



Formalizing Deductive Coherence: An Application to Norm Evaluation

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Outline



- ★ Motivation- Treatment of Norms
 - Agent Level
 - Normative Multi Agent System Level
- ★ Coherence Framework
 - Coherence Theory
 - Coherence Graphs
 - Computing Coherence
- ★ Deductive Coherence
 - Deductive Coherence Function
 - Properties
- ★ A Coherence Maximizing Agent



Scenario - Water Sharing



Signed Treaty (1989): Region A should release 300 billion ft to Region B



2008

Region A

- control of water source
- experiences large scale urbanization
- depends largely on industries
- experiences diminishing rainfall
- high revenue producing

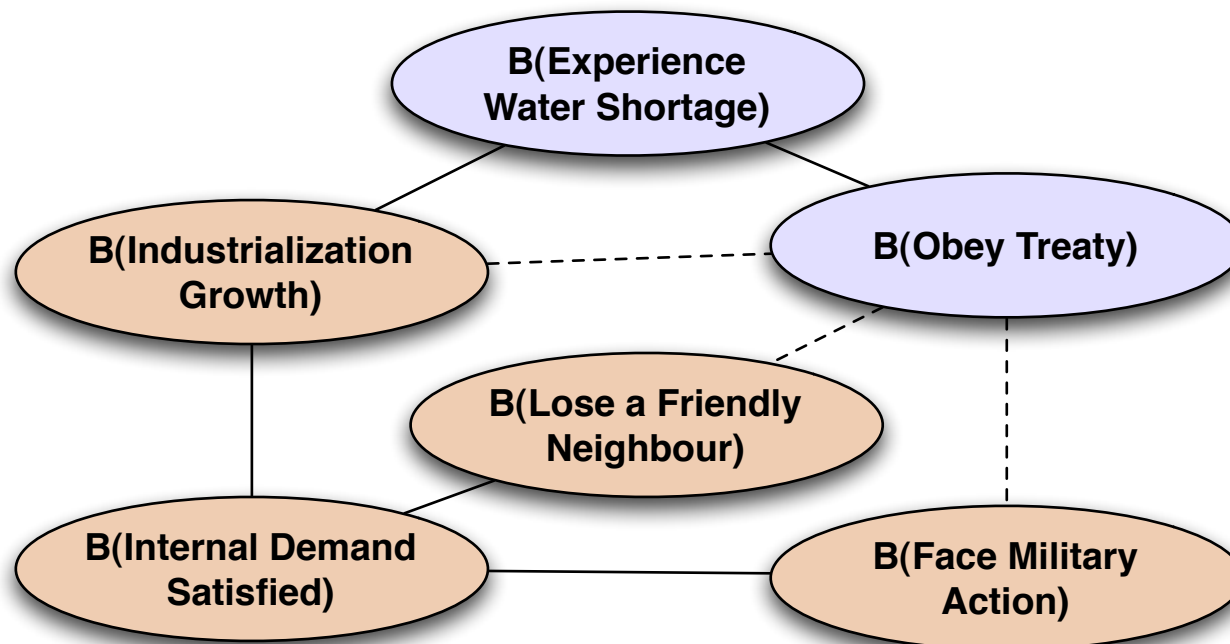
Region B

- depends on agriculture
- depends on water released from s
- increasing demand for water
- strong military power

Should Region A *Share* its water?



A cognitive view of the agent



Associations are at the core



Agent Level - Autonomous Norm Evaluation



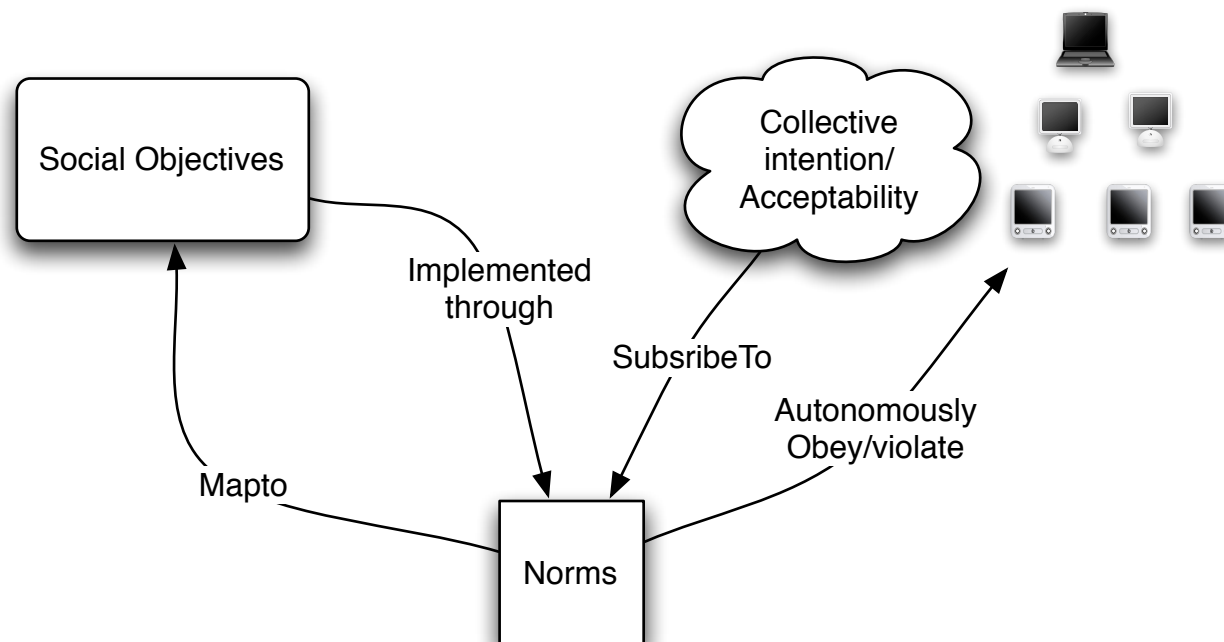
- ★ Norms prevail over time
- ★ No general rule can be applied to follow norms over time
- ★ Consequence of a norms vary over situations
- ★ Norms interact in complex ways with cognitions



Normative Multiagent Systems



- Have certain social/ and functional objectives
- Supported by collective intention
- Implemented through Norms and Structure





Treatment of Norms - System perspective



- ❧ Norm Verification & Validation
 - Verify Norm consistency and correctness
 - Validate against social/functional objectives
- ❧ Norm Evolution
 - ❧ Joining a normative MAS is norm acceptance
 - ❧ Norm violations may be due to shift in collective intention
 - Norm adaptation & redefinition



Normative Multiagent Systems Design



Properties

- ★ Situation dependent
- ★ Conflict in interest
- ★ Consequence of a norm
 - Influence of sanctions & rewards
- ★ Interacting constraints

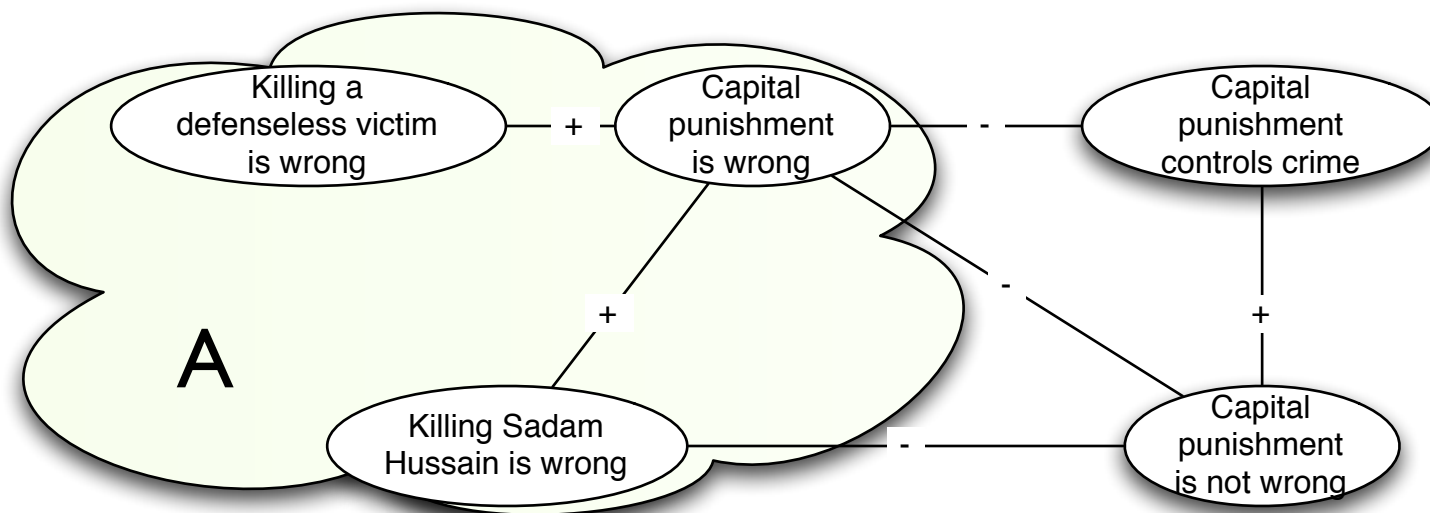
Solutions

- ★ Assign Priorities- at the agent level
 - BOID
- ★ Design normative systems for autonomous agents
 - Normas- normative system design
 - EMIL-A differentiate norm recognition from norm adoption
 - Lopez et al. expressive representation of norms
- ★ Bring in autonomy
 - Coherence Theory



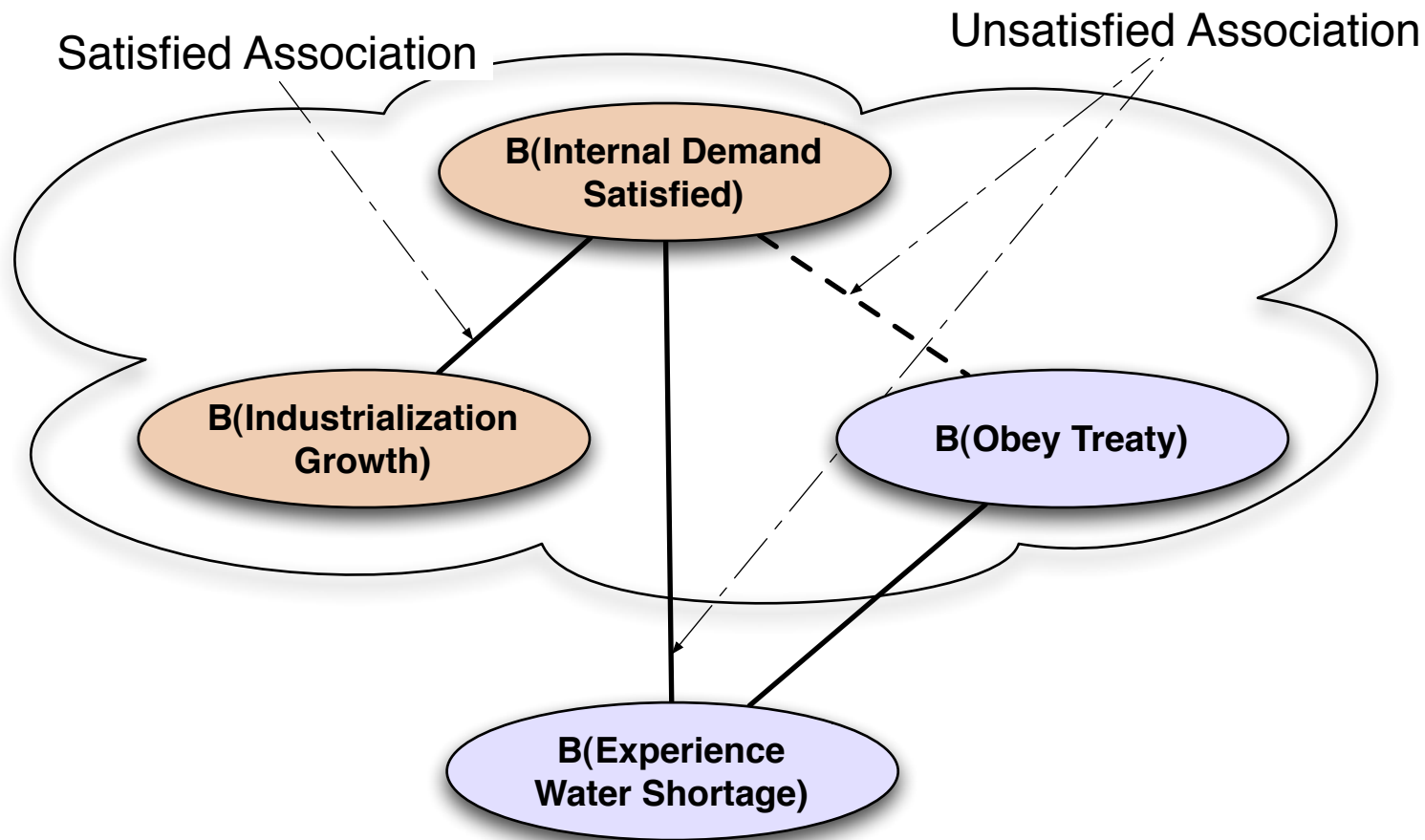
Coherence Theory

- ❧ Coherence study associations between *Pairs of Information*
- ❧ Items in coherent systems mutually support
- ❧ Coherence can be understood as constraint satisfaction





