ and } X \cap \mathrm{WT}(s') = \emptyset\}$

A Mystery

HOW TO EFFECTIVELY DECIDE $s \sqsubseteq_{if} t$?

A Detour: Weak Simulation

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s —— R —— t

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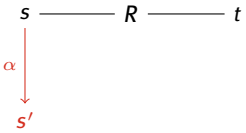

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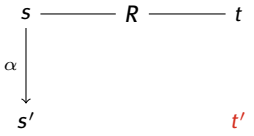

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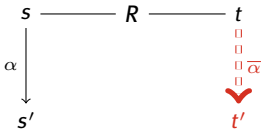

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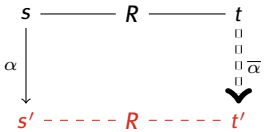

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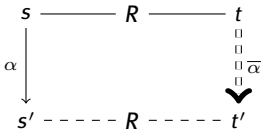

State s is weakly simulated by t, written $s \leq t$ iff there is a weak simulation R such that $s\ R\ t$

A Detour: Weak Simulation Games

A weak simulation game is a game played by Attacker and Defender on a graph $(V_A \cup V_D, E)$, where:

- Attacker owns vertices $V_A = S_1 \times S_2$, and Defender owns $V_D = S_1 \times S_2 \times (\mathrm{Act}_\tau \times S_1)$

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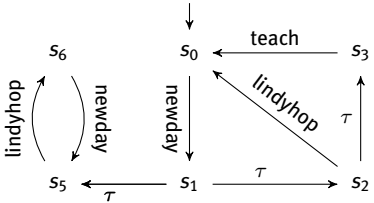

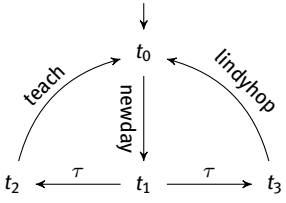

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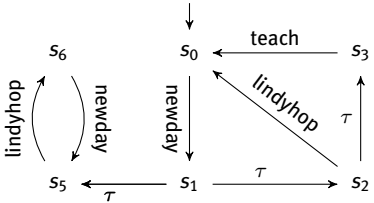

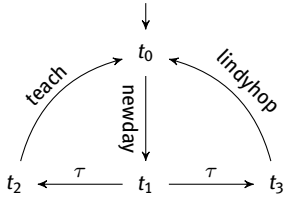

(s_0, t_0)

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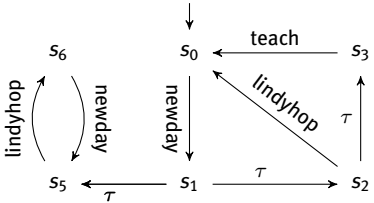

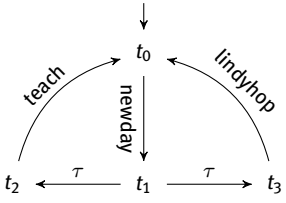

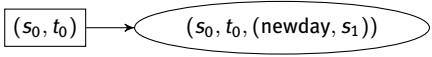

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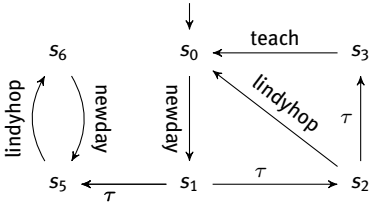

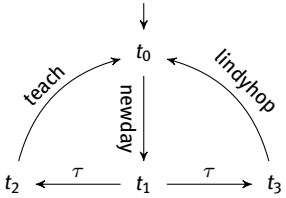

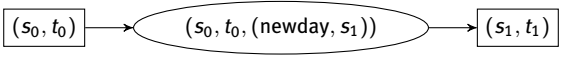

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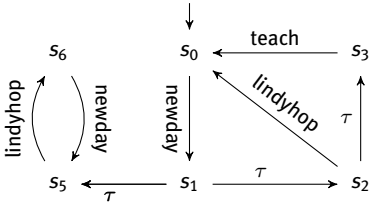

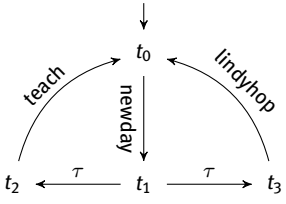

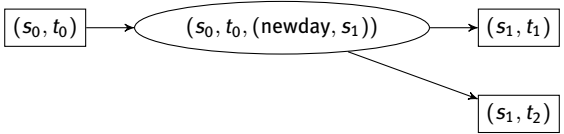

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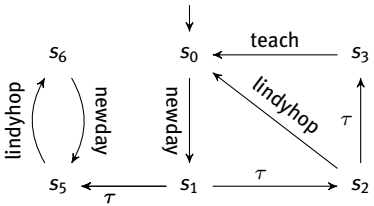

