Norms, Intentions and Actions

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Applied Logic Seminar TU Delft

May 26, 2014

Norms, intentions and actions

Aim:

- investigate the notion of agency and its logic

In particular:

- model the change that the acceptance of a norm triggers in an agent's intentions and actions

Current frameworks

Current frameworks in the logic of agency:

- **external perspective**: stit-logics (e.g., Horty and Belnap 1995, Horty 2001)
- **internal perspective**: intentions-based logics (e.g., Veltman 2012)

Stit (=seeing to it that) logics

- Indeterministic representation of the course of events (forward branching time structure)
- agent's actions constrain the course of events
- an agent *sees to it that* ϕ if she acts in such a way that ϕ is guaranteed

Stit frames

A Stit-frame $\mathcal{F} = \langle Tree, <, Agent, Choice \rangle$:

- *Tree* is a nonempty set of moments
- $<$ is a tree-like ordering on *Tree* (i.e, $\forall m_1, m_2, m_3 \in Tree$, if $m_1 < m_3$ and $m_2 < m_3$, then either $m_1 = m_2$ or $m_1 < m_2$ or $m_2 < m_1$)
- *Agent* is a set of agents
- *Choice* is a function mapping each agent α and moment m into a partition $Choice^m_\alpha$ of the histories $H_{(m)}$

where:

- a *history* h is a maximal set of linearly ordered moments from *Tree* and $H_{(m)} = \{h \mid m \in h\}$

Deliberative stit

A Stit-model $\mathcal{M} = \langle \mathcal{F}, v \rangle$:

- $\mathcal{F}$ is a stit-frame
- $v : \text{At} \to \mathcal{P}(\mathit{Tree} \times H)$ the atomic valuation

Deliberative stit

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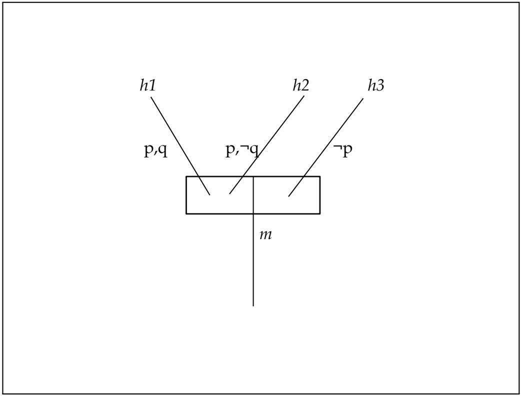
Truth conditions for the deliberative stit:

- $\mathcal{M}, m/h \models [\alpha\ dstit]\phi$ iff:
  - $\mathcal{M}, m/h' \models \phi$ for each $h' \in Choice^m_\alpha(h)$ *(positive requirement)*
  - $\exists h'' \in H_{(m)}$ such that $\mathcal{M}, m/h'' \not\models \phi$ *(negative requirement)*

The stit picture

- Agent α's action picks out a partition cell: $\{\{h_1, h_2\}, \{h_3\}\}$
- at m/h_1 agent α guarantees that p
- $[\alpha\ dstit]\phi$ true at m/h_2



Stit setting

- External representation of the course of events
- an agent's action constrains the course of events to lie within some subset of the possible histories still available
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Hence:

- agency represented purely in terms of outcomes of actions

Limitations

- Stit-logics are static
- purely external perspective (Belnap's slogan: *Leave the mind out!*)

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However:

- reasoning about what an agent does/can do is typically dynamic
- agent's intentions also count!

Especially when dealing with the case of the agent's acceptance of a norm, looking only at the outcomes of the agent's actions is **not** sufficient.

- Compare: Today (Friday) you eat fish for dinner because you have only fish left in the fridge vs. you eat fish for dinner because you are following a Christian norm

Veltman's intentions-based logic

- dynamic semantics: update operations over states
- states represent cognitive states of an agent

In particular:

- "$!\phi$, if accepted, induces a change of intentions in the agent's cognitive state"

Plans and realizations

A cognitive state S is a triple $\langle W, P, R \rangle$:

- if $w \in W$ then, for all an agent in that cognitive state knows, w might be the actual world
- if $w \in W$ then $P(w)$ is the plan the agent has developed for w
- $w \in W$ and $v \in R(w)$ then v is a possible successor of w. Every successor of w realizes one of the options of the plan for w

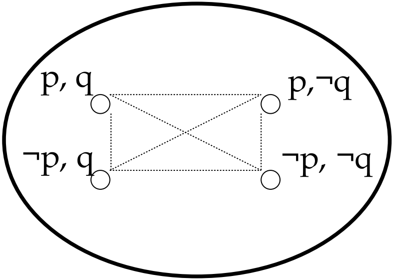
Plans and realizations, cont'd

In particular:

- A plan is a set of consistent to-do lists, none of which is a proper subset of another
- the acceptance of $!\phi$ triggers a change in the agent's plan (i.e., in the to-do lists)
- the agent is then committed to that plan: the set of possible successors is such that ϕ is realized

