Dynamic Aspects of the Erotetic Decomposition Principle

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Outline

(Erotetic Decomposition Principle): Transform a principal question into auxiliary questions in such a way that:

- consecutive auxiliary questions are dependent upon previous questions and, possibly, answers to previous auxiliary questions, and
- once auxiliary questions are resolved, the principal question is resolved as well.

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What is IEL?

- Inferential Erotetic Logic (IEL for short) is a logic that analyzes inferences in which questions perform the role of conclusions, and proposes criteria of validity for these inferences.
- The following semantical concepts are introduced:
  - **evocation** of questions by sets of declarative sentences/d-wffs, and
  - **erotetic implication** of questions by questions and sets of declarative sentences/d-wffs.
- **Validity** is then defined in terms of evocation or erotetic implication, depending on the type of inference under consideration.
- The general setting of IEL does not require the underlying logic of declaratives to be classical. In other words, IEL is neutral in the controversy concerning what "The Logic" of declaratives is.

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Examples of Erotetic Implication

Is Andrew lying?
Andrew lies if, and only if he speaks very slowly.

Does Andrew speak very slowly?

Where did Andrew leave for: Paris, London or Moscow?
If Andrew left for Paris, London or Moscow, then he departed in the morning or in the evening.
If Andrew departed in the morning, then he left for Paris or London.
If Andrew departed in the evening, then he left for Moscow.

When did Andrew depart: in the morning, or in the evening?

Where does Andrew live?
Andrew lives in a university town in Western Poland.

Which towns in Western Poland are university towns?

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Erotetic Implication: Intuitions

Soundness: A question is *sound* iff at least one direct answer to the question is true.

Roughly, question Q (erotetically) **implies** question Q_1 **on the basis of** a set X of declarative sentences/d-wffs if:

(I) (TRANSMISSION OF SOUNDNESS/TRUTH INTO SOUNDNESS):

- *If Q is sound and X consists of truths, then Q_1 must be sound.*

(II) (OPEN-MINDED COGNITIVE USEFULNESS):

- *For each direct answer B to Q_1 there exists a non-empty proper subset Y of the set of direct answers to Q such that the following condition holds:*
  - (•) *if B is true and X consists of truths, then at least one direct answer (to Q) in Y must be true.*

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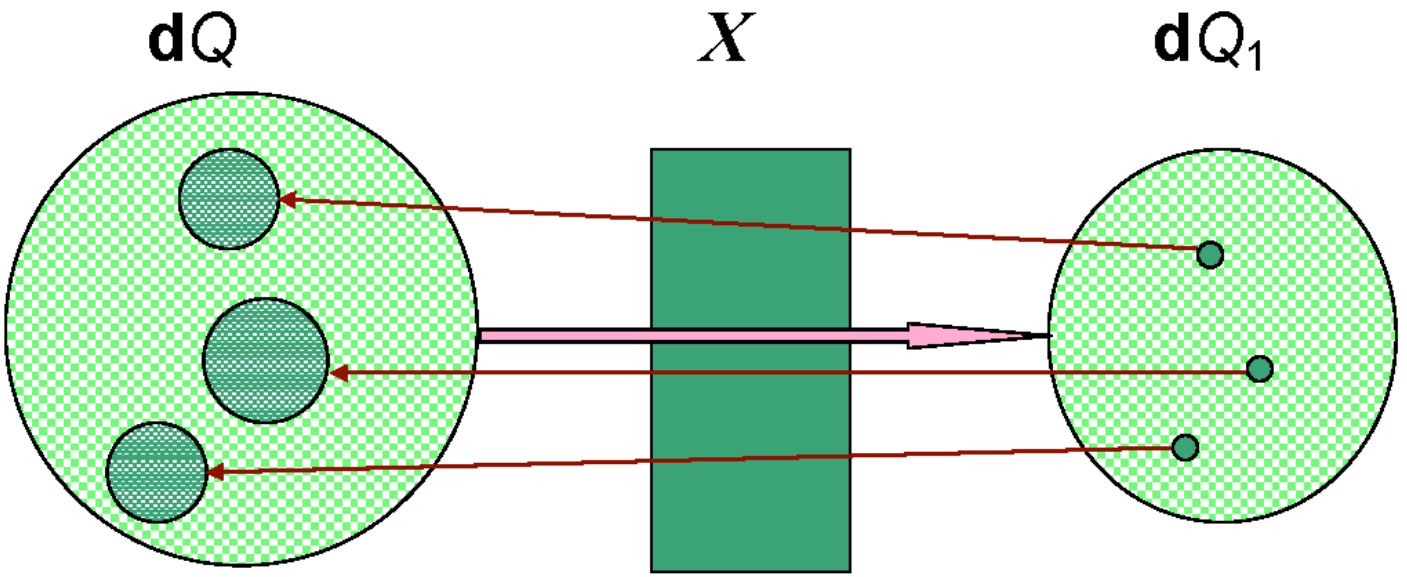

Figure: *Two directions*

Definition of Erotetic Implication

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(Erotetic Implication) $\mathbf{Im}(Q, X, Q_1)$ iff:

1. for each $A \in \mathbf{d}Q : X \cup \{A\} \mid\models \mathbf{d}Q_1$, and
2. for each $B \in \mathbf{d}Q_1$ there exists a non-empty proper subset Y of $\mathbf{d}Q$ such that $X \cup \{B\} \mid\models Y$.

