



# Argument Schemes and Critical Questions for Decision Aiding Process

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# Examples

## Example 1

- Decision Problem: choose a pair of shoes;
- Alternatives:  $a, b$ ;
- Criteria:  $h_1$  (color),  $h_2$ (producer),  $h_3$  (sort or style);
- DM's preferences: black  $\succeq$  red, Italian  $\succeq$  French, heels  $\succeq$  brogues.



# Examples

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## Example 1: Performance Table

	$h_1$	$h_2$	$h_3$
$a$	red	Italian	brogues
$b$	black	French	heels



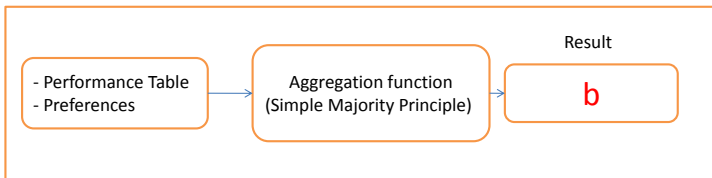
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## Example 1: Performance Table

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# Examples

## Example 1 (bis): Performance Table

	$h_1$	$h_2$	$h_3$
$a$	red	Italian	brogues
$b$	black	French	heels

## Example 1 (bis): DM's preferences

- I like the black color;
- I go to a lot of parties then I like wearing heels;
- A statistical study reported that Italian's shoes are very comfortable...



## Examples

### Example 1(bis): Performance Table

	$h_1$	$h_2$	$h_3$
$a$	red	Italian	brogues
$b$	black	French	heels

### Example 1(bis): DM's preferences

- I like the black color;
- I go to a lot of parties then I like wearing heels;
- A statistical study reported that Italian's shoes are very comfortable...

### Problem

The DM's preferences don't fit the formal language traditionally used for representing preferences in Multi-criteria Decision Analysis  $\rightsquigarrow$  a Binary Relation.



# Examples

## Example 2

- Decision problem: a sorting problem;
- Alternatives : set of computers {a,b,c,d};
- Criteria :  $h_1$ : price,  $h_2$ : capacity,  $h_3$ : warrant;
- categories :  $C_3$ : acceptable,  $C_2$ : negotiable,  $C_1$ : rejectable.

	$h_1$	$h_2$	$h_3$
$P_1$	600	40	1
$P_2$	400	80	2

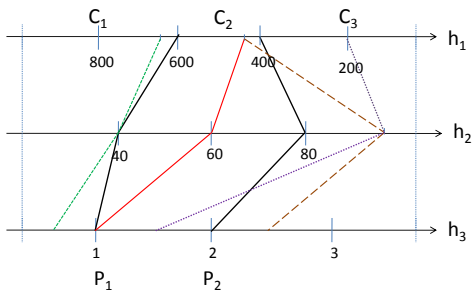
Table: Profiles

	$h_1$	$h_2$	$h_3$
a	200	100	1.5
b	450	100	2.5
c	450	60	1
d	650	40	0.5

Table: Performance table



## Examples



a

c

b

d

acceptable	negotiable	rejectable
a,b	c	d

# Examples

## Example 2 (bis)

Now suppose you want to use a new criterion (how much you trust that brand,  $h_4$ ). You only know that  $b$  is average, and nothing about other candidates.

	$h_1$	$h_2$	$h_3$	$h_4$
$a$	200	80	1.5	?
$b$	450	100	2.5	average
$c$	450	60	1	?
$d$	650	40	0.5	?
$P_1$	600	40	1	good
$P_2$	400	80	2	bad



## Examples

### MCDA Sorting Model : consequences

- we can assign  $b$  into a category  $\Rightarrow b \in C_2$ ;
- but we can't conclude anything for the others alternatives, because the hypothesis done in almost all Multiple Criteria Decision Analysis methods is that criteria represent complete preferences (all alternatives being comparable to all the other ones).



# A solution !

## Argumentation Theory

- construct arguments for and against each alternative;
- compare pairs of choices on the basis of their arguments.

## Example 1 (bis) (Intuition!!)

- From “I like the black color” we can construct an argument in favor of the alternative  $b$  and an argument against the alternative  $a$ ;
- $b \succeq a$  on the basis of positive arguments.



# Outline

## Motivations

## Argument schemes and Critical Questions

- Argumentation Theory

- Argument Scheme

## Argumentation Scheme and Decision

- Argument in multi-criteria context

- Example

## Conclusions

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# Context and Motivations

## Decision Aiding Process(DAP)

In the DAP <sup>a</sup> we have :

- at least two actors, the client (Decision Maker)and the analyst;
- the aim is to help the client to find “a solution” to his decision problem.