A simple example: update of the minimal state S with $!p$ and then with $!q$

S



true	false

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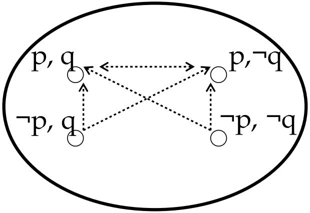
S[!p]



true	false

→

true	false
p	

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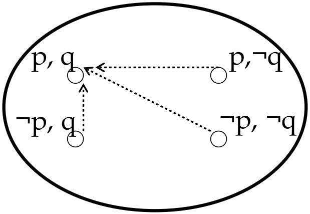

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Limitations

- every accepted norm has to be realized immediately (one-step realizations)
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However:

- flexibility in planning is more realistic
- stand norms like *Don't kill!* are different from one-time norms *Bring the trash out by tomorrow morning!*

A logic for norms, intentions and action

We combine external and internal perspective on agency, in order to model the changes that the acceptance of a norm triggers

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We combine external and internal perspective on agency, in order to model the changes that the acceptance of a norm triggers

- cf. Dignum and al. 1996; Broersen 2001 where agent's intentions are simply accessibility relations – the relationship between agent's intentions and actions remains unexplained

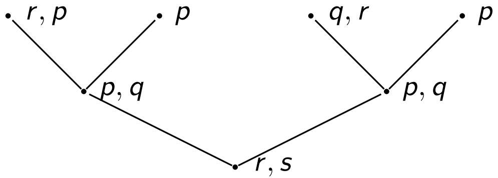
A logic for norms, intentions and action

We combine external and internal perspective on agency, in order to model the changes that the acceptance of a norm triggers

Main characteristics:

- agent' actions represented in a tree-like structure (vectors are actions, nodes are states of affairs)
- agent's intentions are represented in to-do lists attached to nodes
- $!\phi$ - if accepted- triggers a change in the agent's intentions and, consequently, in her actions
- we look at the nodes (for norms: Meinong/Chisholm reduction)

The Setting



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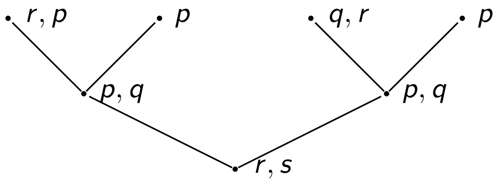
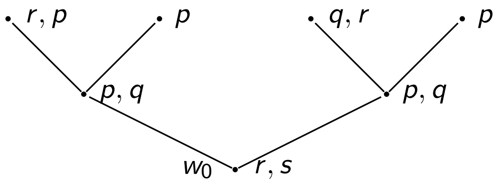


- No names for actions, all evaluations at nodes
- only one agent
- no epistemic uncertainty
- no uncertain success
- abstract representation of the world
- Conditions to be relaxed later

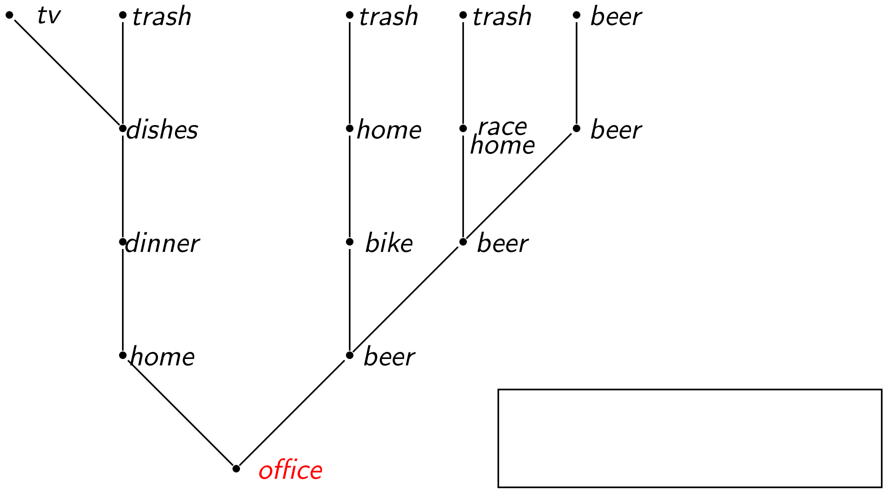
Formal Definition



For the rest of the talk fix a set of atoms At. An *action tree* is a 4-tuple $T = \langle W, w_0, \prec, V \rangle$ where

- W is a set of worlds with $w_0 \in W$
- $Val : \text{At} \to \mathcal{P}(W)$ the atomic valuation
- $\prec$ is a tree order on W with root w_0