Remarks:

$\mathbf{d}Q$ and $\mathbf{d}Q_1$ stand for the sets of *direct answers* to Q and Q_1, respectively.

It is assumed that a question has at least two (sentential) direct answers.

$\mid\models$ denotes *multiple-conclusion entailment*.

Erotetic Implication: Further Examples

Where did Andrew leave for: Paris, London, or Rome?
Andrew left for Paris, London or Rome.
If Andrew flew by Air France, then he left for Paris.
If Andrew did not fly by Air France, then he did not leave for Rome.

Did Andrew fly by Air France?

Where did Andrew leave for: Paris, London, or Rome?
Andrew left for Paris or London.

Did Andrew leave for London?

Did Andrew leave for London?
Andrew left for London if and only if he flew by BA or Rynair.

Did Andrew fly by BA, or by Rynair, or by neither of them?

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"Smart" Decomposition

Let the principal question be:

- *Where did Andrew leave for: Paris, London, or Rome?*

Assume that it is known that, int.al., the following hold:

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The problem is: how to decompose the principal question such that the following would hold:

- consecutive auxiliary questions are dependent upon previous questions and, possibly, answers to previous auxiliary questions, and
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An option is: let us build an **erotetic search scenario**.

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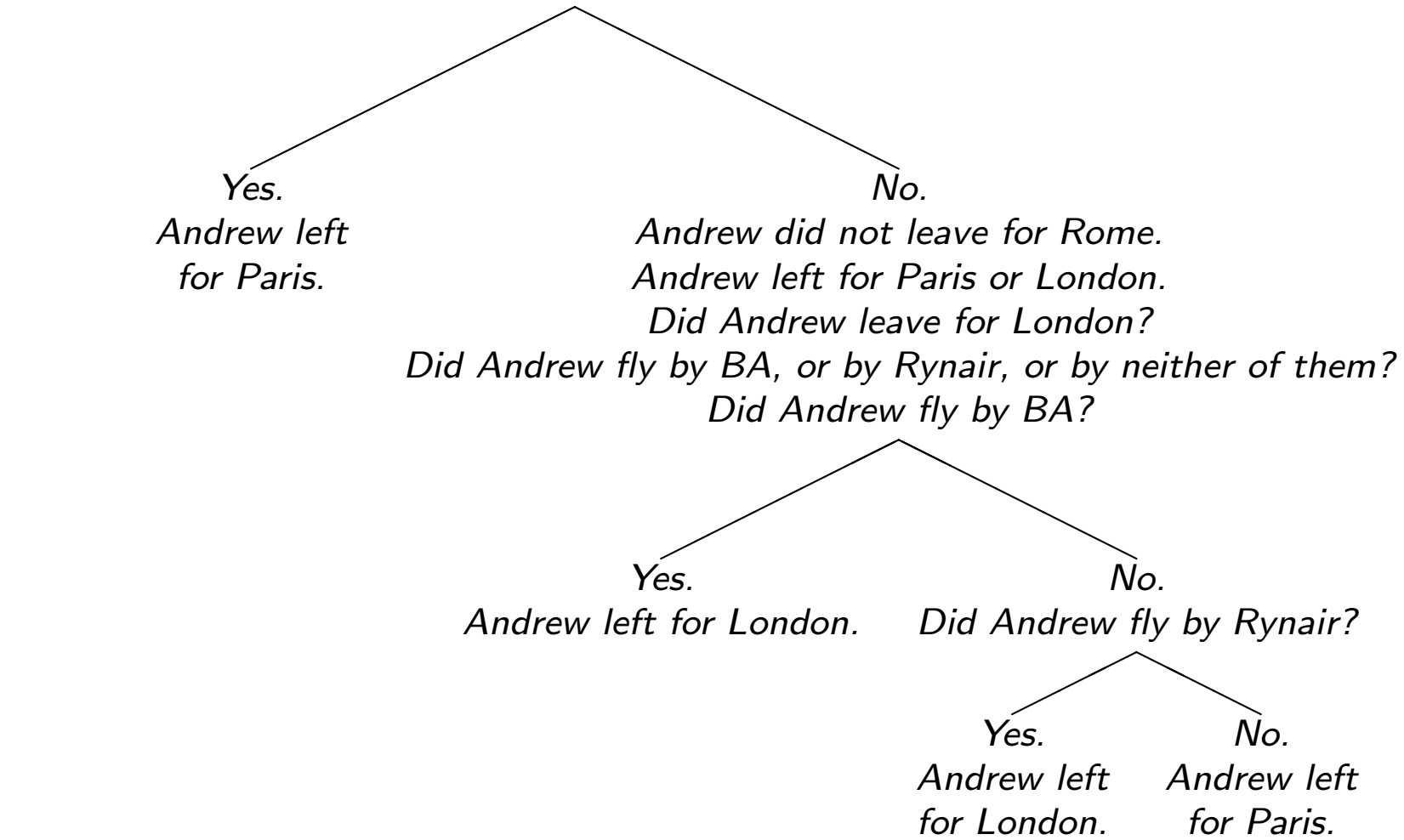