## A model of DAP

Four cognitive artifacts as products of the DAP :

1. A formulation of the problem situation;
2. A problem formulation;
3. An evaluation model;
4. A final recommendation.

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<sup>a</sup>D. Bouyssou, T. Marchant, M. Pirlot, A. Tsoukiàs and Ph. Vincke. Evaluation and decision models: stepping stones for the analyst. International Series in Operations Research and Management Science. Springer, 2006.



# Context and Motivations

## A model of DAP: Evaluation Model

1. A formulation of the problem situation;
2. A problem formulation;
3. **An evaluation model**: is an 5-uplet :

$$\mathcal{M} = \langle \mathcal{A}, \mathcal{D}, \mathcal{E}, \mathcal{H}, \mathcal{U}, \mathcal{R} \rangle$$

$\mathcal{A}$ : set of alternatives;  $\mathcal{D}$ : set of attributes;  $\mathcal{E}$ : set of scales;  
 $\mathcal{H}$ : set of criteria;  $\mathcal{U}$ : set of uncertainty;  $\mathcal{R}$ : set of  
aggregation operators.

4. A final recommendation.



## Context and Motivations

### DAP: some problems

- the lack of explicit justification and explanation for the final recommendation;
- the preferences of the DM don't necessarily fit the formal language used for representing preferences ( $\rightsquigarrow$  **Example 1(bis)**);
- the incomplete information are not taking into account ( $\rightsquigarrow$  **Example 2(bis)**);
- the revision (or update) of the process is not taken into account by the current model;
- ...



# Context and Motivations

## A solution

In AI, the growing field of Argumentation Theory (AT) offers different approaches and models to: support, justify and explain choices and decisions.

## Idea

Is it possible to integrate elements of AT in the DAP?



# Context and Motivations

## Questions to reply?

- What is an argument in favor and against an action in a multi-criteria context?
- How is this argument constructed?
- How are the element of multi-criteria evaluation (preferences, aggregation procedure,...) captured?
- How to inform the DM of the consequences of changing his preferences and/or objectives?
- ...

We use the notion of **argument schemes** and specify the related **critical questions**.



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# Non-Monotonic Reasoning?

## Monotonicity

If a conclusion  $\varphi$  is a consequence of a set of premisses  $S$ , and  $S'$  is a set of sentences containing  $S$ , then  $\varphi$  is a consequences of  $S'$ .

$\rightsquigarrow$  e.g. standard logics are monotonic (propositional logic, first order predicate logic, standard modal logic..)

## Non-monotonic logic

Adding premisses can be lead to the withdrawal of conclusions.

$\rightsquigarrow$  e.g. default reasoning, belief revision, argumentation-based approach...



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## Non-monotonic logic

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# Non-Monotonic Reasoning?

## Example (Reiter, 1987)

- Birds fly;
- Tweety is a bird;
- Therefore, Tweety flies.

But what if Tweety= penguin, type of bird that does not fly?



## Non-Monotonic Reasoning?

### Example (Reiter, 1987)

- Birds fly;
- Tweety is a bird;
- **Tweety is a penguin;**
- ~~Therefore, Tweety flies.~~ **False**

### Consequence (classical Logic)

The “Birds fly” must be false !!!



## Non-Monotonic Reasoning?

### Example (Reiter, 1987)

- Birds fly;
- Tweety is a bird;
- Tweety is a penguin;
- Therefore, ~~Tweety flies.~~ False

### Consequence (classical Logic)

The “Birds fly” must be false !!!



# Non-Monotonic Reasoning?

## We can say

- “Normally, birds fly” or “if x is a typical bird, then we can assume by **default** that x flies”;
- default  $\rightsquigarrow$  in the absence of evidence that Tweety is atypical, we can provisionally assume that Tweety flies.



# Argumentation?

## Argumentation

The argumentation is a branch of logic which is interested in non-monotonic logics (*Defeasible Reasoning*). It is the process of collecting arguments in order to justify conclusions.

An argumentation system :

- $A$  : set of arguments  $\rightsquigarrow$  an argument: (premises, conclusion);
- $R \subseteq A \times A$  : attack-relationship between arguments.



# Argumentation?

## Example (H. Prakken)

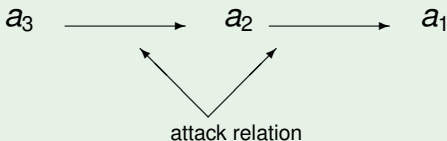
- P1 : my car is safer than your car, since *it has an airbag*;
- P2 : that is true, but I disagree that this makes your car safe : *the newspaper recently reported on airbags expanding without cause*;
- P1 : I also read that report, but a recent scientific study showed that cars with airbag are safer than car without one, and *scientific studies are more reliable than sporadic newspaper reports*.