Norms and Obligations



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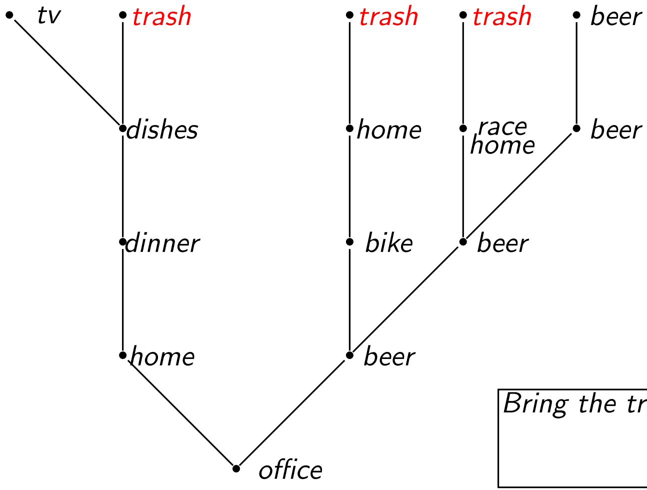
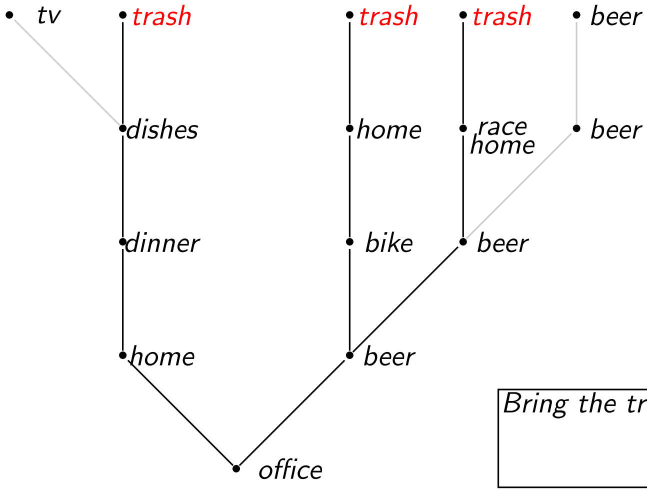


Bring the trash out!

Norms and Obligations



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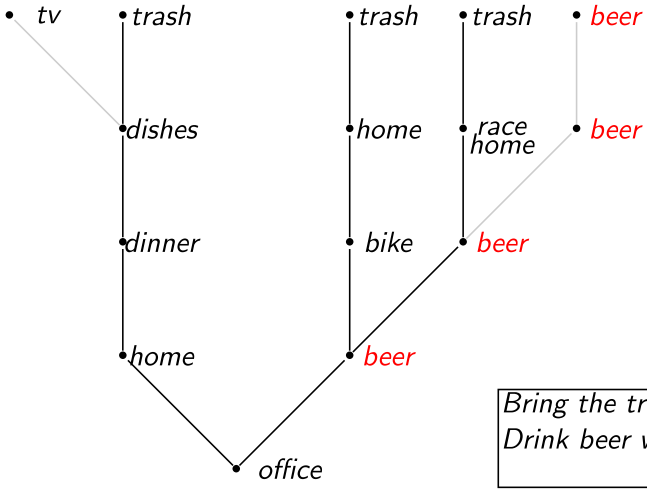

Bring the trash out!
Drink beer with your friends!

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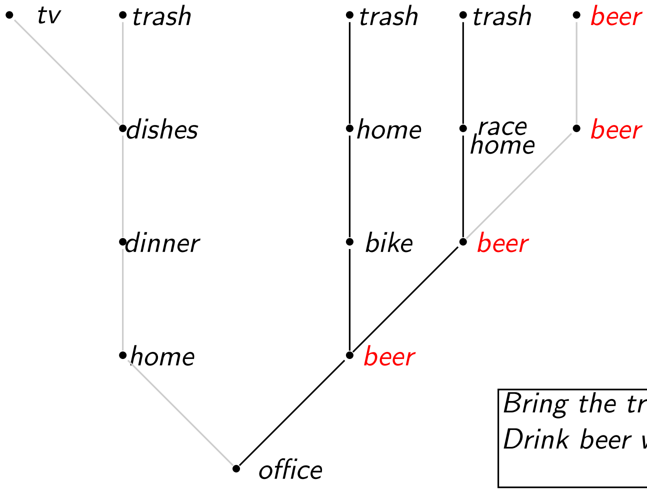