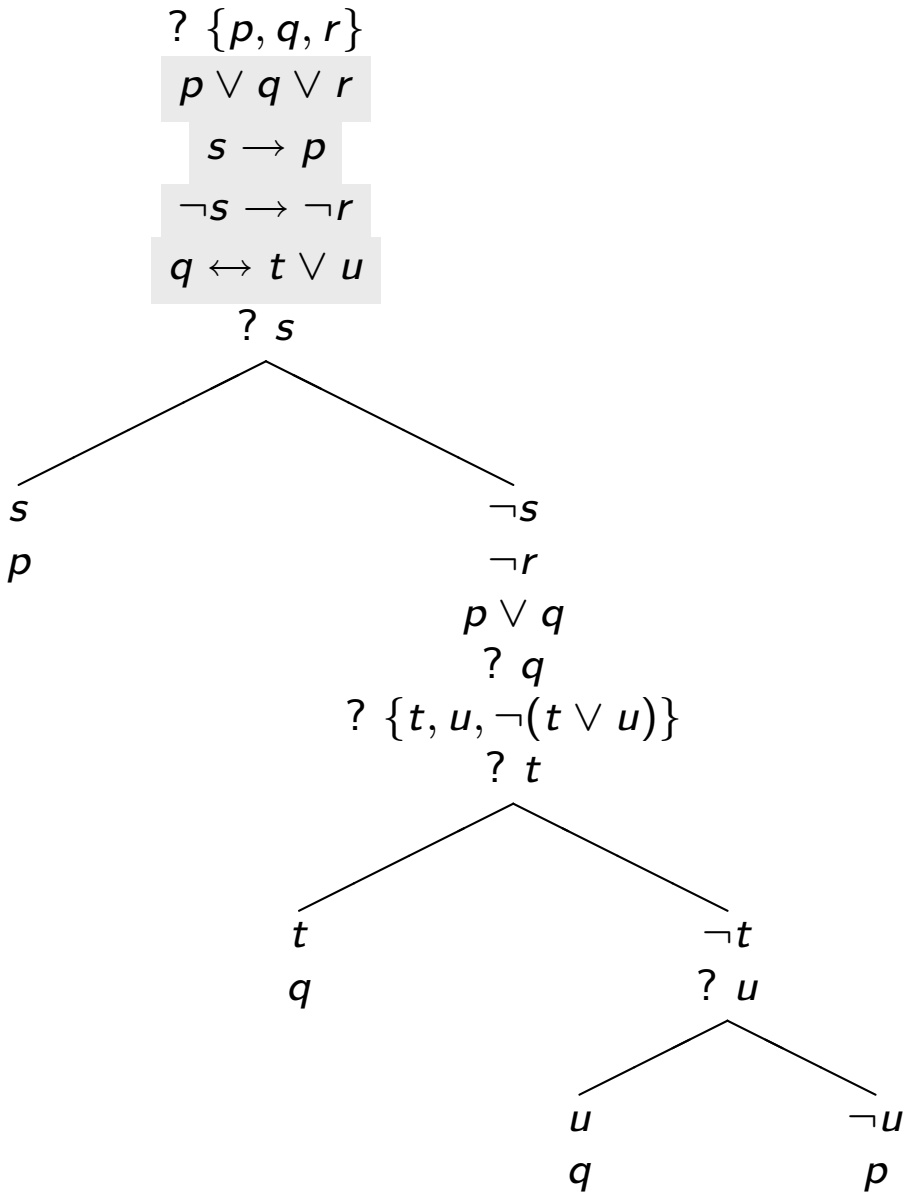

Figure: *An example of an e-scenario*

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Erotetic search scenarios (e-scenarios for short) can be defined in terms of:

- families of interconnected e-derivations,
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(2) Q labels the root of Φ;

(3) each leaf of Φ is labeled by a direct answer to Q;

(4) $\mathbf{d}Q \cap X = \emptyset$;

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  (c) $\{B_1, \ldots, B_n\} \models A$, where B_i $(1 \leq i \leq n)$ labels a d-node of Φ that precedes the d-node γ_δ in Φ;

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Paths, Queries, and the Remaining Auxiliary Questions

- A **query** of an e-scenario Φ can be defined as a question that labels an e-node of Φ which is different from the root and whose immediate successor is not an e-node.
- It follows that a question is a query iff it labels an e-node such that all the immediate successors of it are d-nodes labeled with direct answers to the question.
- An e-scenario can involve auxiliary questions that are not queries.
- **Paths** of e-scenarios can be identified with downward sequences of labels of nodes of branches, that is, sequences having the principal question as the first term and direct answers to the question as last terms.