# Argumentation?

## Example (H. Prakken)

- $A = \{a_1, a_2, a_3\}$ 
  - $a_1$ : (it has an airbag, car is safer);
  - $a_2$ : (the newspaper recently reported on airbags expanding without cause, car is not safer).
  - $a_3$ : (scientific studies are more reliable than sporadic newspaper reports, car is safer );
- $R = \{(a_2, a_1), (a_3, a_2)\}$





# Argument scheme

## Argument Schemes

Argument schemes are forms of arguments that capture stereotypical patterns of humans reasoning, especially defeasible ones.

## Two devices

- when constructing arguments, they provide a **repertory of forms of argument(scheme)** to be considered, and a template prompting for the pieces that are needed;  $\rightsquigarrow$  identify the premises and conclusion.
- when attacking, arguments provide a set of **critical questions** that can identify potential weaknesses in the opponents case.  $\rightsquigarrow$  evaluate the arguments.



## Argument scheme

### Example (Walton, 1996)

**First tourist:** could you tell me where the Central station is?

**Shopkeeper:** it is across the bridge. one kilometer south.

**First tourist:** Thank you. [To second tourist] Ok. Let's head for the bridge. Or do you want to stop for a coffee first?

The tourist presumes that the shopkeeper is familiar with the city and therefore recommends to the second tourist that they act on the information given.



# Argument scheme

## Argument scheme from position to know

**Major premise:** Source  $a$  is in a position to know about things in a certain subject domain  $S$  containing proposition  $A$ .

**Minor Premise:**  $a$  asserts that  $A$  (in Domain  $S$ ) is true (false).

**Conclusion:**  $A$  is true (false).

## Critical Questions

$CQ_1$ : Is  $a$  in a position to know whether  $A$  is true (false)?

$CQ_2$ : Is  $a$  an honest (trustworthy, reliable) source?



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# Argument and DAP

## Idea

Represent each cognitive artifact of the Decision Aiding Process by an: **Argument scheme** and its associated **critical questions**.

## Why?

- by presenting the reasoning steps under the form of argument schemes, it makes justification possible, and offers the possibility to handle default reasoning with incomplete models;
- by defining the set of attached critical questions, it establishes how the revision procedure can be handled.



# Argument and DAP

## First we focus on

The construction of an Argument scheme to represent the Evaluation Model.

## Argument for an action

- Typically, argument are build for Epistemic reasoning (Beliefs).
- Several works, [Walton 2002, Atkinson 2005, Amgoud 2007,...], have introduced arguments for Practical Reasoning

↪ Argument for an action.

## Arguments in Multi-criteria context

### Question?

What is exactly “an argument is in favour of an action  $a$ ”  
(Premises, conclusion)?

### Conclusion of the argument

- **intrinsic valuation** —  $C =$  is  $a$  acceptable?  
comparison against a (sometimes implicit) neutral point:  
 $a \succeq p$
- **pairwise comparison** —  $C = a \succeq b$   
the proposition must be read as “ $a$  is at least as good as  $b$ ”.  
each criterion is an argument supporting or defeating  $C$ .



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## Arguments in Multi-criteria context

### Premises of the argument

In our context, the premises of the argument can only be based upon the information provided by the DM's preferences and the performance table: the scores of the alternatives on the criteria considered.

### Example

$a \succeq b$  according to the criterion "price" (conclusion)  
because price( $a$ )=200 < price( $b$ )=600 (premiss)  
(criterion to be minimized)