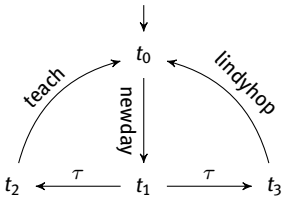

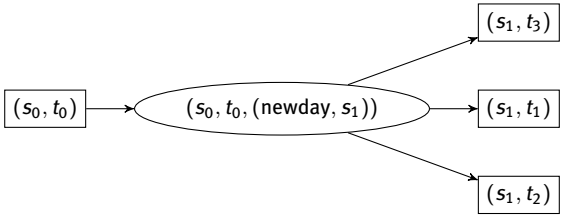

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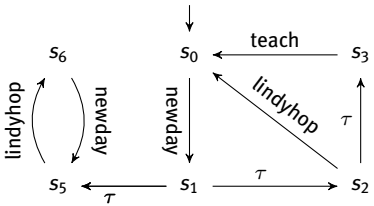

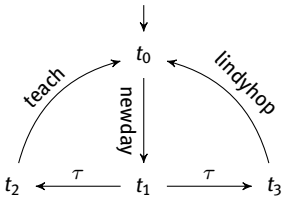

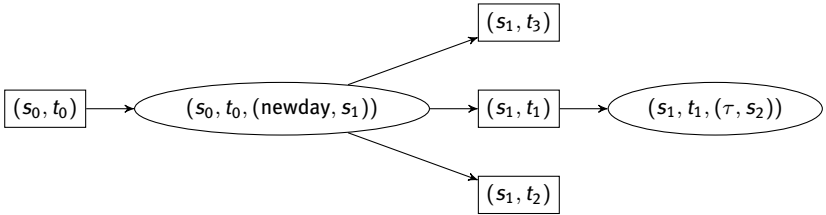

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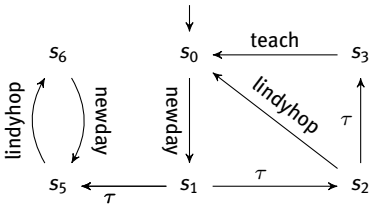

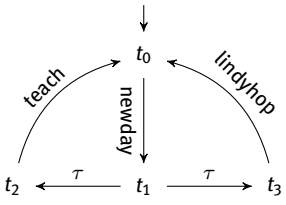

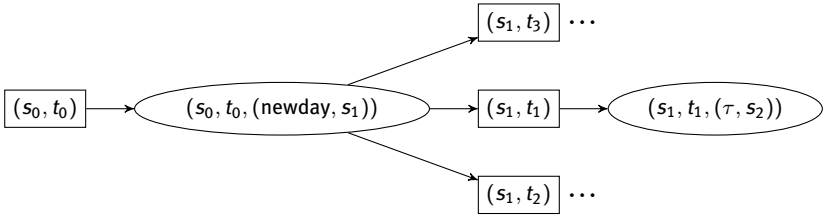

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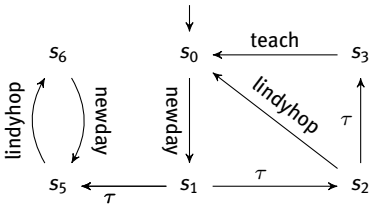

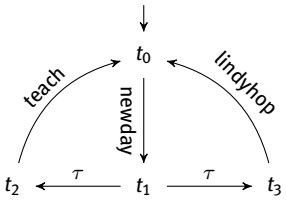

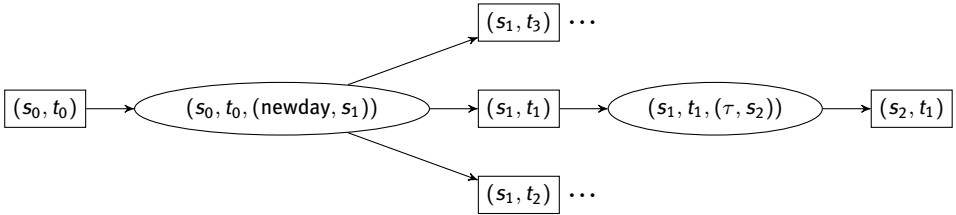

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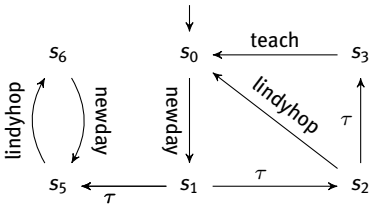