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Non-Queries

Since erotetic implication is not "transitive", non-queries need not be redundant.

For example, (assuming Classical Logic as the basis) one cannot get '? B' from '? A' and '$B \to A$' by erotetic implication. But the following hold:

- $\mathbf{Im}(?\ A, B \to A, ?\ \{A, \neg A, B\})$
- $\mathbf{Im}(?\ \{A, \neg A, B\}, ?\ B)$

Thus non-queries enable arriving at queries.

The Golden Path Property

One can prove the following:

Theorem (Golden Path Theorem)

Let Φ be an e-scenario for a question Q relative to a set of d-wffs X. Assume that Q is sound in an admissible partition $\mathbf{P}$, and all the d-wffs in X are true in $\mathbf{P}$. The e-scenario Φ contains at least one path $\mathbf{s}$ such that:

(1) *each d-wff of $\mathbf{s}$ is true in $\mathbf{P}$,*

(2) *each question of $\mathbf{s}$ is sound in $\mathbf{P}$, and*

(3) *$\mathbf{s}$ leads to a direct answer to Q which is true in $\mathbf{P}$.*

A Pragmatic Account of E-scenarios

- E-scenarios are abstract entities defined in terms of IEL. But, looking from the pragmatic point of view, an e-scenario provides us with conditional instructions which tell what auxiliary questions should be asked and when they should be asked.
- Queries of e-scenarios can be viewed as requests for information. An e-scenario shows what is the next advisable query if the information request of the previous query has been satisfied in such–and–such way.
- What is important, an e-scenario does this with regard to any possible way of satisfying the request, where the ways are determined by direct answers to the question which functions as a query.
- Moreover, an e-scenario behaves in this manner in the case of any query of the e-scenario.
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- When faced with a problem-solving task, it is **advisable** to build an INITIAL E-SCENARIO for the question that expresses the problem just considered.
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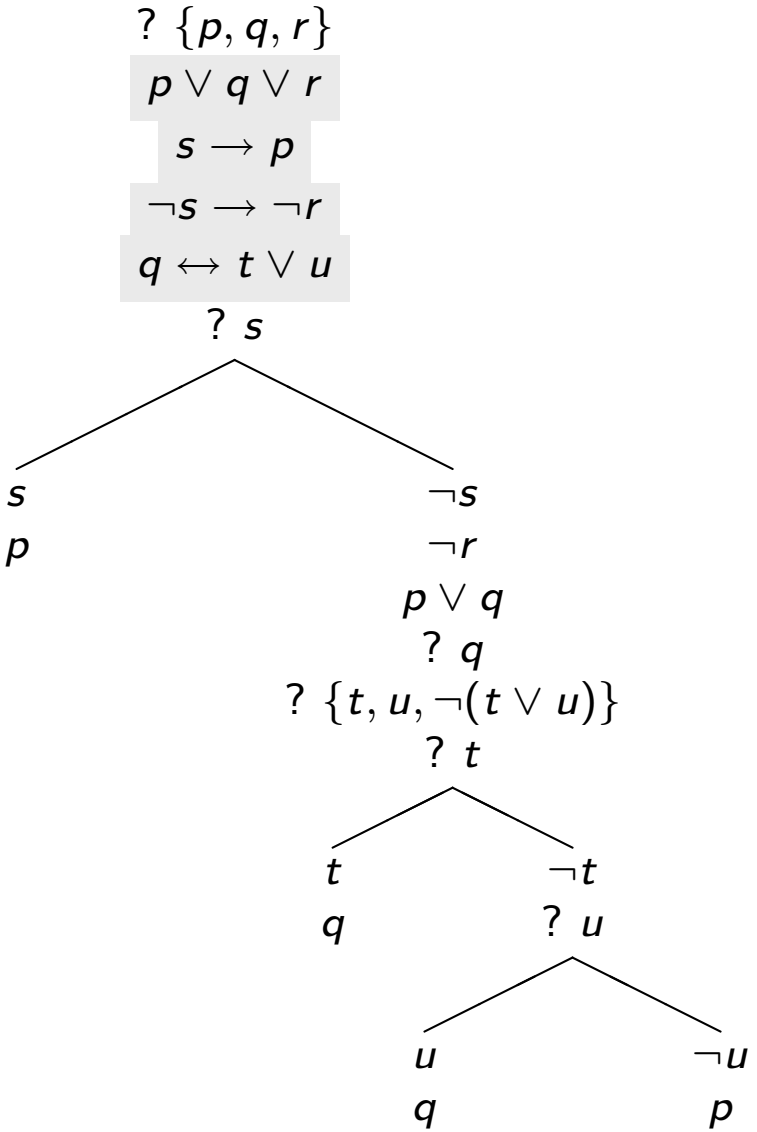