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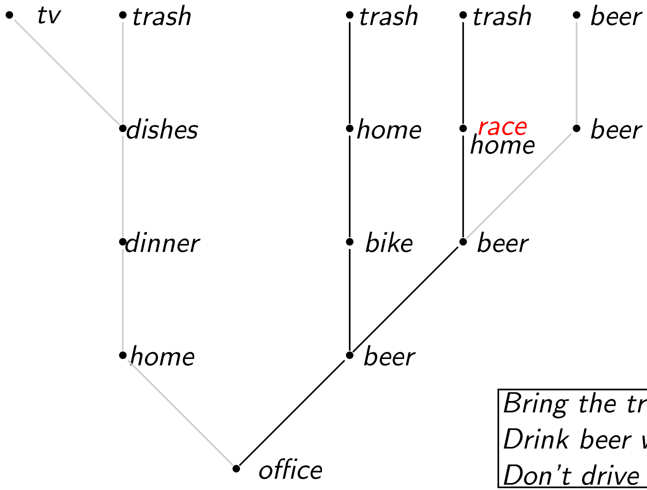
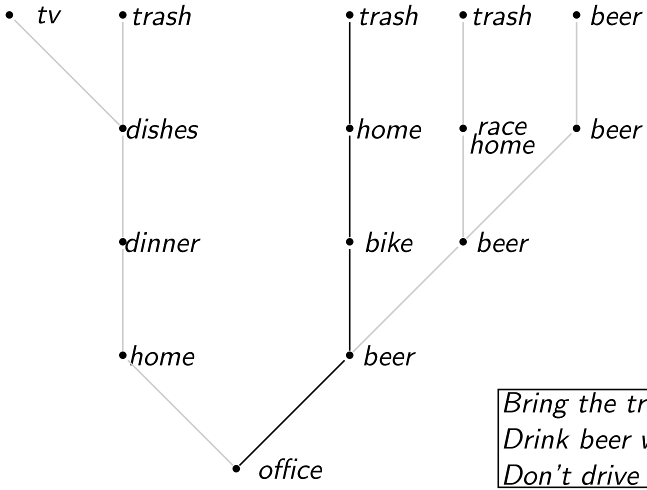


Bring the trash out!
Drink beer with your friends!
Don't drive too fast!

Norms and Obligations



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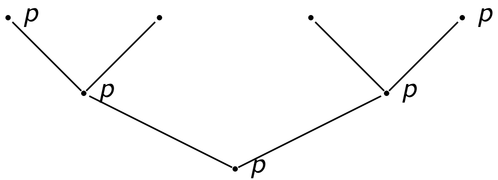
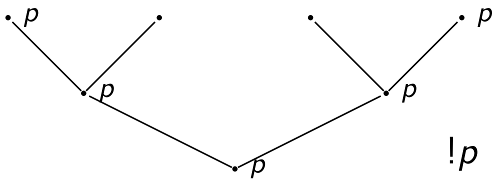


Crucial Distinction:

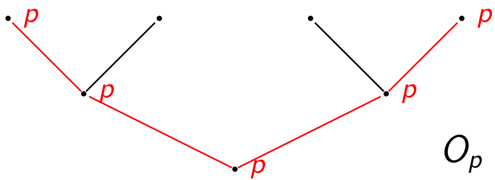
Norms and Obligations



Crucial Distinction:

1 Norm(, command or goal) = linguistic item

Norms and Obligations

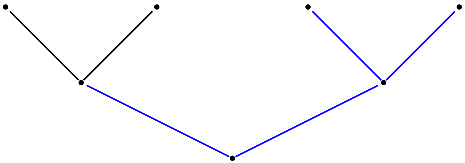


Crucial Distinction:

1 Norm(, command or goal) = linguistic item

2 Obligation = Semantic item, parts of the tree to land up in

Obligations

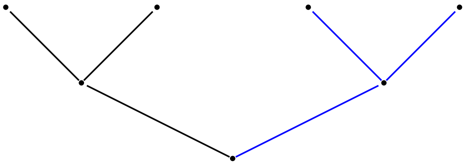


Definition

i) An *obligation* in an action tree T is a subtree S of T

- Obligations correspond to consistent, extendable actions the agent can perform

Obligations



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i) An *obligation* in an action tree T is a subtree S of T such that for every $v \in S$ that has a successor in T it also has a successor in S

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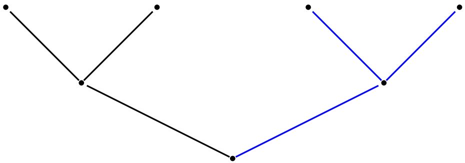

Definition

i) An *obligation* in an action tree T is a subtree S of T such that for every $v \in S$ that has a successor in T it also has a successor in S

ii) For any subtree S of T let $\overline{S}$ be the tree derived from S by iteratedly removing dead ends.
(Technically: $\overline{S} = \bigcup\{h \subseteq S | h \text{ a maximal history of } T\}$

- Obligations correspond to consistent, extendable actions the agent can perform

Obligations, cont'd

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Obligations, cont'd

- Obligations correspond to consistent, extendable actions the agent can perform
- But where do obligations come from? Norms

How to talk about Norms (and Commands)?

- one time norms *Bring the trash out!*
- standing norms *Don't kill!*

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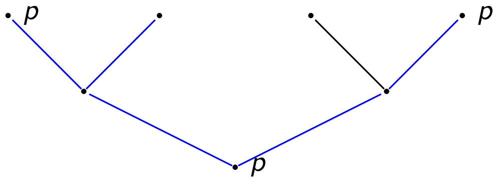
- one time norms *Bring the trash out!*
- standing norms *Don't kill!*

Let At $= \{p_1 \dots p_n\}$ be a set of atomic propositions (*I kill, I bring the trash out, I drink a beer...*)
The obligational language is given by

$$\varphi := p^{\exists} | p^{\forall} | \neg p^{\exists} | \neg p^{\forall} | \varphi \wedge \varphi | \varphi \vee \varphi$$