Coherence as Constraint Satisfaction



Satisfied Constraints

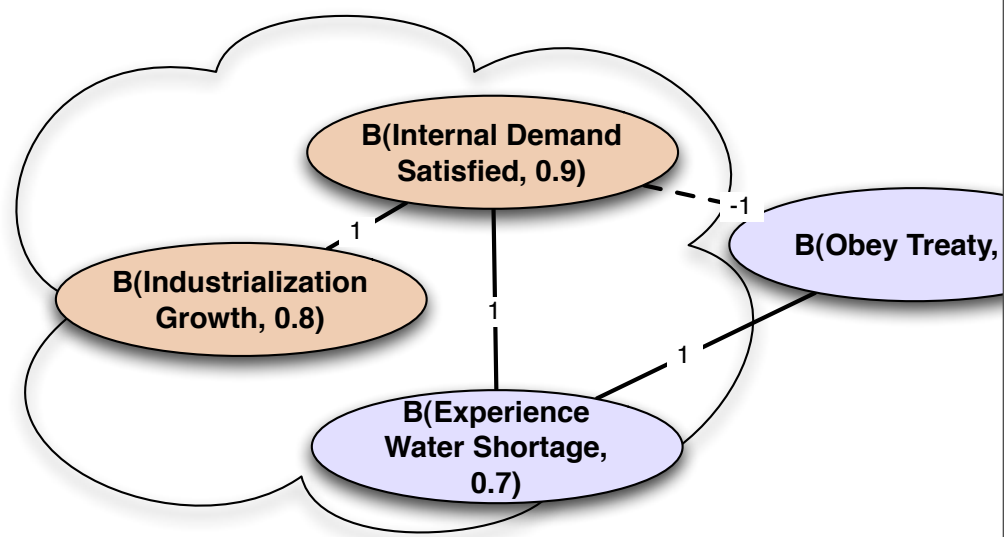
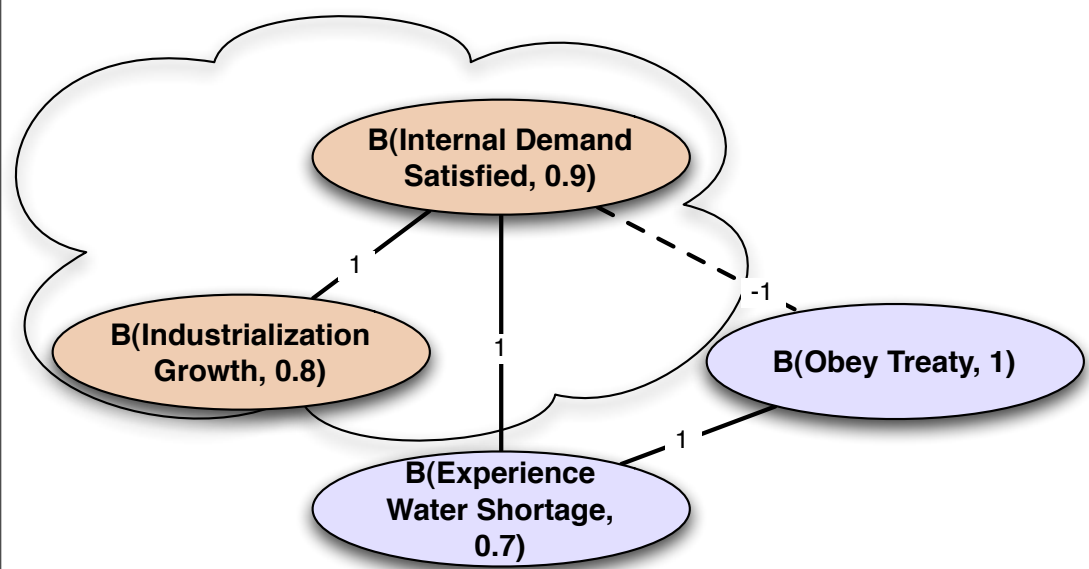
$$C_A = \left\{ (v, w) \in E \left| \begin{array}{l} v \in \mathcal{A} \text{ iff } w \in \mathcal{A}, \text{ when } \zeta(v, w) > 0 \\ v \in \mathcal{A} \text{ iff } w \notin \mathcal{A}, \text{ when } \zeta(v, w) < 0 \end{array} \right. \right\}$$



Computing Coherence

$$(1 \times 0.8 \times 0.9 + 1 \times 1 \times 0.7 + 1 \times 0.9 \times 0.7) / 3 = .68$$

$$(1 \times 0.8 \times 0.9 + 1 \times 0.7 \times 0.9 + 1 \times 0.9 \times 1) / 3 = .75$$



Total Strength

Coherence = 0.75

$$S(g, \mathcal{A}) = \frac{\sum_{(v,w) \in C_{\mathcal{A}}} |\zeta(v,w)| \cdot \alpha(v) \cdot \alpha(w)}{|E|}$$

$$C(g) = \max_{\mathcal{A} \subseteq V} S(g, \mathcal{A})$$



Deductive Coherence - Constructing a coherence Graph



Thagard's Principles

- 1) Deductive coherence is symmetric relation.
- 2) proposition coheres with propositions deducible from it.
- 3) Propositions that together are used to deduce some other proposition cohere with each other.
- 4) The more hypotheses it takes to deduce something, the less the degree of coherence.
- 5) Contradictory propositions are incoherent with each other.
- 6) Propositions that are intuitively obvious have a degree of acceptability on their own.
- 7) The acceptability of a proposition in a system of propositions depends on its coherence with them

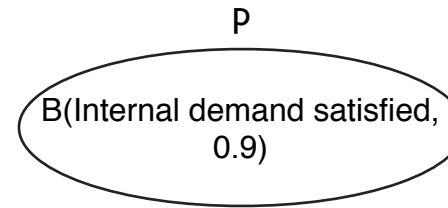


Deductive Coherence - Constructing a coherence Graph



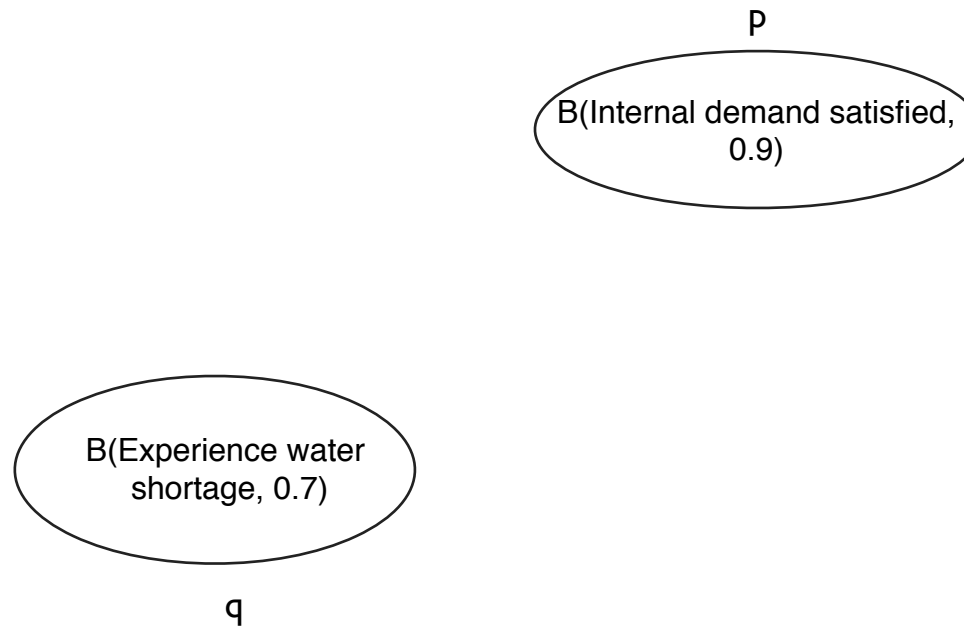


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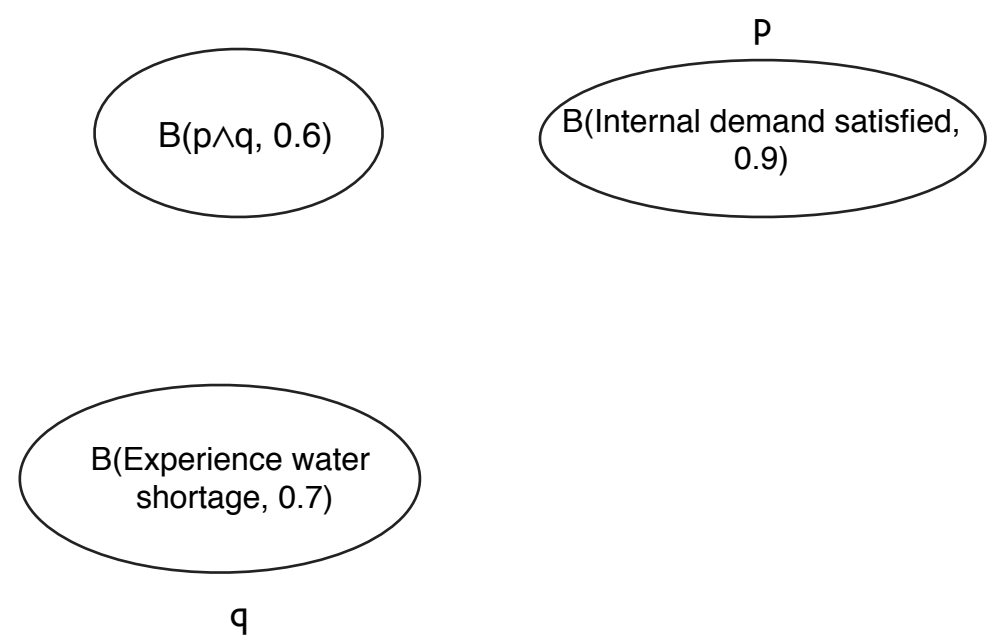