Figure: *The already presented e-scenario*

Embedding

- Question ? t is a query. Suppose, however, that it cannot be answered by existing means or answering the question is "costly" (in terms of time, or resources needed, etc.). Suppose further that it is known that:
  - $t \leftrightarrow w$
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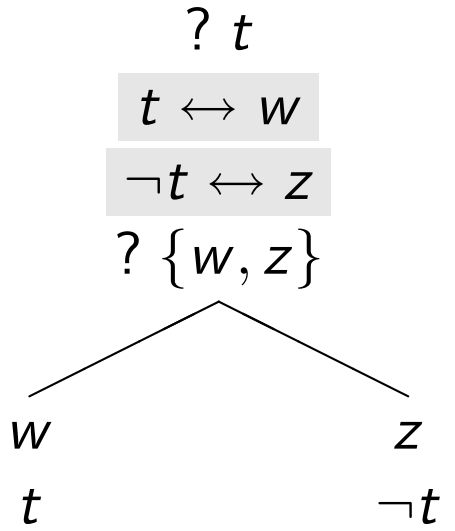

Embedding

- When question ? $\{w, z\}$ has a priority over question ? t in terms of availability of answers and/or "costs" of receiving an answer, it is rational to embed the e-scenario into the initial e-scenario.
- Embedding takes place with respect to the query ? t of the initial e-scenario, which is also the principal question of the e-scenario which is embedded.
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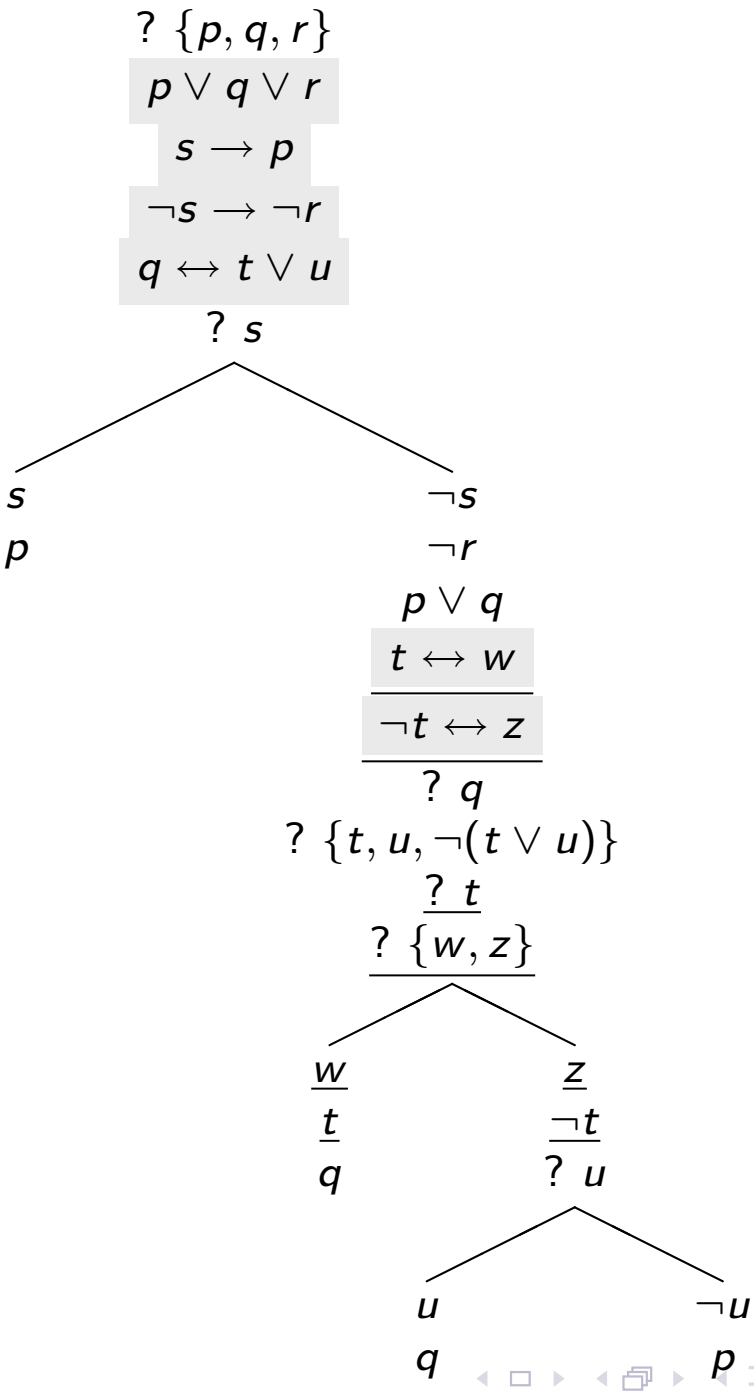
? {p, q, r}
p ∨ q ∨ r
s → p
¬s → ¬r
q ↔ t ∨ u
? s
s
p
¬s
¬r
p ∨ q
t ↔ w
¬t ↔ z
? q
? {t, u, ¬(t ∨ u)}
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- In this particular example the embedded e-scenario has only one query. This is not a rule, however.
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Embedding