Norms and Obligations

Norm φ gives rise to an obligation O_φ



Inductive definition of O_φ

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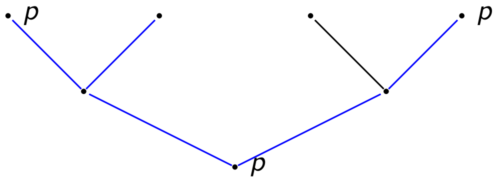

Inductive definition of O_φ

$$O_{p^{\exists}} = \bigcup\{h | h \text{ history of } T \text{ and some world in } h \text{ satisfies p}\}$$

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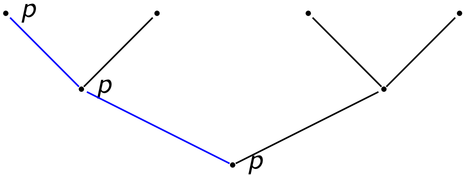

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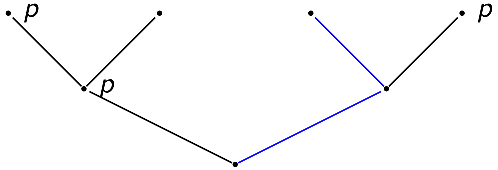

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$$O_{\neg p^{\exists}} \text{ similar to } O_{p^{\forall}}$$

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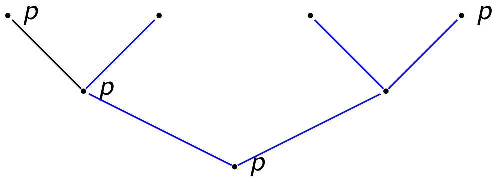

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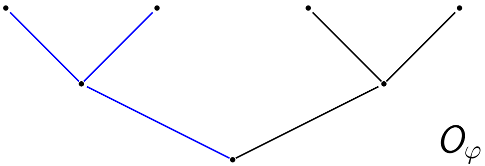

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$$O_{\varphi \vee \psi} = O_\varphi \cup O_\psi$$

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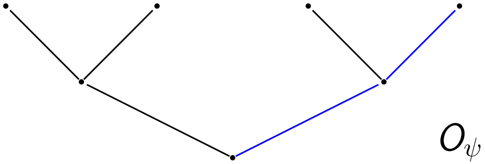

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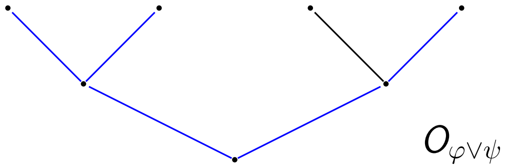

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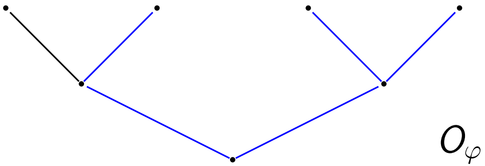

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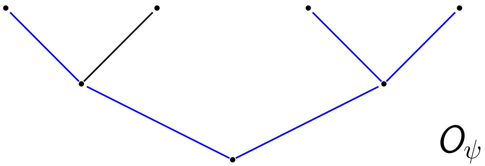

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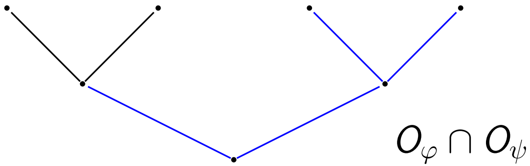

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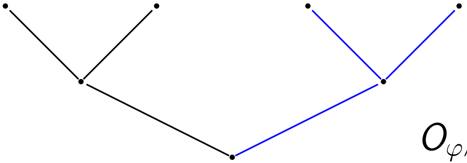

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Planning to Fulfill a Norm

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true	false

$\Rightarrow$

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$p^{\exists}$	

Obligations and Intentions

- Once accepted, an agent intends to fulfill his norms/goals/commands
- Mental representation of accepted commitments: To-Do Lists
  To-Do List of the form $\langle p, true, \exists\rangle\langle q, false, \forall\rangle \ldots$

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- Problem of Free Choice: *Bring the trash out* or *Wash the Dishes*
- Several To-Do-Lists, one per choice, give rise to a *Plan*

true	false
$p^{\exists}$	

true	false
$q^{\exists}$	

To-Do-Lists and Plans

Definition

i) A *to-do list* is a Set D

$$D \subseteq \text{At} \times \{\textit{true}, \textit{false}\} \times \{\forall, \exists\}$$

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iii) A plan P is a set of to-do lists such that $D \subsetneq D'$ for all $D, D' \in P$

Attentie Difference between plans

- $\{\emptyset\}$ Empty To-Do List = *Do whatever you want*
- $\emptyset$ Empty Plan = State of Violation

How do I know what to do?

Consider a norm/command φ (for better readibility we sometimes write $!\varphi$). How does the corresponding Plan $P \uparrow \varphi$ look like?