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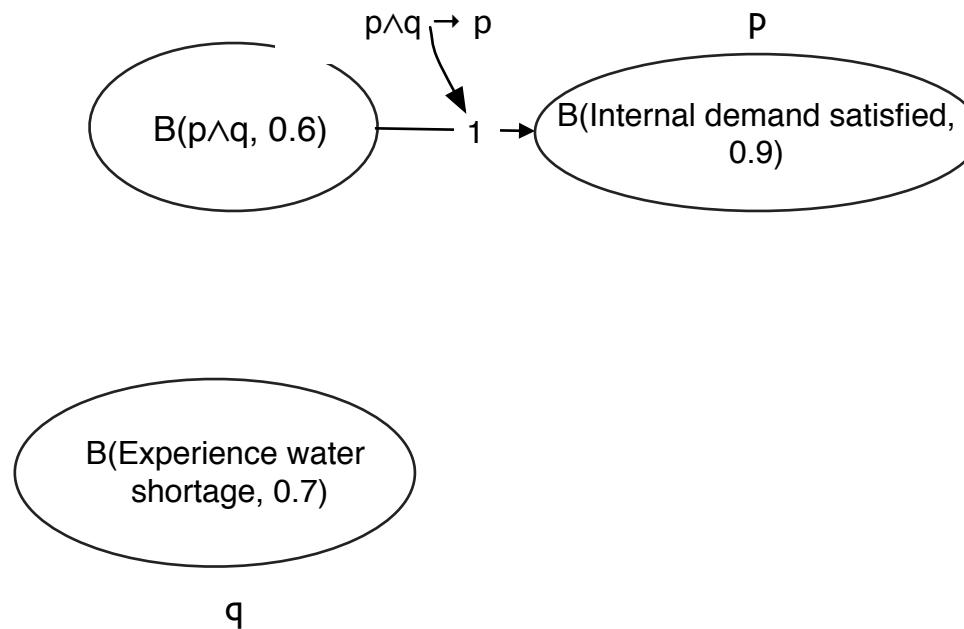


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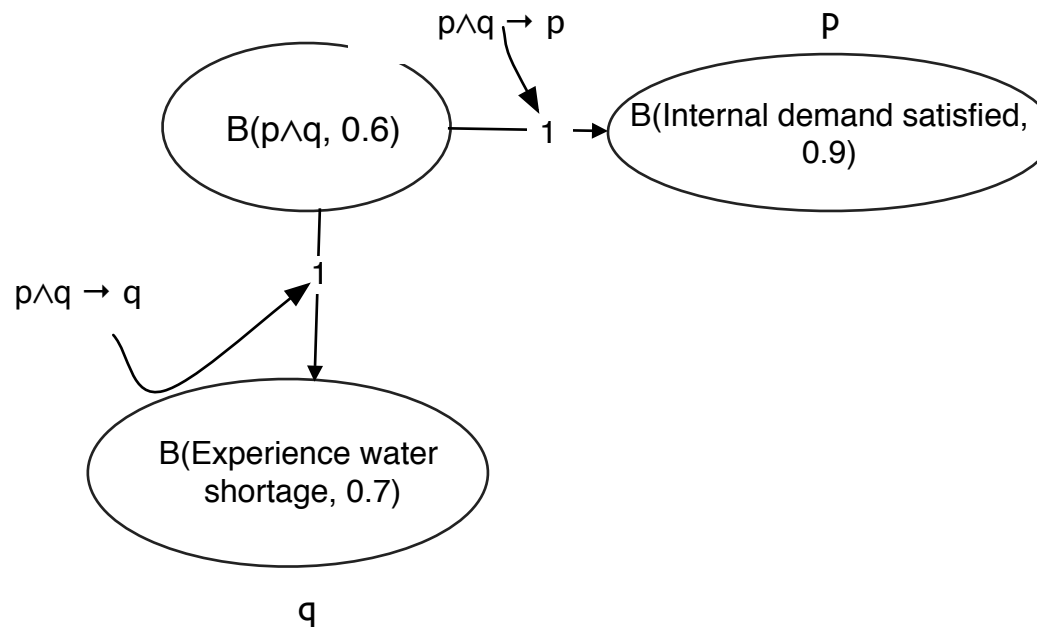


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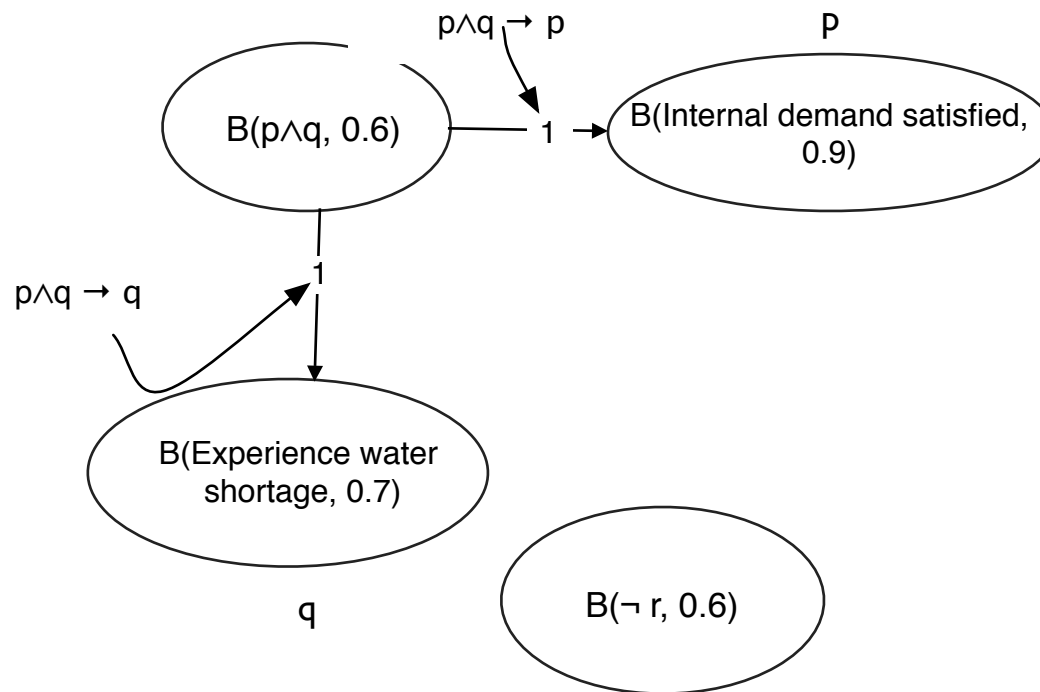


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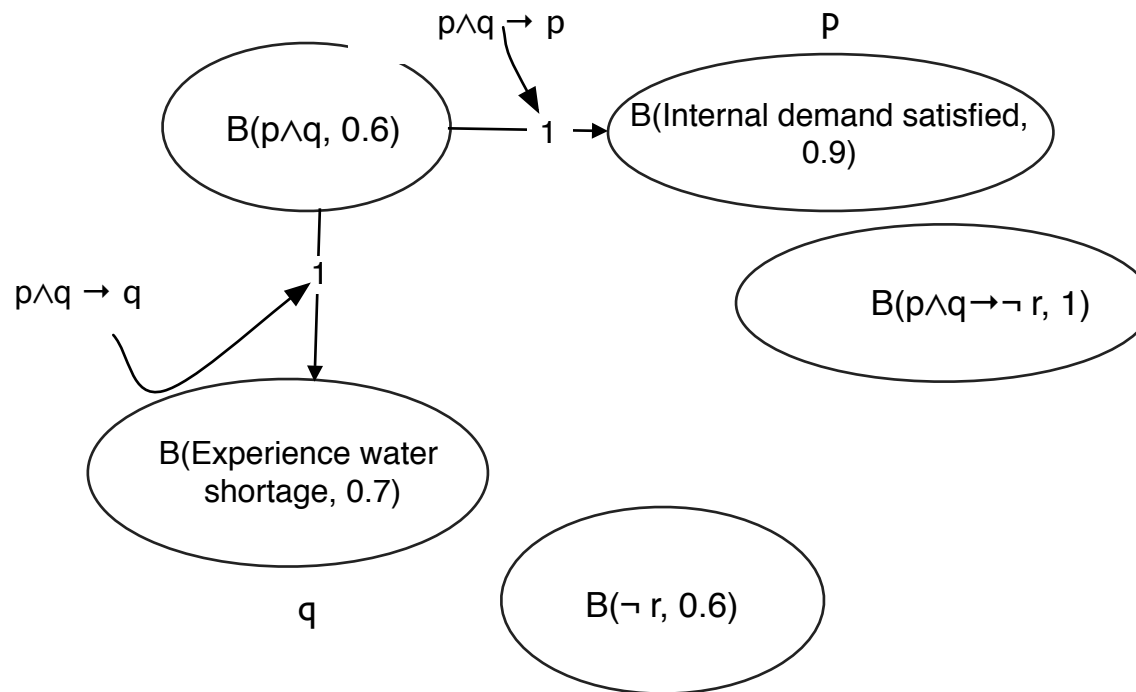


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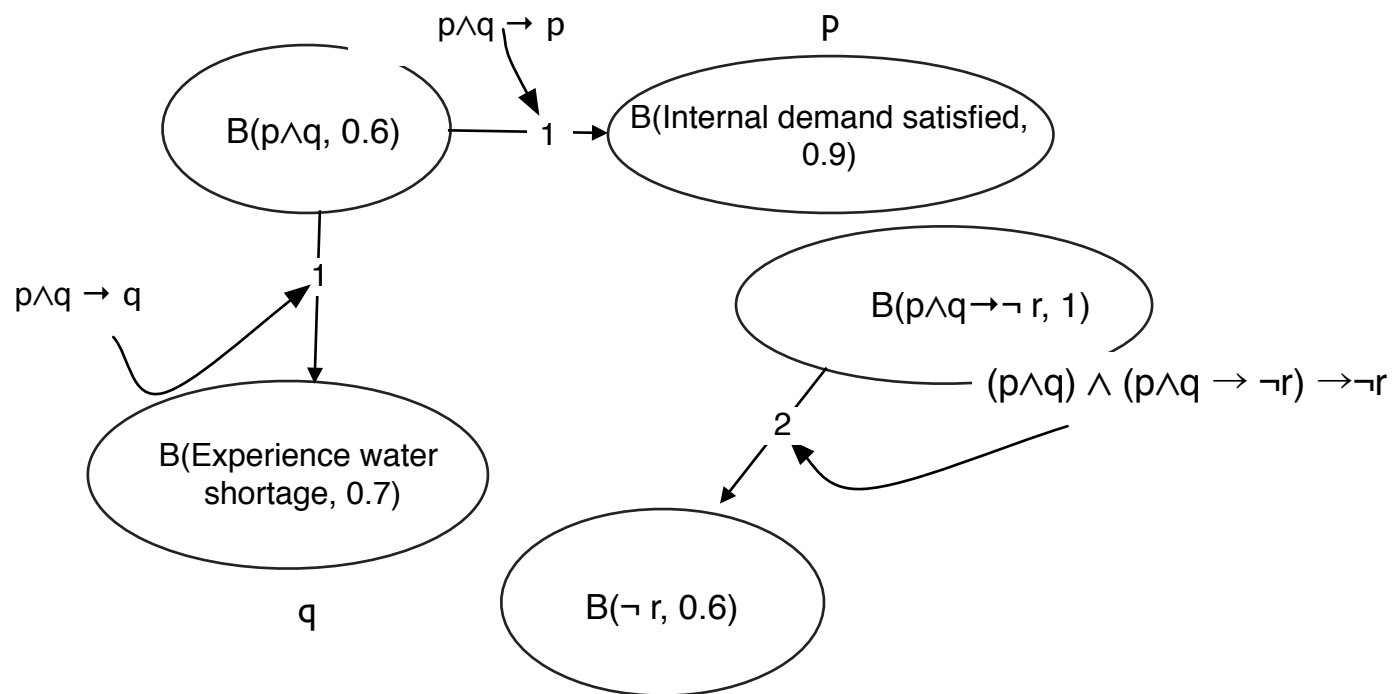