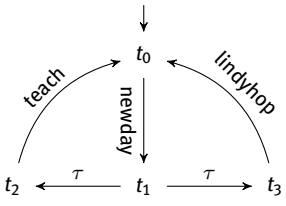

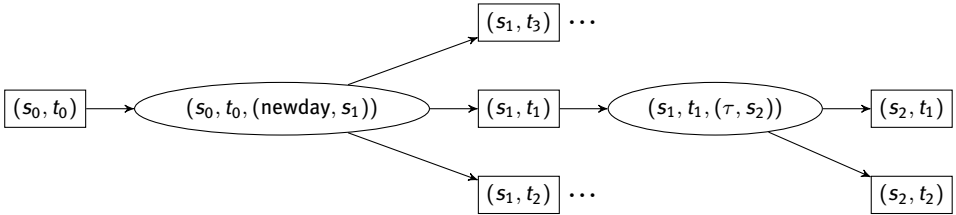

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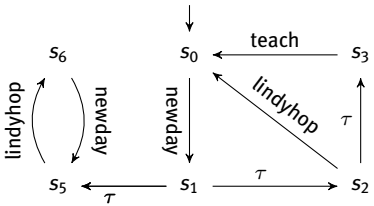

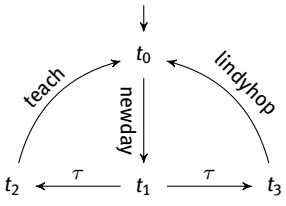

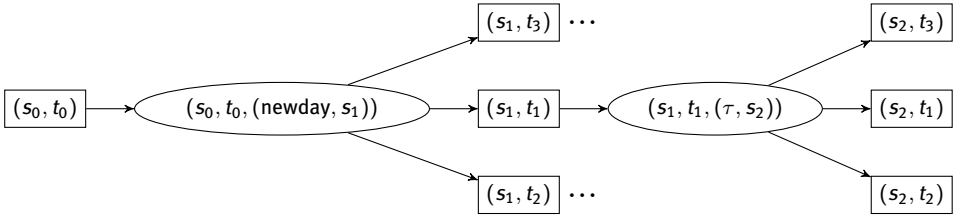

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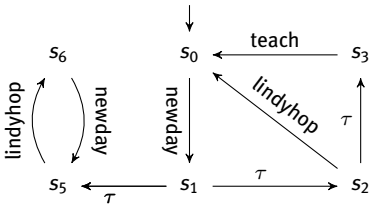

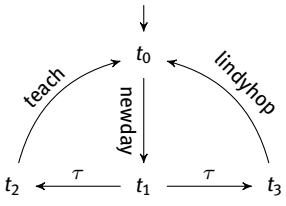

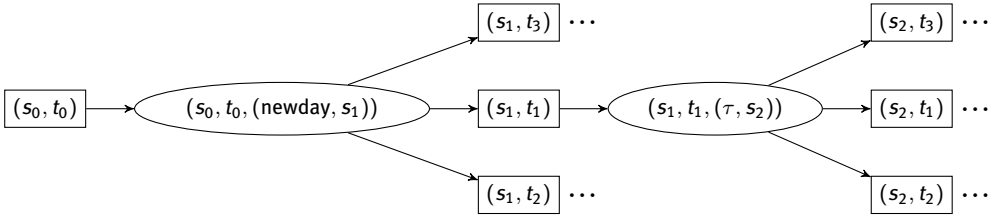

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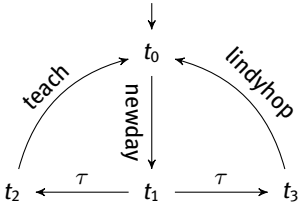
- Hence, Attacker wins a vertex if and only if she can reach a Defender sink vertex
- So in this case $s \sqsubseteq_{wt} t$ is a reachability problem solvable using a breadth-first or depth-first search.

An equivalent deterministic & concrete LTS

The normal form norm(s) of a state s yields a deterministic, concrete LTS satisfying WT(s) = WT(norm(s))

Example



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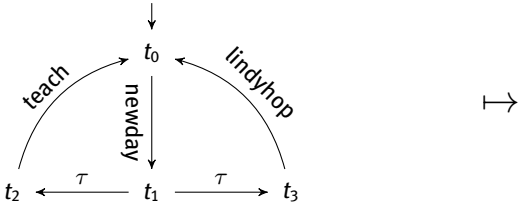