- φ of the form $p^{\exists}$ resp. $p^{\forall}$

  $P \uparrow \varphi = \langle p, true, \exists \rangle$ resp. $\langle p, true, \forall \rangle$

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  $P\uparrow\varphi = \langle p, true, \exists\rangle$ resp. $\langle p, true, \forall\rangle$
- φ of the form $\neg p^{\exists}$ resp. $\neg p^{\forall}$
  $P\uparrow\varphi = \langle p, false, \exists\rangle$ resp. $\langle p, false, \forall\rangle$

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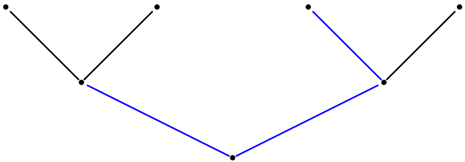
  $P\uparrow\varphi = \langle p, true, \exists\rangle$ resp. $\langle p, true, \forall\rangle$
- φ of the form $\neg p^{\exists}$ resp. $\neg p^{\forall}$
  $P\uparrow\varphi = \langle p, false, \exists\rangle$ resp. $\langle p, false, \forall\rangle$
- φ of the form $\psi \vee \chi$
  $P\uparrow\varphi = min(P\uparrow\psi \cup P\uparrow\chi)$
  (union of both plans)

How do I know what to do?

Consider a norm/command φ (for better readibility we sometimes write $!\varphi$). How does the corresponding Plan $P \uparrow \varphi$ look like?

- φ of the form $p^{\exists}$ resp. $p^{\forall}$
  $P \uparrow \varphi = \langle p, true, \exists \rangle$ resp. $\langle p, true, \forall \rangle$
- φ of the form $\neg p^{\exists}$ resp. $\neg p^{\forall}$
  $P \uparrow \varphi = \langle p, false, \exists \rangle$ resp. $\langle p, false, \forall \rangle$
- φ of the form $\psi \vee \chi$
  $P \uparrow \varphi = min(P \uparrow \psi \cup P \uparrow \chi)$
  (union of both plans)
- φ of the form $\psi \wedge \chi$
  $P \uparrow \varphi = min\{D \cup D' | D \in P \uparrow \psi, D' \in P \uparrow \chi,$
  $D \cup D'$ consistent$\}$
  (all possible unions of to-do-lists)

Finally – A planning tree

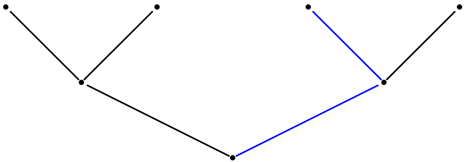


Definition

An NIA tree is a 6-tuple $T = \langle W, w_0, \prec, V, \mathcal{O}, P \rangle$ where

- $T = \langle W, w_0, \prec, V \rangle$ is an action tree
- $\mathcal{O}$ is a set of Obligations in T
- $P : W \to \{Plans\}$ attaches a plan to each node

Finally – A planning tree



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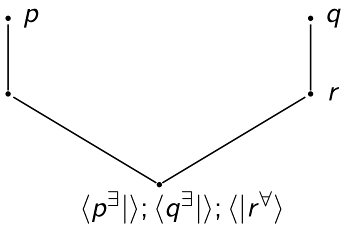
That's not everything – Tracking Fulfillment

- Plans should be executable
- To-Do lists track how plans are gradually fulfilled
- Once satisfied, remove one-time norms from to-do-lists
- All one-time norms should be satisfied at the end of time
- Standing norms should never be violated

That's not everything – Tracking Fulfillment

Definition

An NIA -tree T is coherent iff



That's not everything – Tracking Fulfillment

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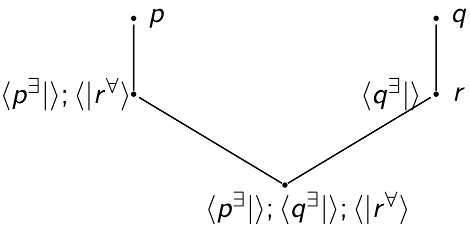


That's not everything – Tracking Fulfillment

Definition

An NIA -tree T is coherent iff

i) *Success:* If w is a leaf of T then no $D \in P(w)$ contains one-time norms

That's not everything – Tracking Fulfillment

Definition

An NIA -tree T is coherent iff

i) *Success:* If w is a leaf of T then no $D \in P(w)$ contains one-time norms

ii) *Gradual Fulfilment* If $v \prec w \in T$ then

$$P(w) \subseteq min(\{D - \{\langle p, true, \exists\rangle | v \in Val(p)\} \\ - \{\langle p, false, \exists\rangle | v \notin Val(p)\} | D \in P(v)\})$$

"Fulfilled existential obligations get removed"

Definition cont'd

iii) *Non violation* If $v \prec w \in T$ then

$$P(w) \subseteq \{D \in P(v) | \langle p, false, \forall \rangle \notin D \text{ if } w \in Val(p), \langle p, true, \forall \rangle \notin D \text{ if } w \notin Val(p)\}$$

"The present state doesn't violate standings norms"

iv) *Efficiency* If $v \prec w$ then for every $D \in \mathcal{P}(v)$ there is some $D' \in \mathcal{P}(w)$ such that D' is obtained from D by removing one-time norms that are satisfied.