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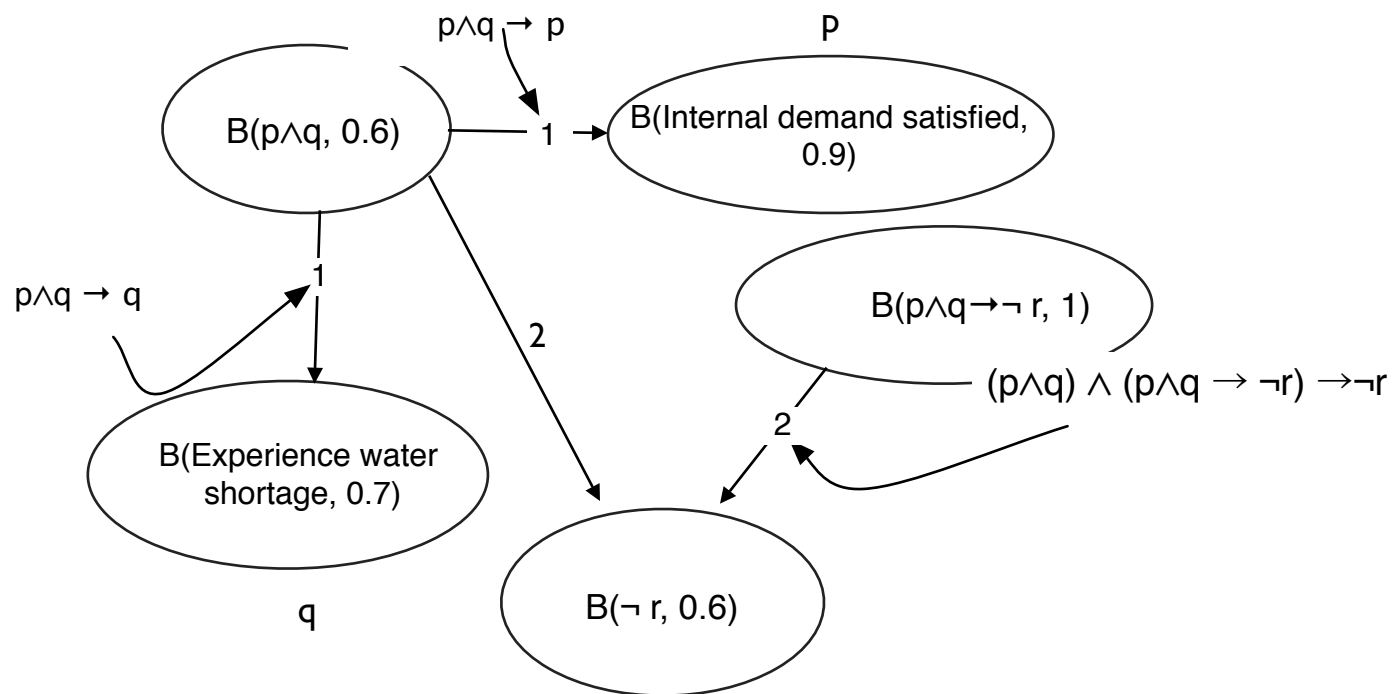


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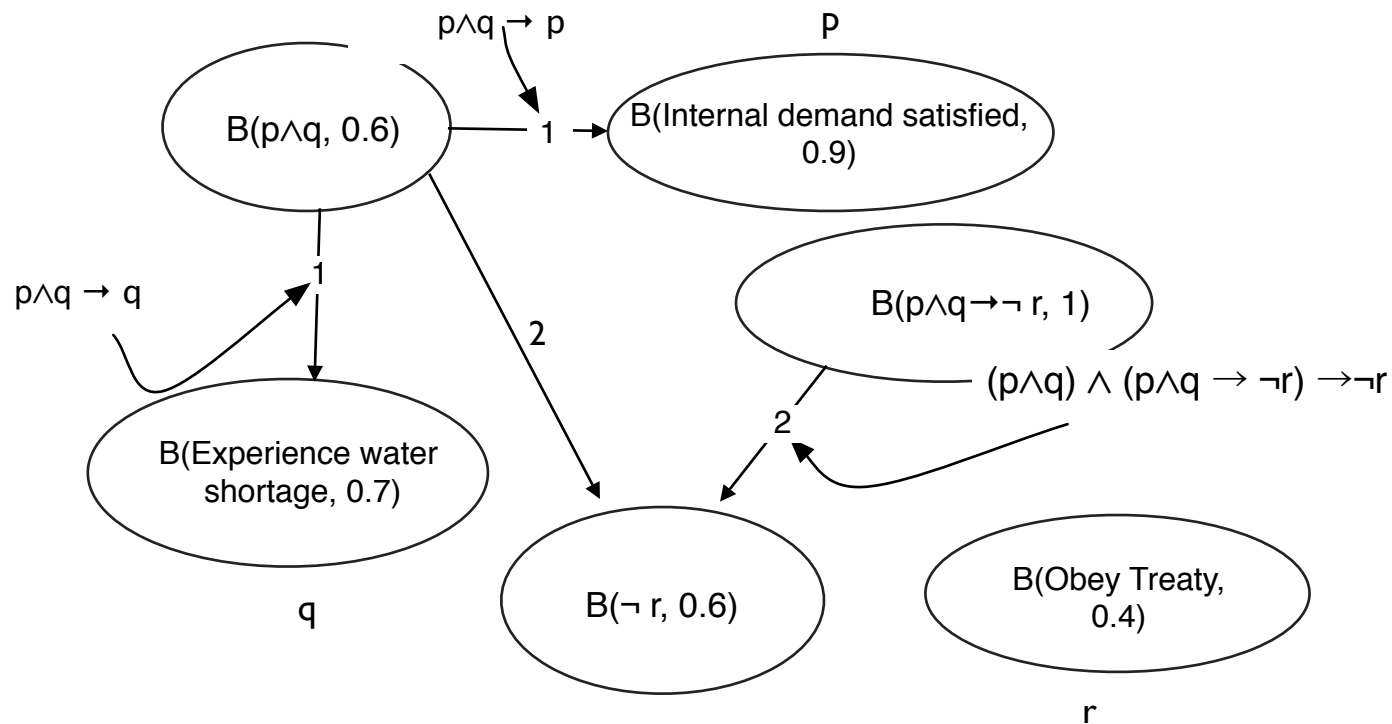


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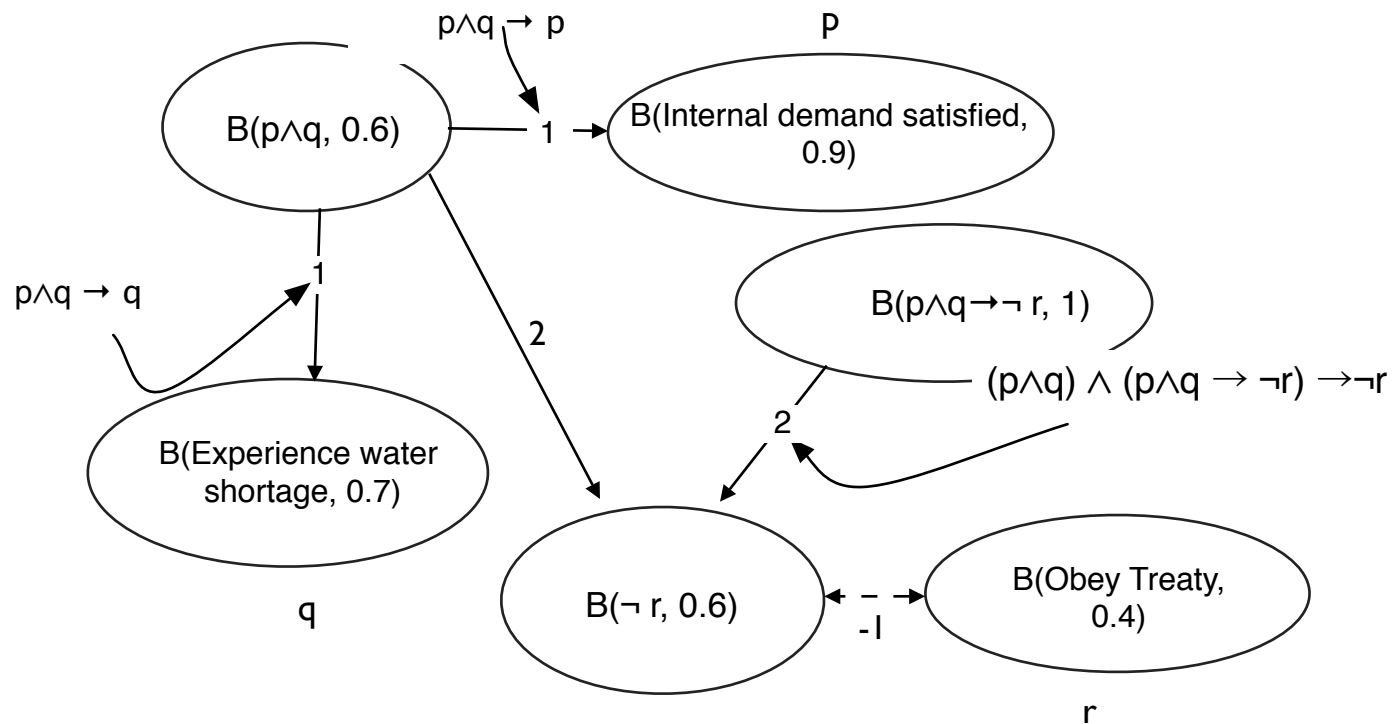


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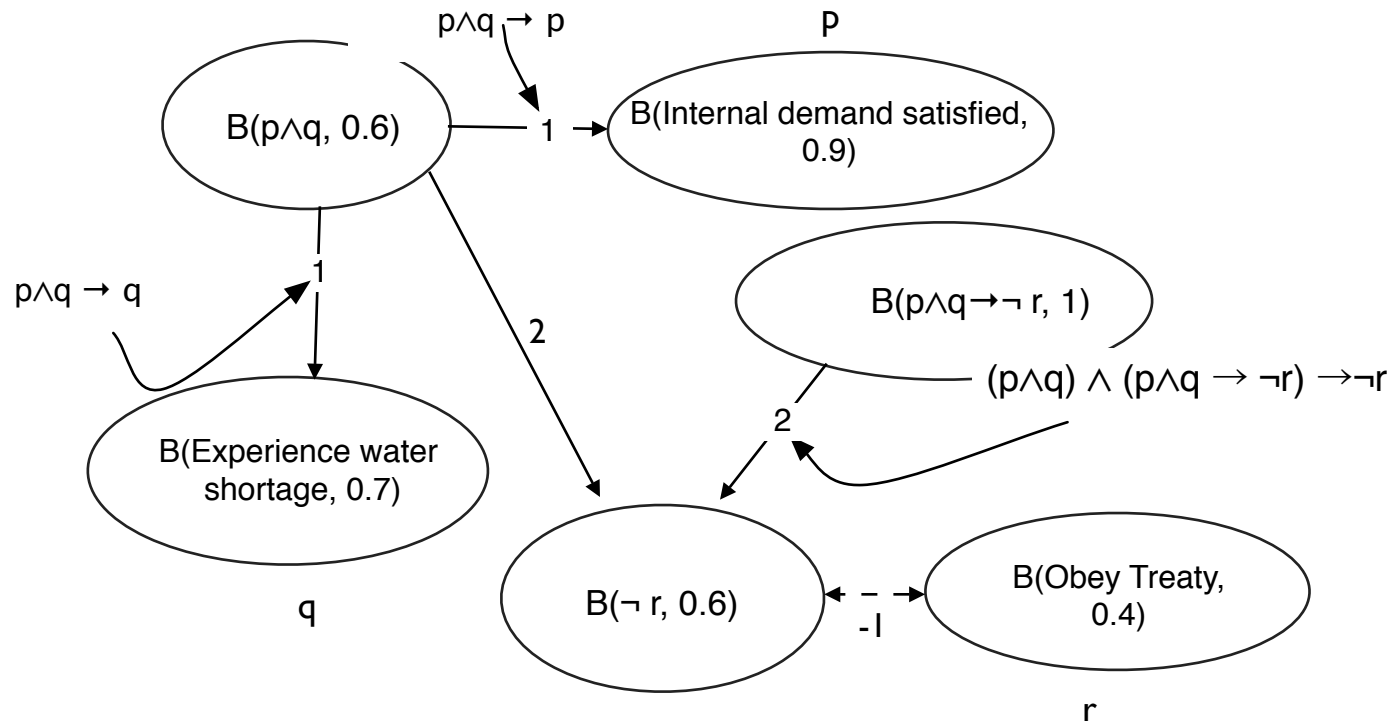