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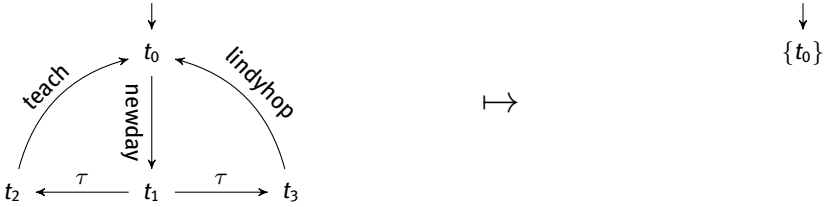

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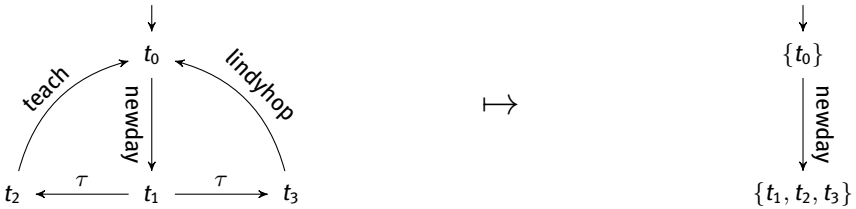

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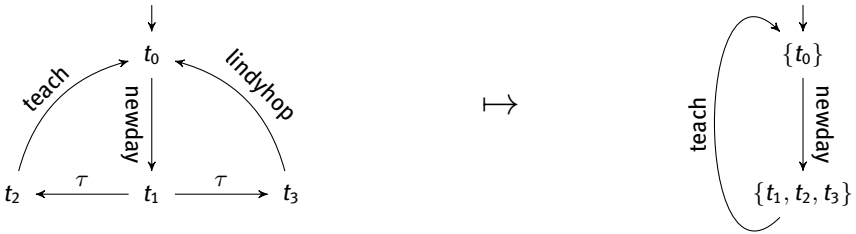

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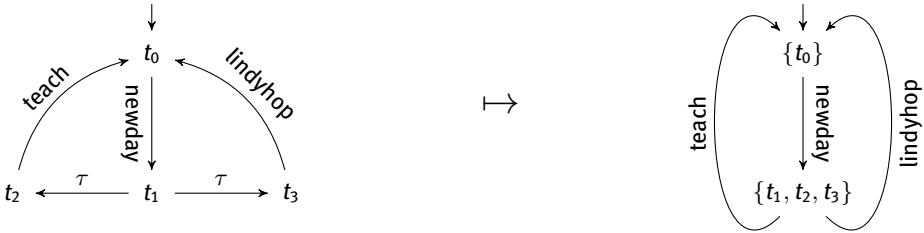

Putting some of these thoughts together

So:

$$s \sqsubseteq_{wt} t$$

if and only if

$$s \sqsubseteq_{wt} \mathrm{norm}(t)$$

if and only if

$$s \leq \mathrm{norm}(t)$$

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No Defender-sink is reachable from $(s, \mathrm{norm}(t))$

How to Decide Impossible Futures?

Modifying the simulation game to decide Impossible Futures:

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But: implemented naively this approach is sloooooooooooooow and does not even terminate in many cases

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- Consequence: once we visit (s, U), we need not further explore any (s, U') larger than (s, U)

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Optimising the search for Defender-sinks in the simulation game:

- Store visited Attacker vertices in an antichain $A \subseteq S_1 \times 2^{S_2} \setminus \{\emptyset\}$
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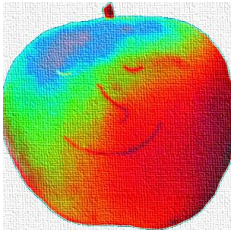
Towards consolidation: Verum is currently investigating how to integrate Impossible Futures in their Dezyne tool

Sjouke's Newton Moments and ...

Portrait of an Artist 1



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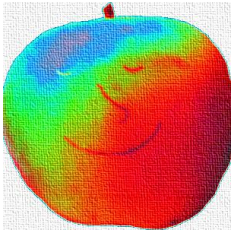
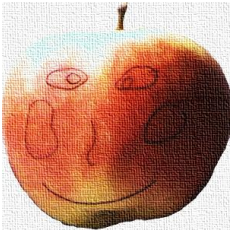


Portrait of an Artist 2



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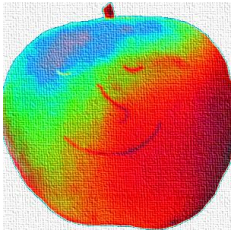

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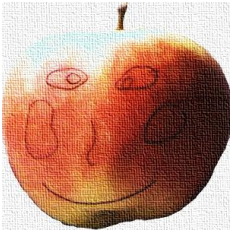

Artist informally known as Sjouke who created both self-portraits

Sjouke's Newton Moments and Footage of Attack Trees