- We embed with respect to (an occurrence of) a query.
- What is embedded is a *complete* e-scenario for the question which is the query. An e-scenario is complete iff its leaves are labeled by all the direct answers to the principal question (there is no direct answer which does not label any leaf).
- If the embedded e-scenario has a non-empty initial declarative segment, this segment is placed either just before the query considered, or – when the query is preceded by a sequence of e-nodes – just before the first e-node of the sequence.
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Embedding Theorem

- Embedding produces a new e-scenario only if some conditions are met.

Theorem (Embedding Theorem)

Let Φ be an e-scenario for Q relative to X. Let Q^* be a query of Φ, and Φ^* be a complete e-scenario for Q^* relative to Y. The result of embedding Φ^* for Q^* in Φ is an e-scenario for Q relative to $X \cup Y$ if:

- $Y \cap \mathbf{d}Q = \emptyset$, *and*
- *no e-node of Φ^* is labeled by a question whose set of direct answers equals $\mathbf{d}Q$.*

Embedding

- As for problem-solving, embedding is not restricted to the initial e-scenario. When needed, one can embed an e-scenario which has resulted by embedding.

Feasibility Results: CL

Theorem

Let Φ be a non-atomic e-scenario for a question Q relative to a set of d-wffs X such that each query of Φ is a quantifier-free safe question. If Q is not an atomic yes-no question, then there exists an e-scenario Φ^* for Q relative to X such that all the queries of Φ^* are atomic yes-no questions based on atoms that occur in the queries of Φ.

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Let Φ be a non-atomic e-scenario for a question Q relative to a set of d-wffs X such that each query of Φ is a quantifier-free question. Let Y be a set whose elements are disjunctions of all the direct answers to risky queries of Φ such that for each risky query of Φ, exactly one disjunction of all the direct answers to the query belongs to Y. If Q is not an atomic yes-no question and $\mathbf{d}Q \cap Y = \emptyset$, then there exists an e-scenario Φ^* for Q relative to $X \cup Y$ such that all the queries of Φ^* are atomic yes-no questions based on atoms that occur in the queries of Φ.

Feasibility results

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Let Φ be a non-atomic e-scenario for an atomic yes-no question Q relative to a set of d-wffs X such that: (a) each query of Φ is a quantifier-free safe question, and (b) the atom occurring in Q does not occur in any query of Φ. There exists an e-scenario Φ^* for Q relative to X such that all the queries of Φ^* are atomic yes-no questions based on atoms that occur in the queries of Φ.

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Contraction

- The idea which underlies the concept of contraction is the following.
- We have an e-scenario Φ for a question Q relative to a set of d-wffs X, a query Q^* of Φ, and a direct answer A to Q. [Clearly, A labels a d-node of Φ which is an immediate successor of the e-node labeled with Q^*.]
- We assume that Q^* has been answered with A.
- The answer A becomes a new initial premise and Φ contracts with respect to "new" information carried by A; roughly:
  - the paths of Φ which go through the other answers to query Q^* become irrelevant and thus are deleted,
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- As an illustration, let us consider the already analyzed e-scenario:

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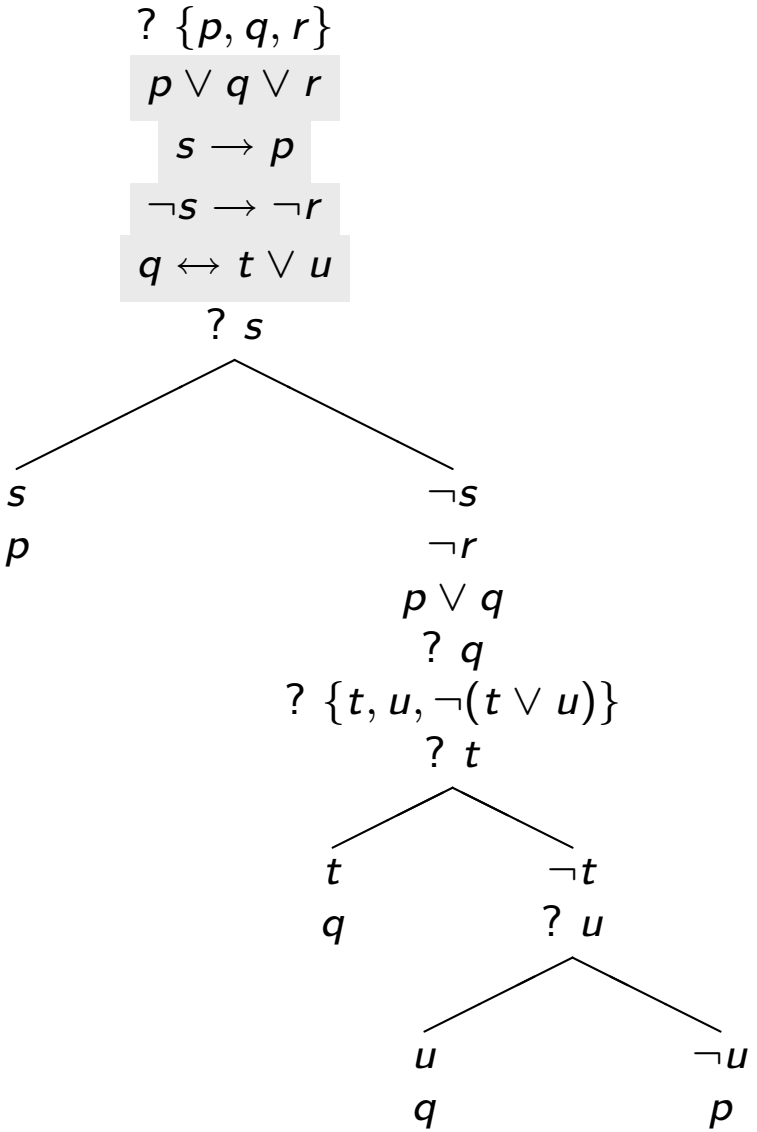

Figure: *The already presented e-scenario*

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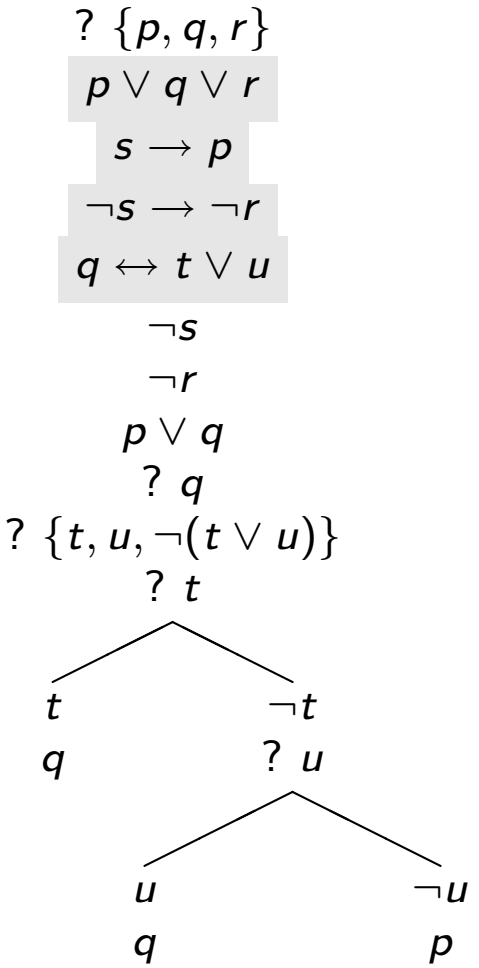

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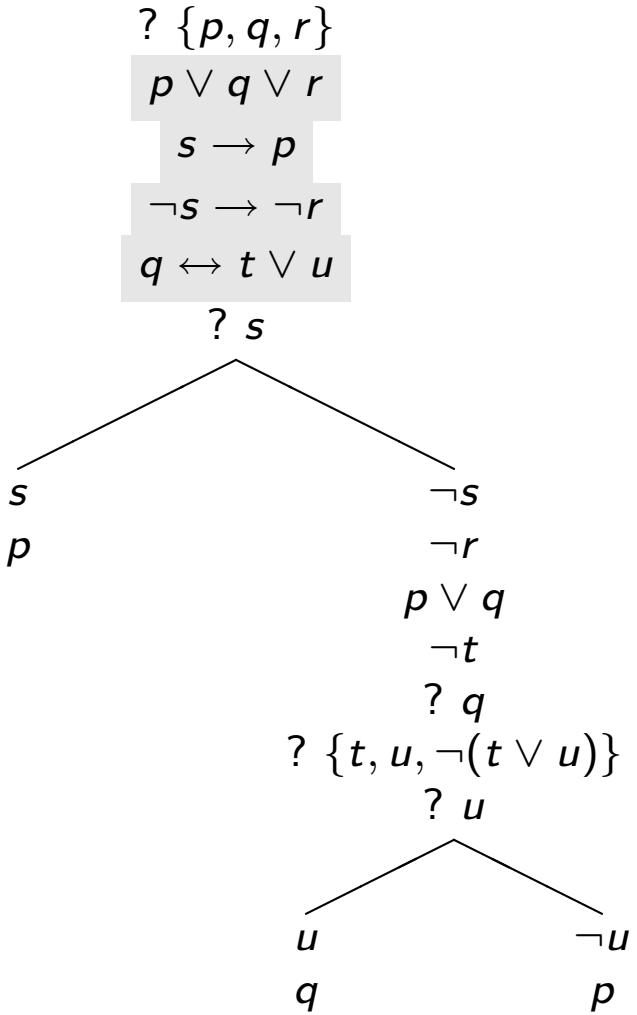