Deductive Coherence - Constructing a coherence Graph





Deductive Coherence - Constructing a coherence Graph



$$SD(\alpha, \beta) = \begin{cases} n + 1 & \text{if there exists } \Gamma \subseteq \mathcal{T}, \text{ the smallest set, such that } \Gamma, \alpha \vdash \beta \\ & \text{and } |\Gamma| = n \text{ and } \Gamma, \alpha \not\vdash \text{ and } \Gamma \not\vdash \beta \\ 1 & \text{if } \vdash \beta \text{ and } \alpha \not\vdash \\ -1 & \text{if } \alpha, \beta \vdash \\ \text{undefined} & \text{otherwise} \end{cases}$$



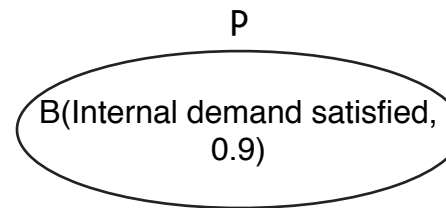
Deductive Coherence - Constructing a coherence Graph



We show that ζ Satisfies Thagard's Principles



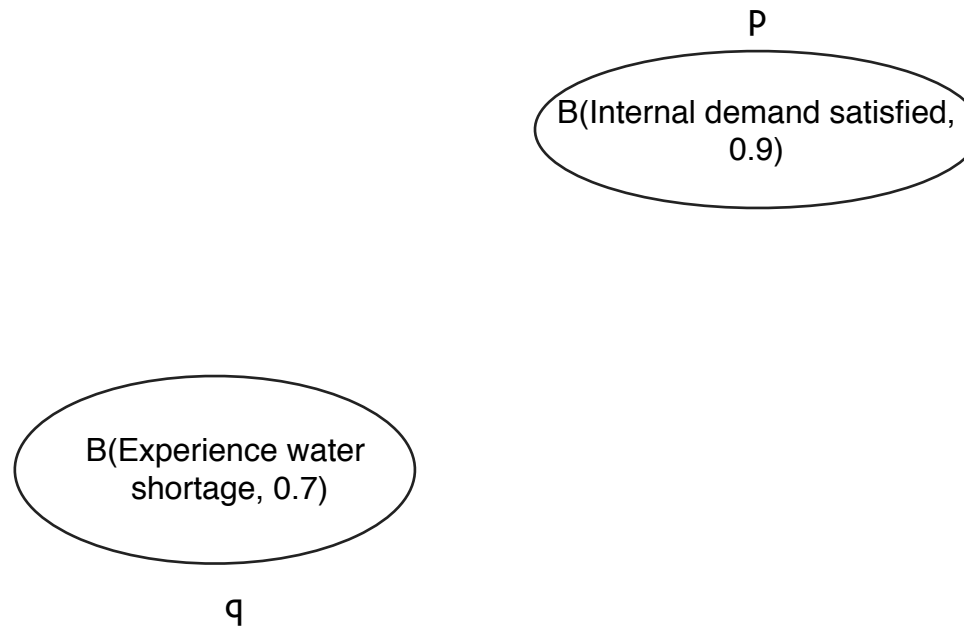