"All To-Do lists refer to some future branch"

Remark: Given $P(w_0)$, there is an algorithm to make the function P coherent (Upward-Downward Procedure)

Learning and accepting norms: intentions and actions

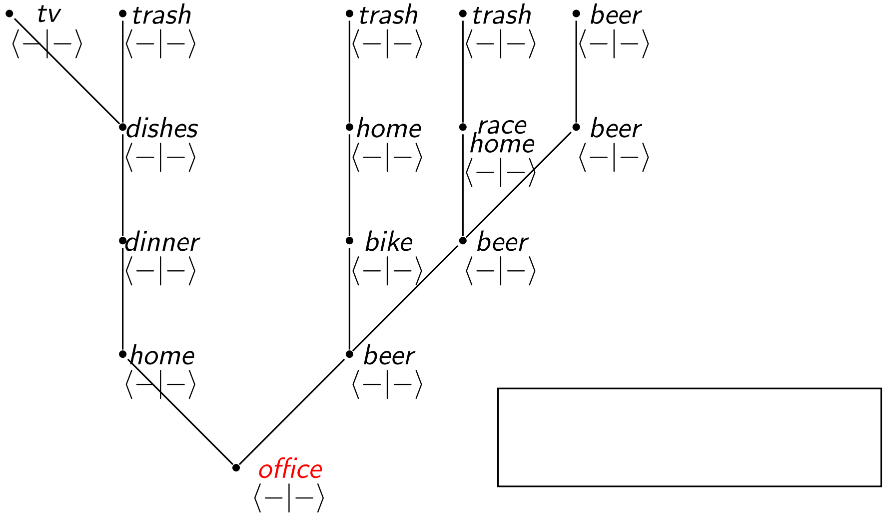
Let T be an NIA -tree. Accepting the norm $!\varphi$ updates T to T' with

- No change in the underlying action tree
- $\mathcal{O}' = \mathcal{O} \cup O_\varphi$
- To obtain P' update $P(w_0)$ with φ and run the down-up-down algorithm to make P' consistent

We say that ...

- ...the obligation that φ was supported if $\mathcal{O}' = \mathcal{O}$
  Write: $T \vDash O\varphi$
- ...the agent already incorporated φ if $P' = P$
  Write: $T \vDash !\varphi$

Example


tv
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⟨—|—⟩
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dinner
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home
⟨—|—⟩
trash
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bike
⟨—|—⟩
beer
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trash
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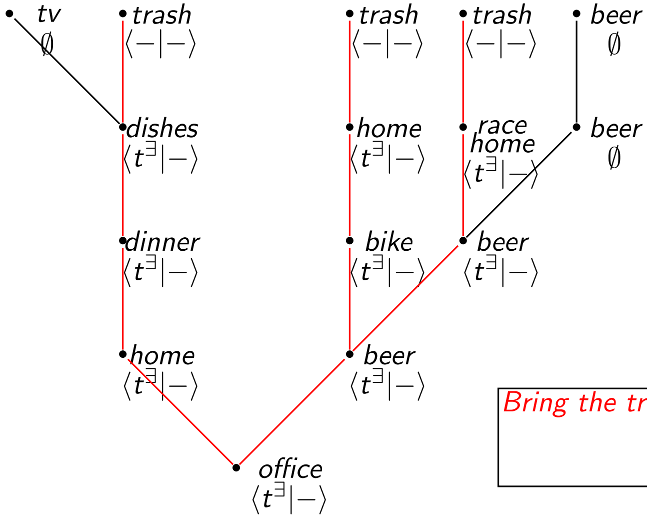
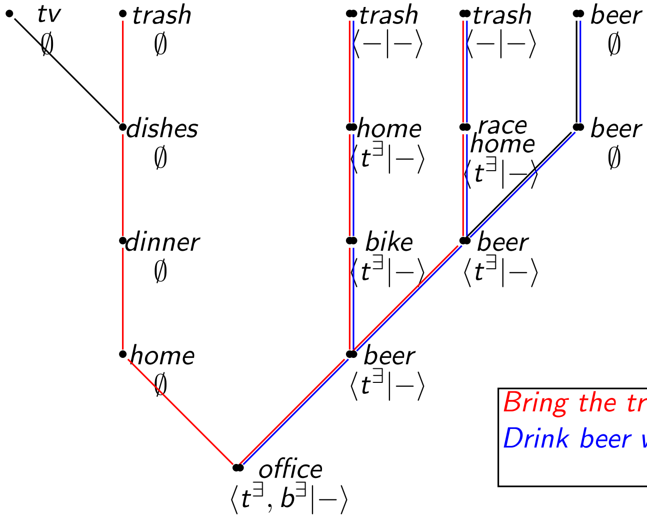
Example