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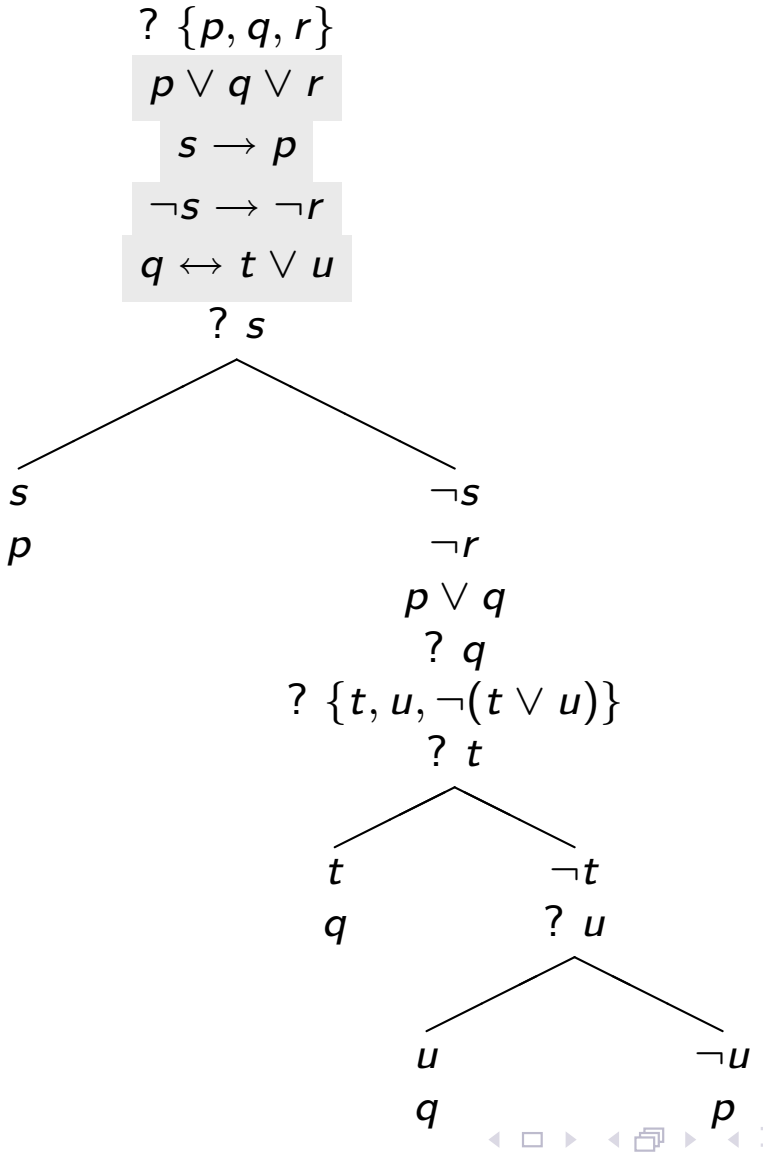
Recall that the e-scenario subjected to contraction was:



Contraction

- We contact by a (direct) answer to a query.
- To be more precise, we contract by a direct answer A to a question Q^* such that: (a) Q^* is a query, (b) Q^* labels an e-node, $\widehat{Q}^*$, and (c) A labels a d-node that is an immediate successor of the e-node $\widehat{Q}^*$.
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Let Φ be an e-scenario for a question Q relative to a set of d-wffs X, let Q^* be a query of Φ and A be a direct answer to Q^*. The result of contraction of Φ by A is an e-scenario for Q relative to $X \cup \{A\}$ if

(1) $A \notin \mathbf{d}Q$ *and*

(2) *it still involves at least one query.*

Contraction

- Contraction can be performed upon the initial e-scenario:
  - when it starts to be executed (in this case we contract by the answer received to the first query),
  - before the initial e-scenario starts to be executed (generally speaking, this happens when there are good reasons to believe that some answer(s) to query/queries are highly probable).
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