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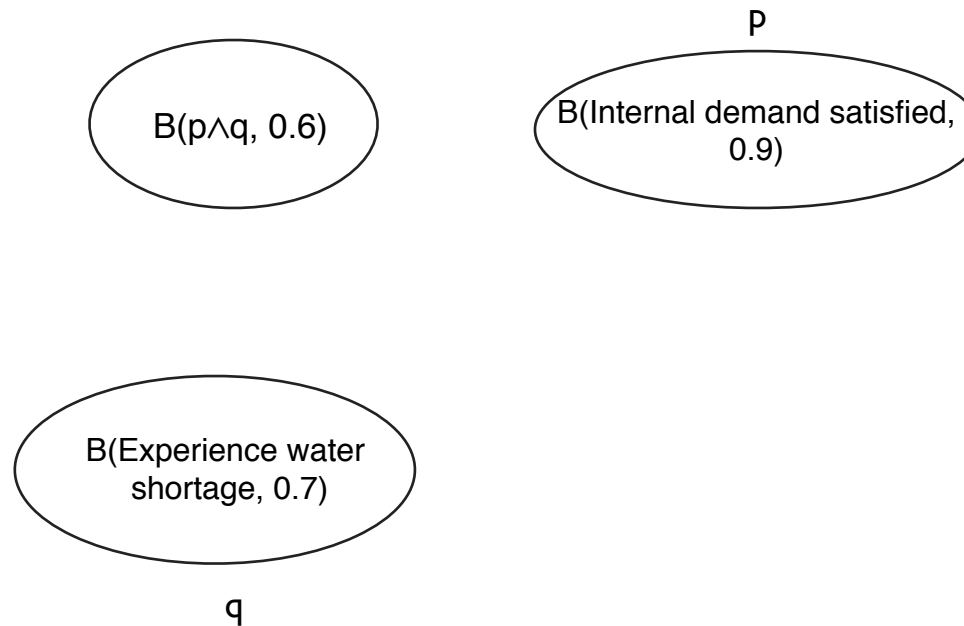
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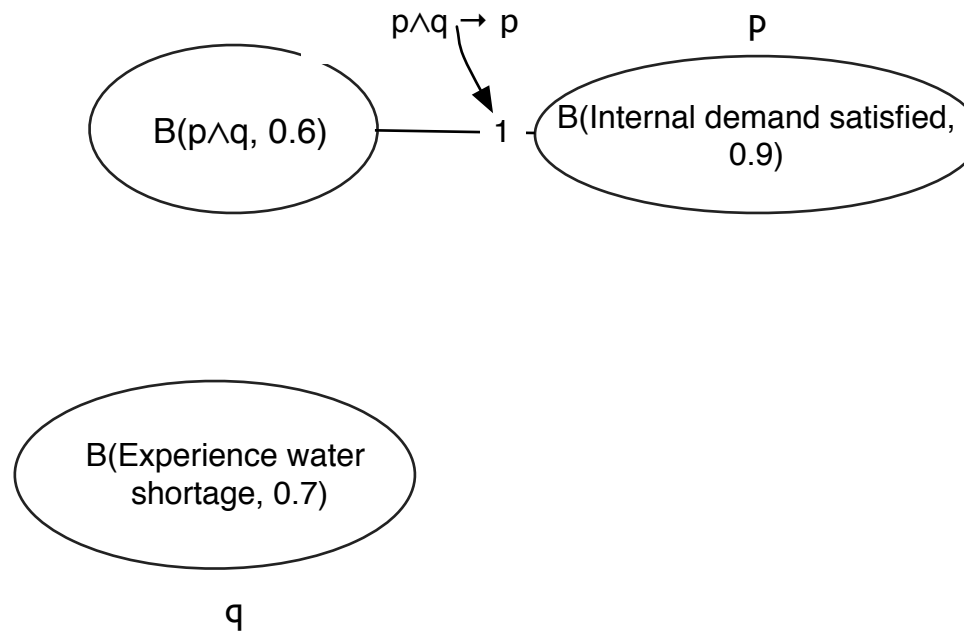
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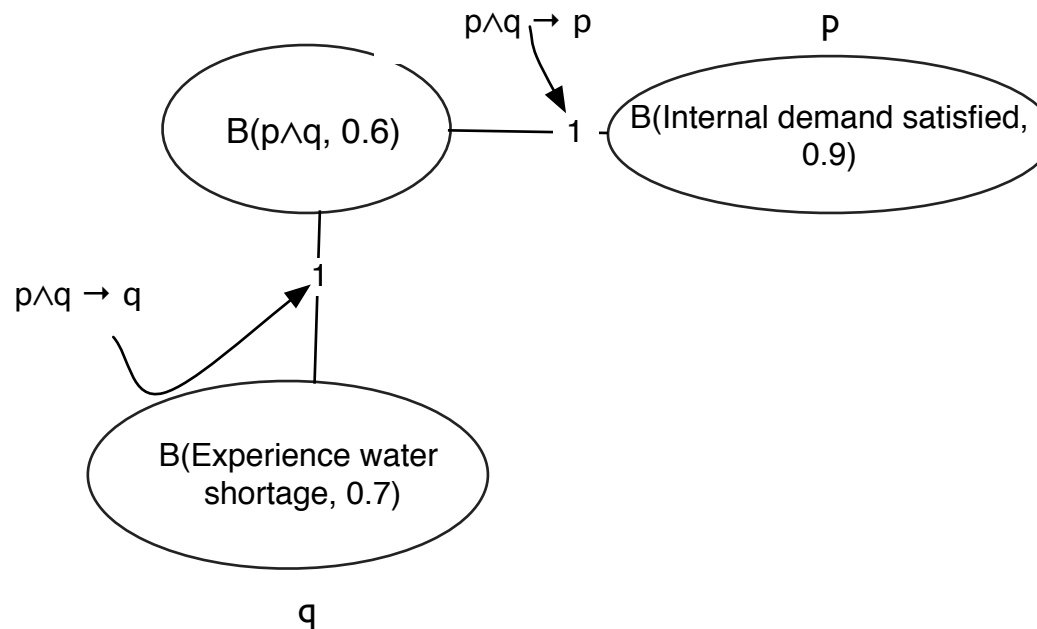
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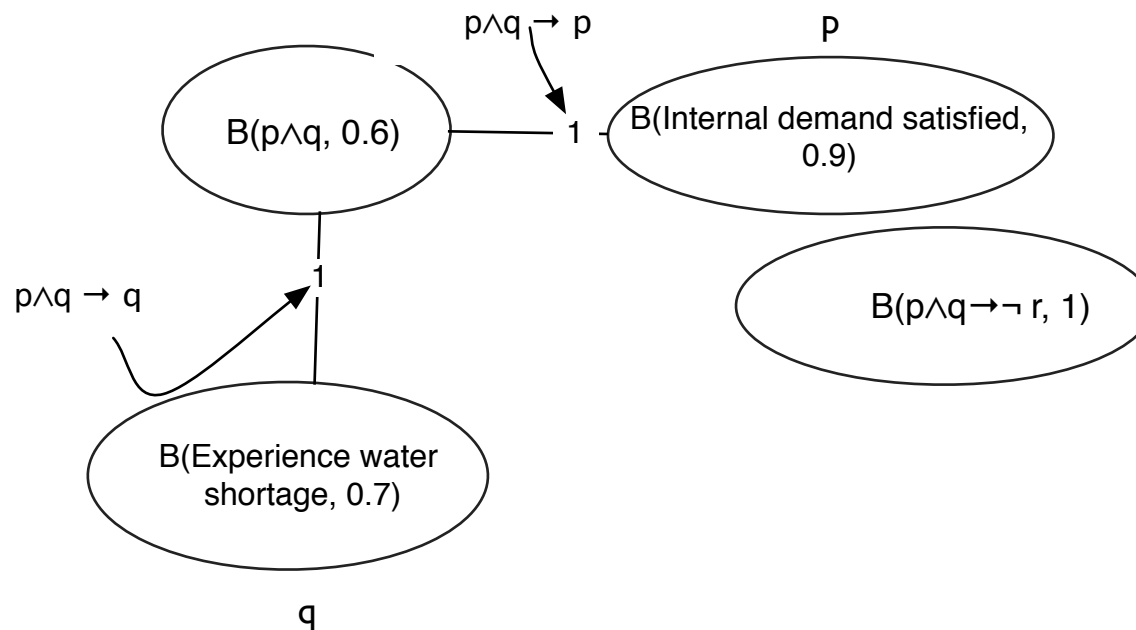
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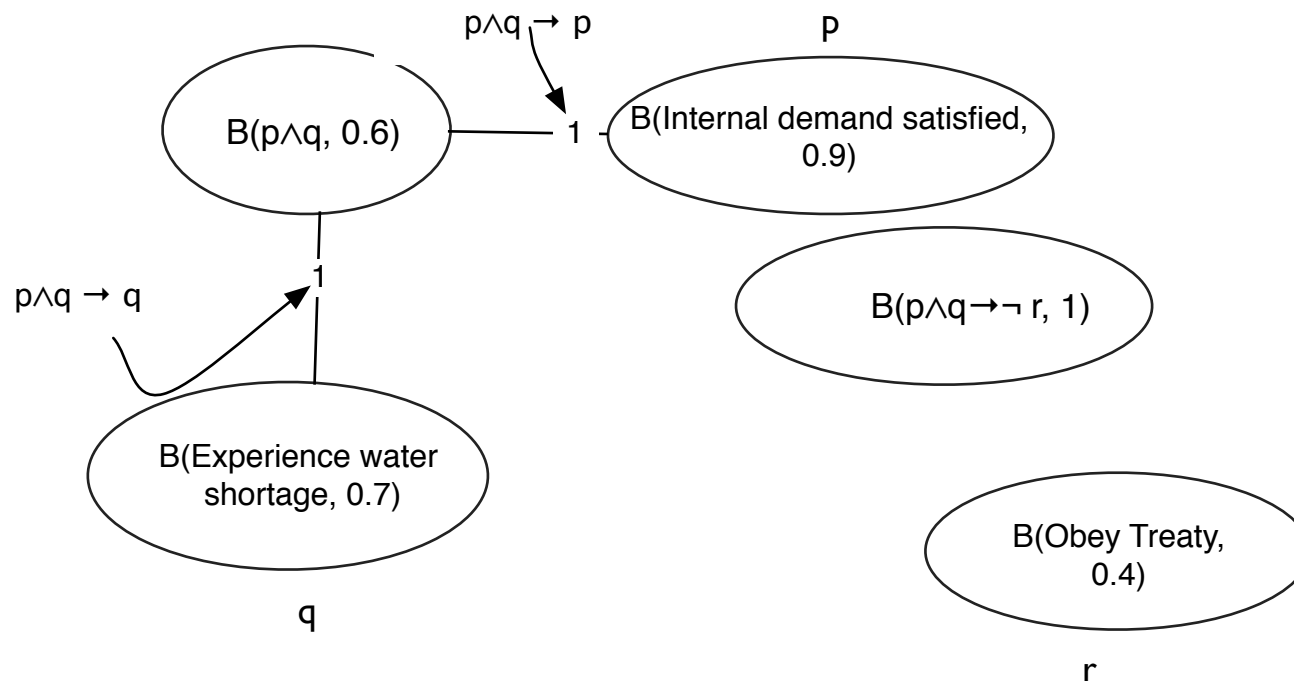
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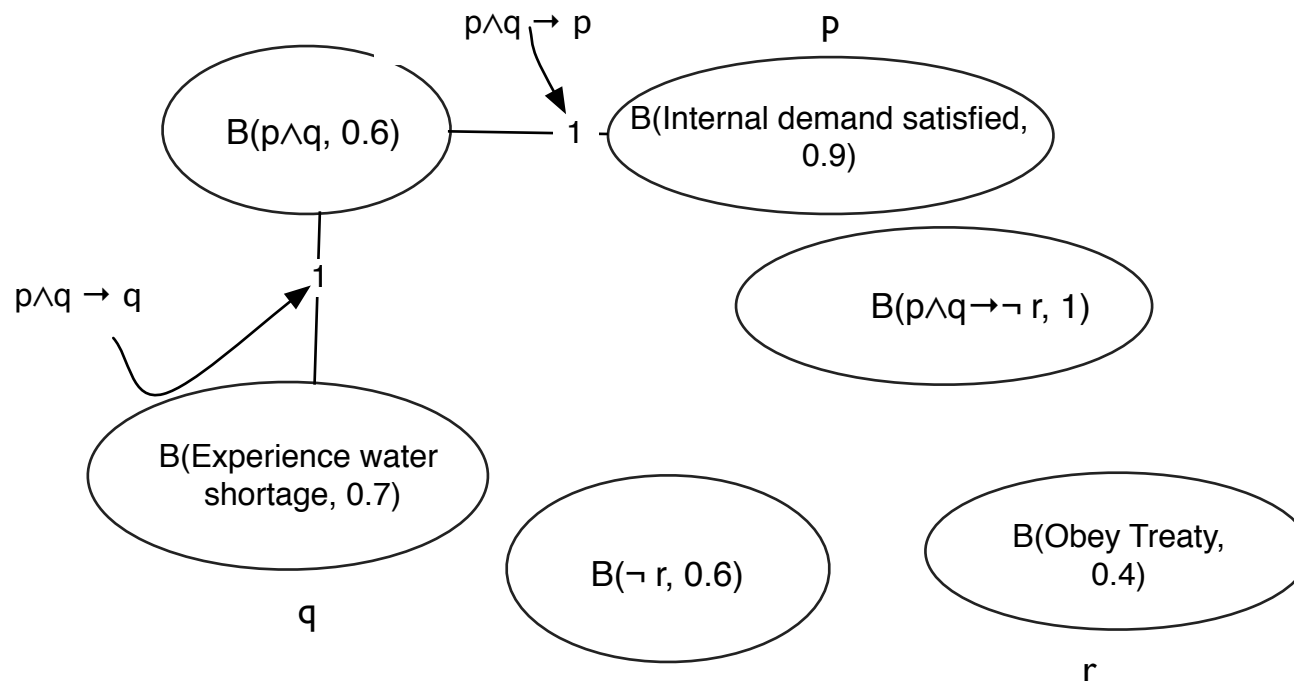
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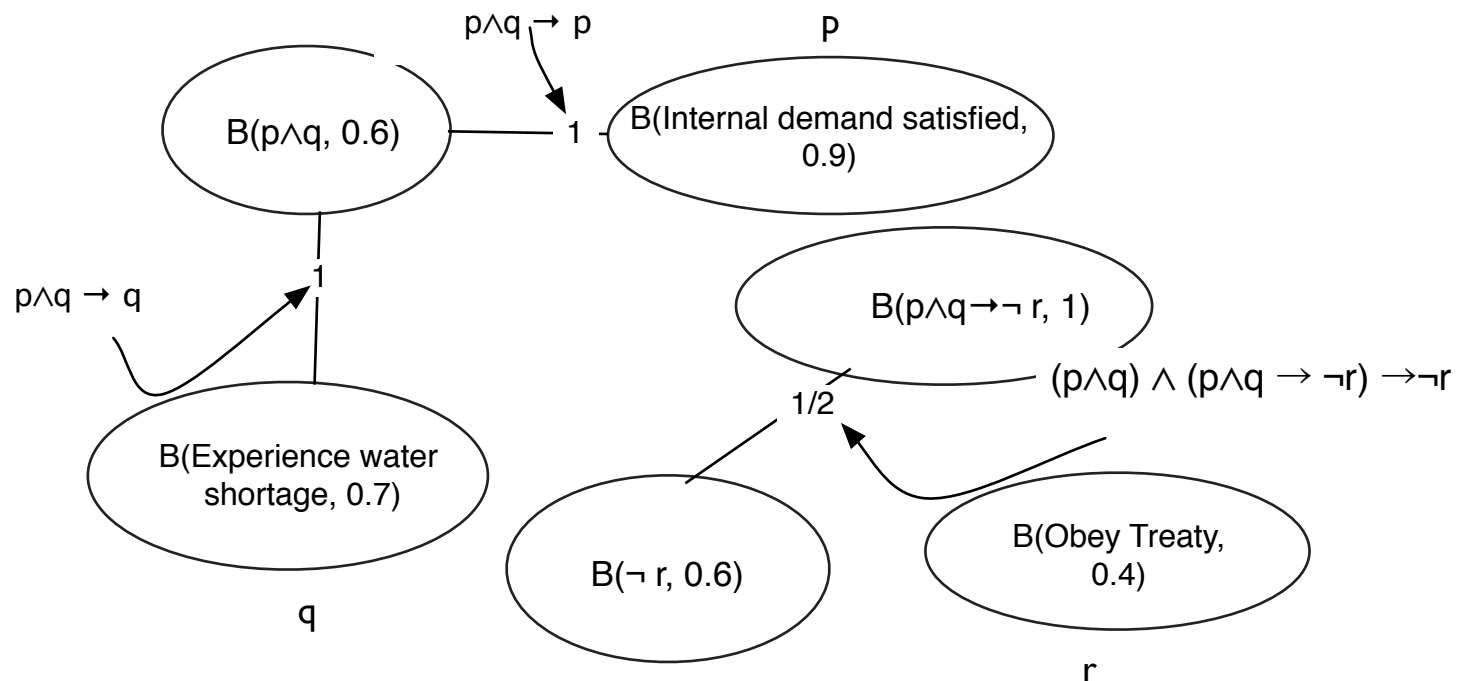
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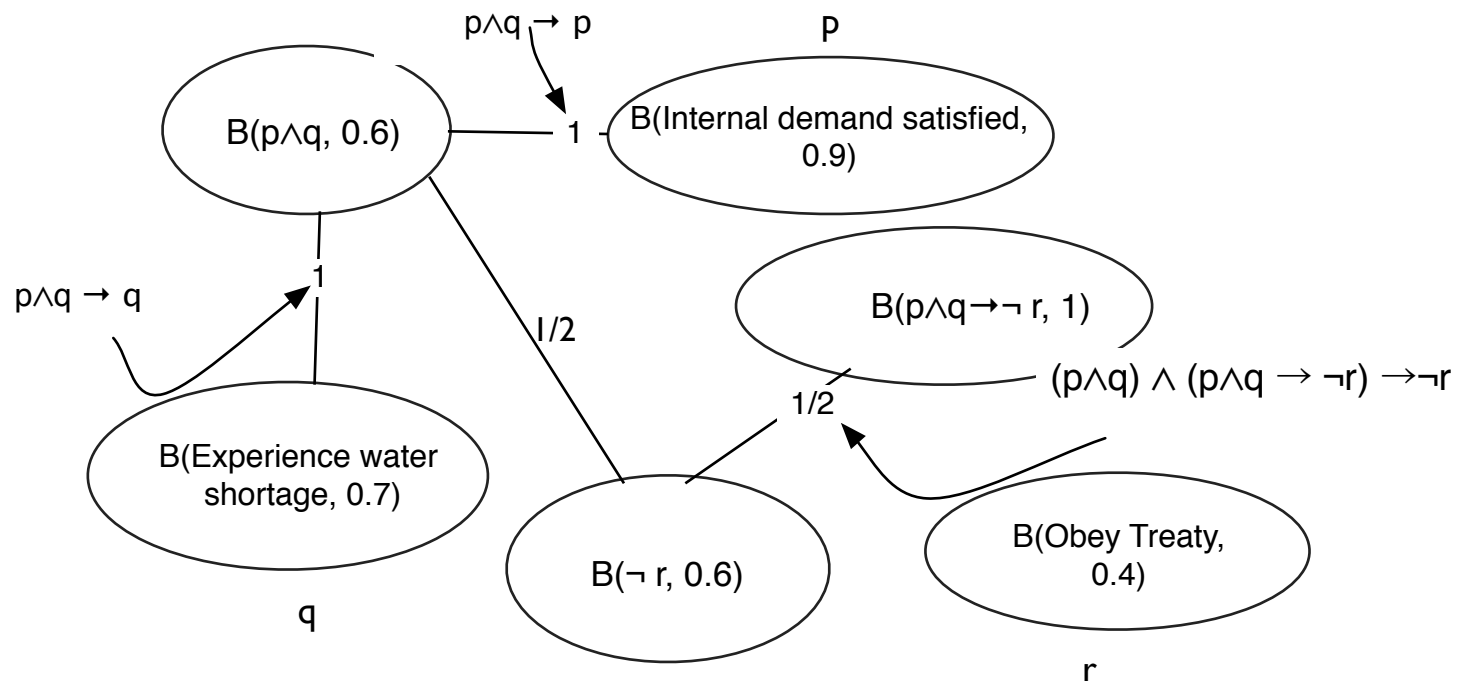