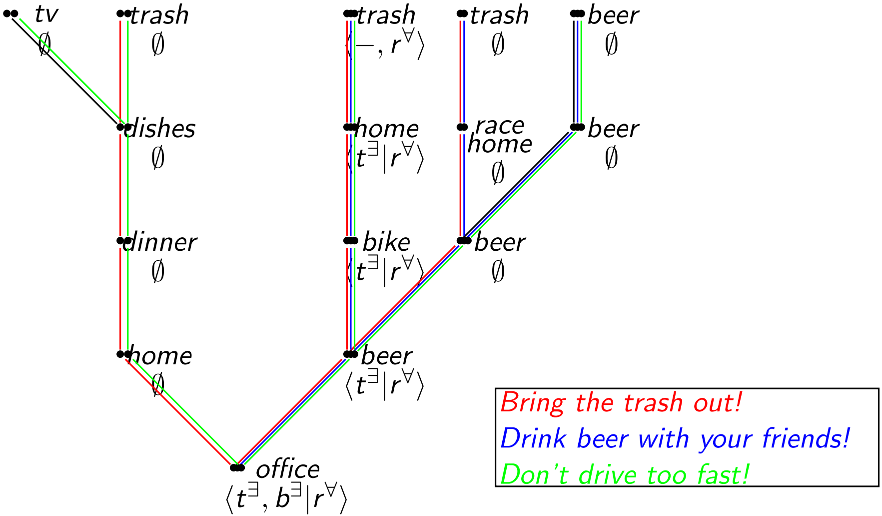
Bring the trash out!

Example



Bring the trash out!
Drink beer with your friends!

Example


tv
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race
home
∅
beer
∅
dinner
∅
bike
⟨t∃|r∀⟩
beer
∅
home
∅
beer
⟨t∃|r∀⟩
office
⟨t∃, b∃|r∀⟩
Bring the trash out!
Drink beer with your friends!
Don't drive too fast!

A Theorem

Theorem

Let T be an NIA -tree obtained by starting with no obligations and empty to-do lists through iterated updating with norms $!\varphi$. Then:

$$\overline{\bigcap_{O \in \mathcal{O}} O} = \{w \in W | P(w) \neq \emptyset\}$$

An agent following his to-do list will end up with the maximal set consistent with all Obligations around.

Extensions and Future Developments

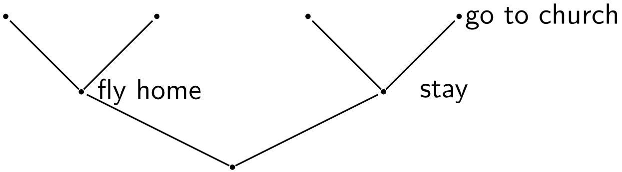
- Introduce Payoffs for the Agents (Intrinsic Interest vs. Outside Conditions)
- Attach Plans to non-optimal worlds

  Contrary to Duty: *Go home over Easter. If you don't go home at least go to church*

  Conflicting Obligations
- Introduce epistemic uncertainty (possibly with belief order)
  - Move by Nature
  - Uncertain Success of Actions
  - Distinguish between not accepting φ and failing to meet O_φ

Contrary to Duty

Go home over Easter. If you don't go home at least go to church



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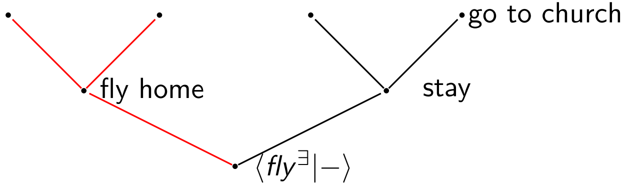

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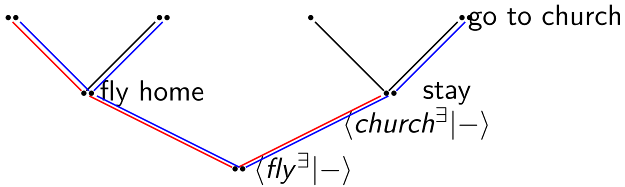

Conclusions

- Agency as complex notion which involves agent's actions and intentions
- Formal framework which takes into account both external and internal dimensions
- Application to the process of acquisition of norms
- Dynamic approach which distinguishes between different kinds of norms (stand vs. one-time) and allows for flexibility in the process of fulfilling norms
- Future directions: epistemic uncertainty, multi-agent setting, etc.

References

- Broersen et al., *Resolving Conflicts Between Beliefs, Obligations, Intentions, and Desires*. *Symbolic and Quantitative Approaches to Reasoning and Uncertainty*, Springer, 2001.
- Dignum et al., *A Modal Approach to Intentions, Commitments and Obligations*. In *Deontic logic, agency and normative systems*, Springer, 1996.
- Horty J.F., Belnap N., *The Deliberative Stit: A Study of Action, Omission, Ability, and Obligation*. *Journal of Philosophical Logic*, Vol.24, No.6, 1995.
- Horty J.F., *Agency and Deontic Logic*. Oxford University Press, 2001.
- Veltman F., *Or else, what? Imperatives on the borderline of semantics and pragmatics*. Institute for Logic, Language and Computation, Lego Seminar, Amsterdam, 2012.