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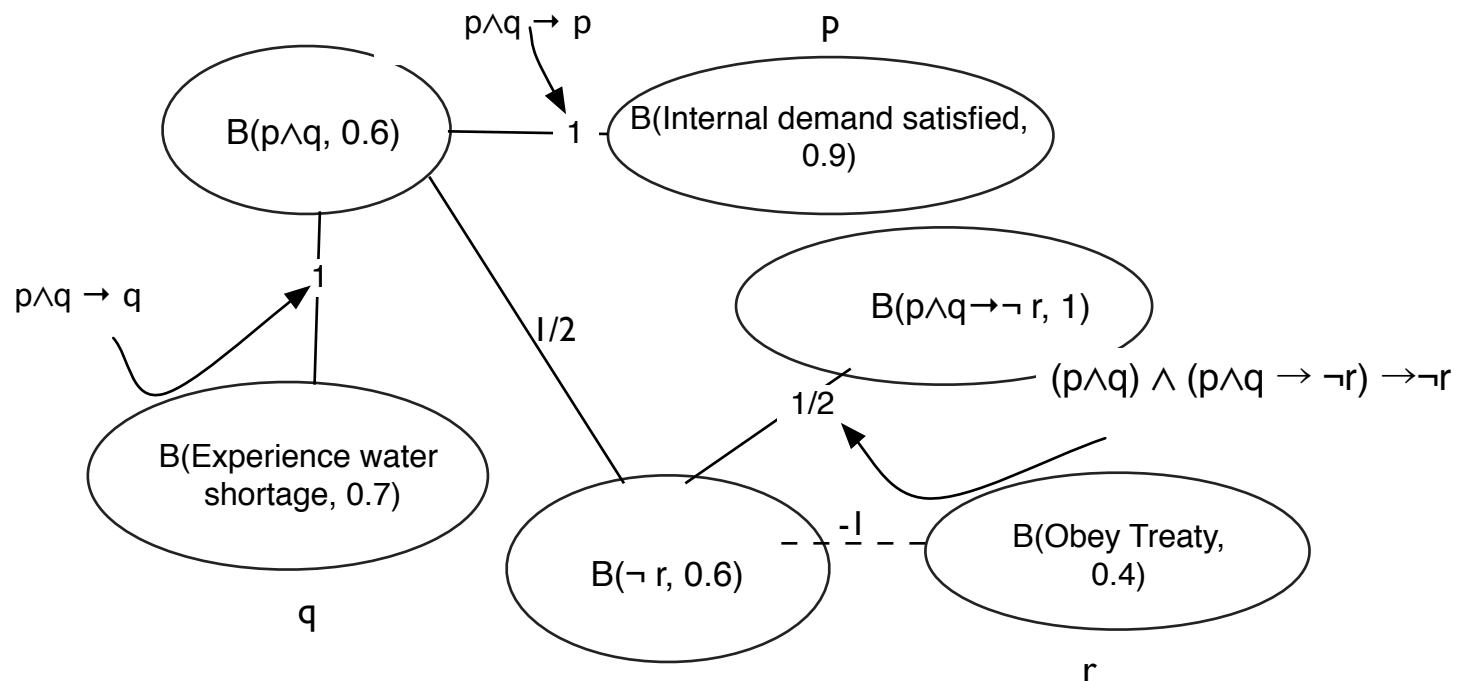
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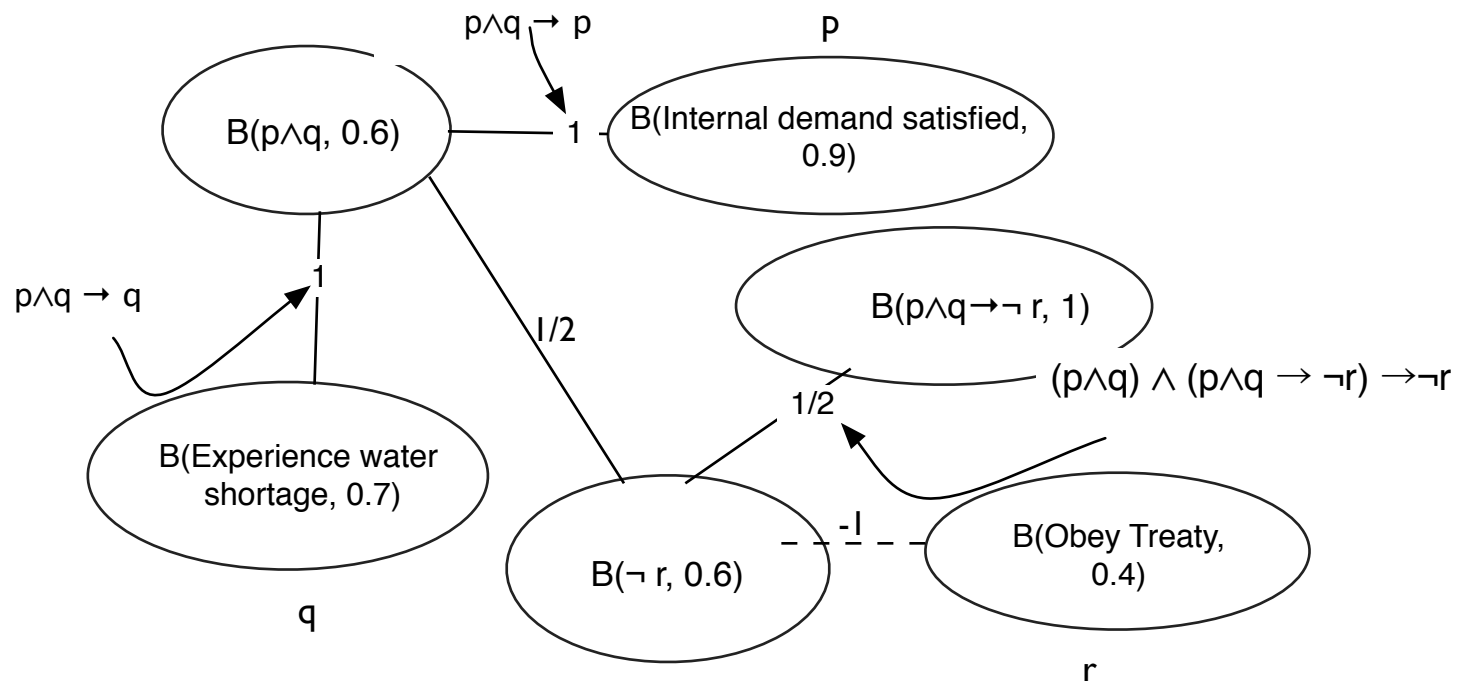
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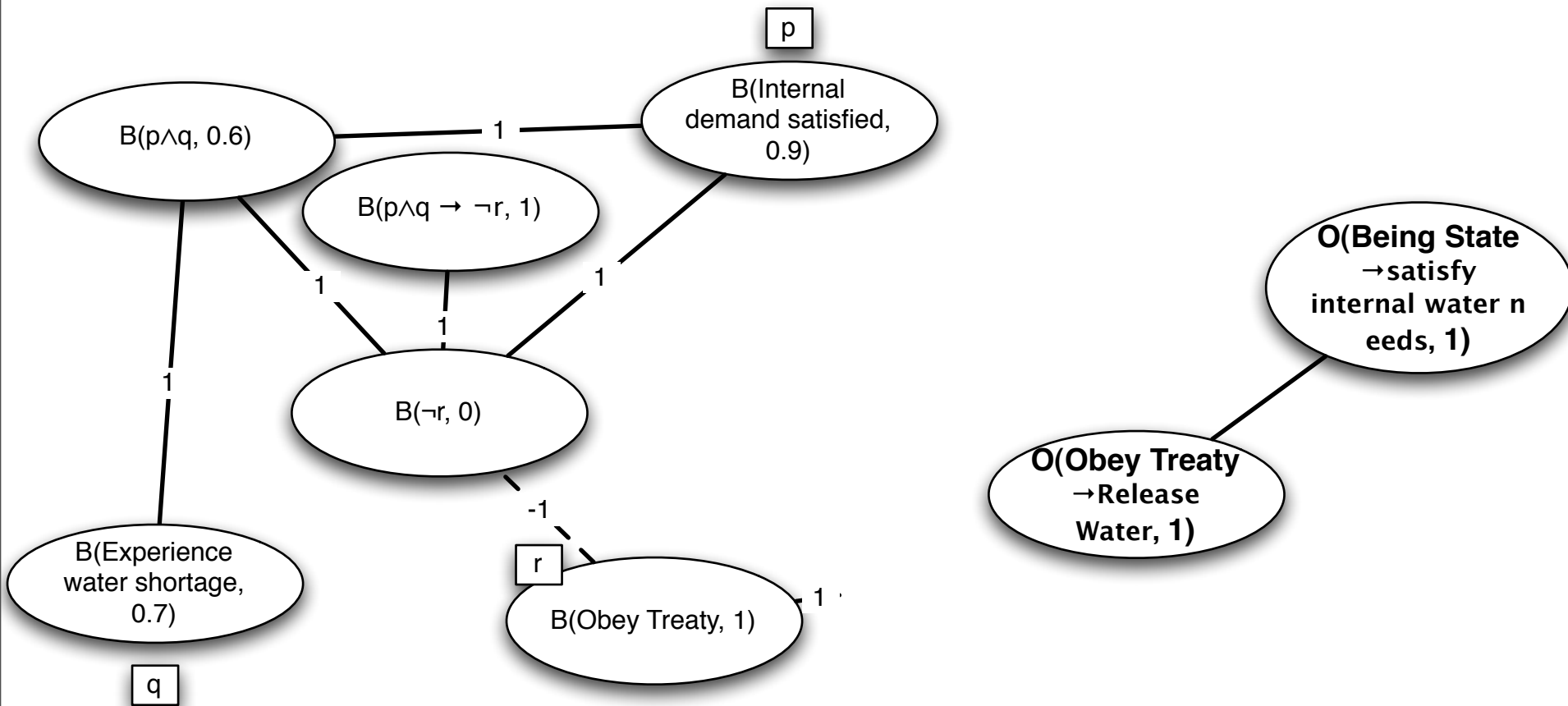
$$\zeta(\alpha, \beta) = \begin{cases} 1 / \min(\eta(\alpha, \beta), \eta(\beta, \alpha)) & \text{if both } \eta(\alpha, \beta) \text{ and } \eta(\beta, \alpha) \text{ are defined} \\ 1 / \eta(\alpha, \beta) & \text{if } \eta(\alpha, \beta) \text{ is defined and } \eta(\beta, \alpha) \text{ undefined} \\ 1 / \eta(\beta, \alpha) & \text{if } \eta(\beta, \alpha) \text{ is defined and } \eta(\alpha, \beta) \text{ undefined} \\ \text{undefined} & \text{otherwise} \end{cases}$$

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Special Coherence Graphs

- ★ Corresponding to a BDI- normative agent





Composing Coherence graphs



- Composition preserves existing relations
- May Add new nodes to participating graphs
- Adds new edges between participating graphs



A Coherence Agent Architecture



An agent is a multi-context System $\langle \{C_i\}, \Delta_b, f, h \rangle$

$$\text{Br} = \frac{o : O(\varphi \rightarrow \psi), i : I(\varphi)}{i : I(\psi)}$$



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O(Obey Treaty
→Release
Water, 1)

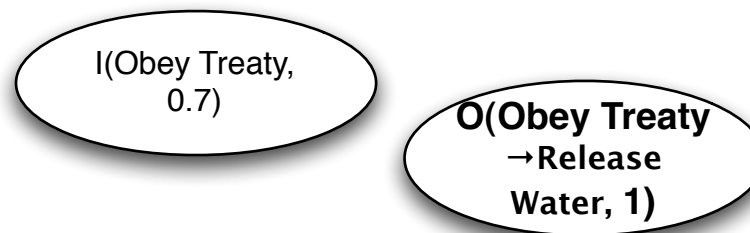


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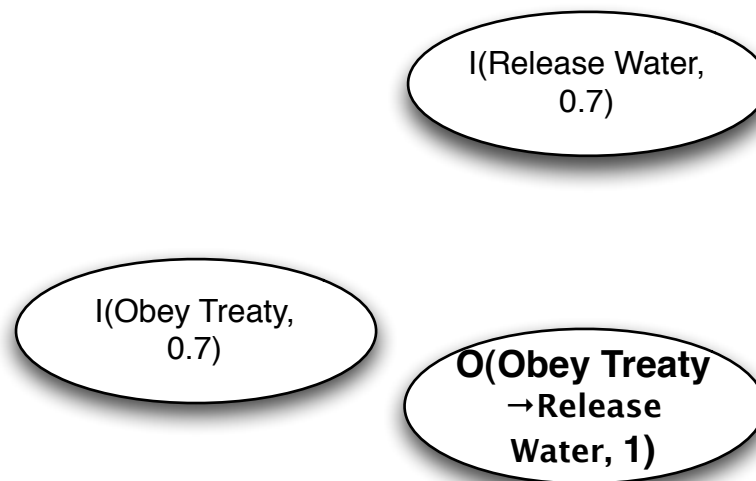




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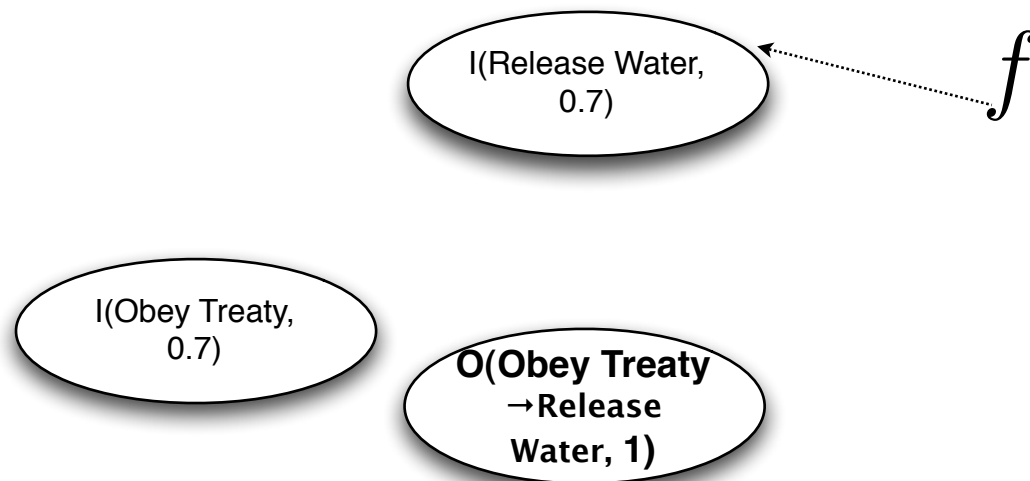




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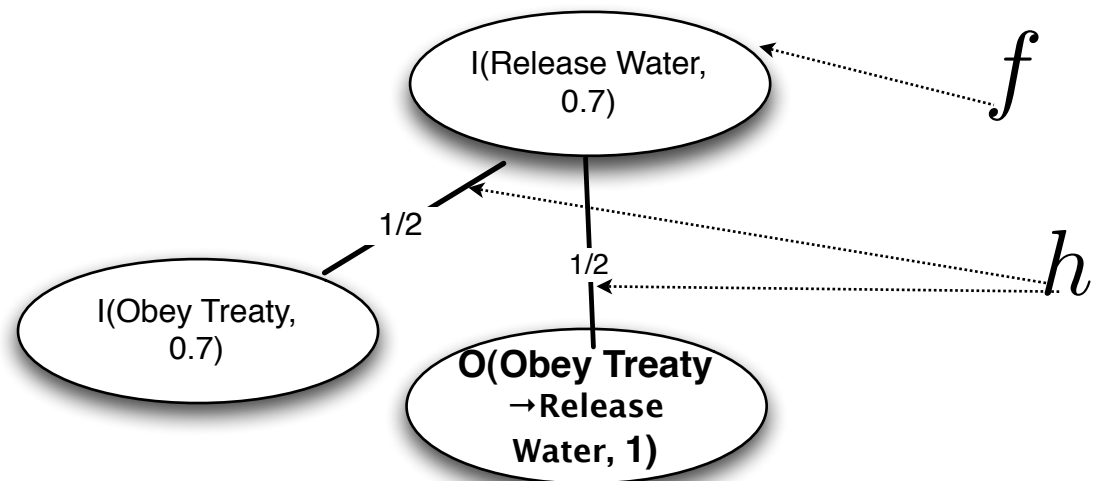




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A Coherence Maximizing Agent



- ★ Evaluates each Action against coherence maximization

Accepts signing the treaty:

$$V_1 := V_1 \cup \{B(p_{16}, 1), I(p_{16}, 1)\}$$

$$\text{Coherence } 4.41/16 = 0.28$$

Rejects Signing the treaty:

$$V_1 := V_1 \cup \{B(\neg p_{16}, 1), B(p_{15}, 1)\} \setminus \{I(\neg p_{15}, 1)\}$$

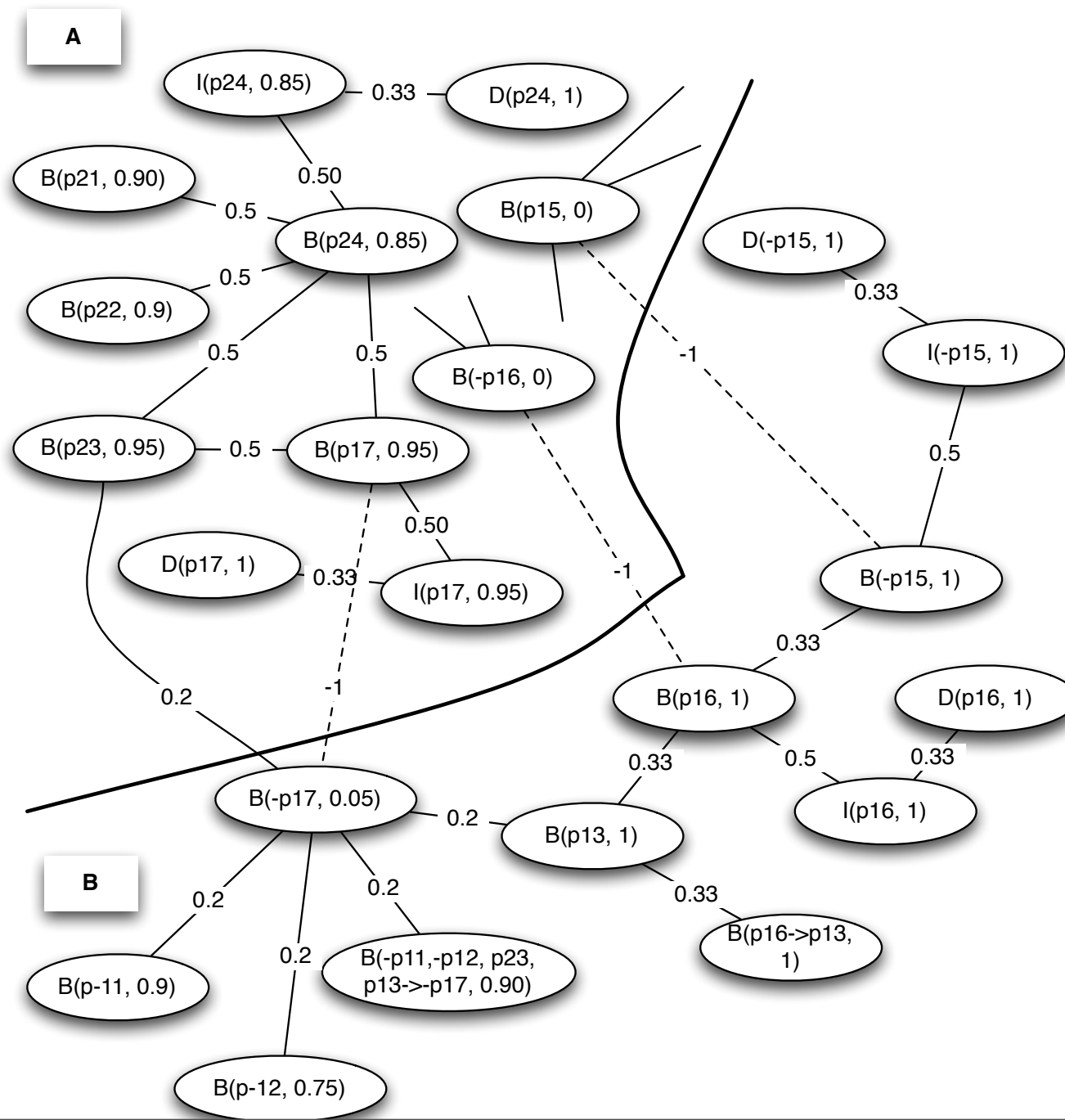
$$\text{Coherence } 3.07/16 = .19$$

$p_{15} | \langle s_2_threat, status, realized \rangle$

$p_{16} | \langle norm_proposal, status, accepted \rangle$



Evaluating a Norm





Summary & Future Work



- ❧ Summary
 - ❧ A generic framework to introduce autonomy in a normative multiagent system
- ❧ Future Work
 - ❧ Study norm violation from an institutional perspective
 - ❧ Experimental evaluation of coherence based agents and institutions



Related work in the field

- ❧ Evolutionary /learning techniques for adaptive institutions.
- ❧ Incorporating Rewards and sanctions to influence agent decisions
- ❧ Coherence theory for dialogue generation
- ❧ Coherence from an argumentation perspective
- ❧ Internal Argumentation