# Arguments in Multi-criteria context

## Intrinsic Evaluation

Multi-criteria evaluation

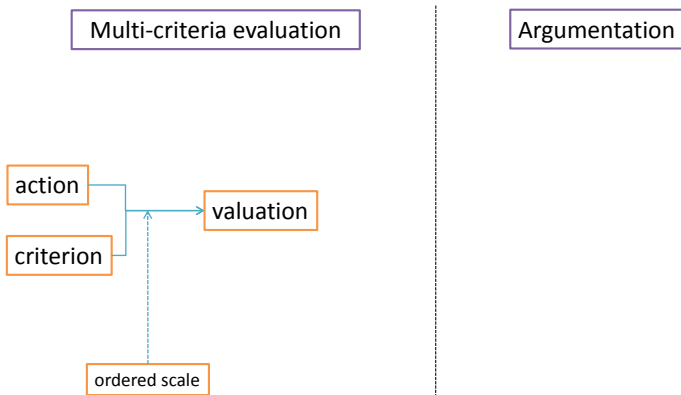
action

criterion

Argumentation

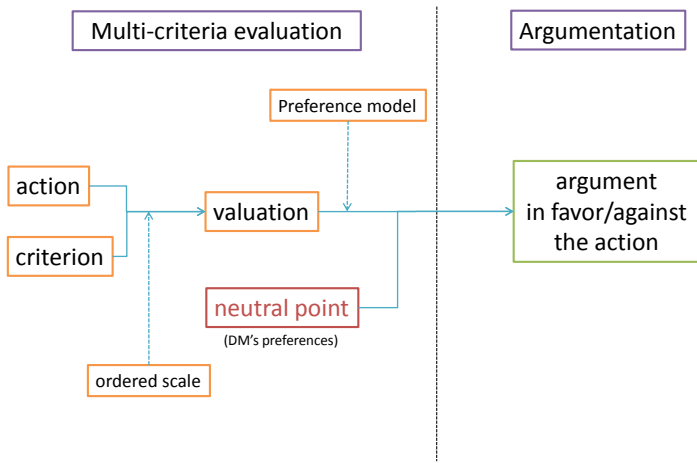
# Arguments in Multi-criteria context

## Intrinsic Evaluation



# Arguments in Multi-criteria context

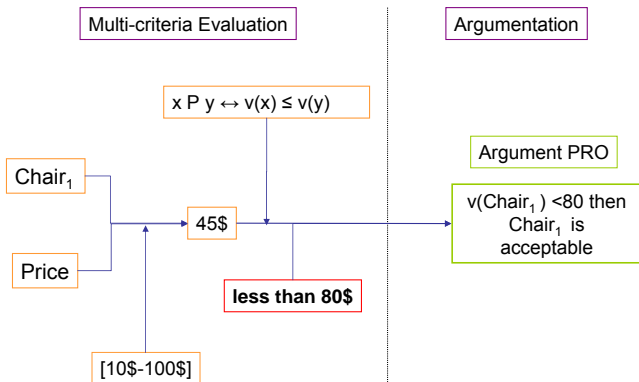
## Intrinsic Evaluation





# Arguments in Multi-criteria context

## Intrinsic Evaluation: Example





## Arguments in Multi-criteria context

### Scheme for Unicriteria Intrinsic Action Evaluation

<b>Premises</b>	an action	$a$
	whose performance is	$g_i(a)$
	along a criteria	$h_i$
	a neutral profile	$p_i$
	whose performance is	$g_i(p_i)$
<b>Conclusion</b>	a preference relation	$\succeq_i$
	$a$ is acceptable according to $h_i$	$a \succeq_i p_i$

### Critical Questions

1. action's performance: Is the performance correct?
2. preference relation: Is the preference relation appropriate?
3. ...



## Arguments in Multi-criteria context

### Scheme for Unicriteria Pairwise evaluation

<b>Premises</b>	a criteria	$h_i$
	an action	$a$
	whose performance is	$g_i(a)$
	an action	$b$
	whose performance is	$g_i(b)$
<b>Conclusion</b>	a preference relation	$\succeq_i$
	$a$ is at least as good as $b$	$a \succeq_i b$

### Critical Questions

1. actions: Is the action possible?
2. criterion: Is the criteria relevant?
3. ...



# Arguments in Multi-criteria context

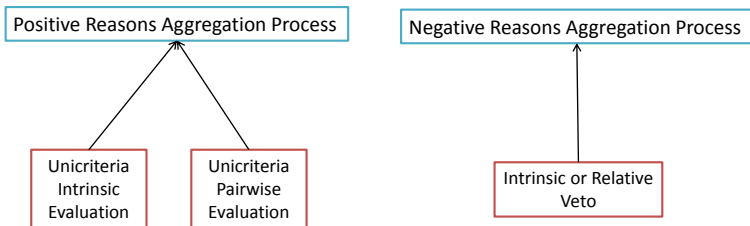
Unicriteria  
Intrinsic  
Evaluation

Unicriteria  
Pairwise  
Evaluation

Intrinsic or Relative  
Veto



# Arguments in Multi-criteria context





## Arguments in Multi-criteria context

### Scheme for Aggregation (Majority Principle)

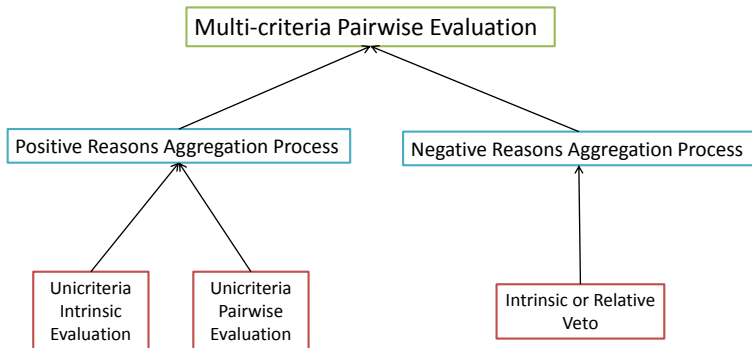
<b>Premises</b>	<p>a set of criteria considered to be of equal importance</p> <p>a set of pairwise evaluation of actions <math>a</math> and <math>b</math></p> <p>the majority support the claim</p>	$\{h_1, \dots, h_n\}$
<b>Conclusion</b>	<p>there are good reasons to support</p> <p><math>a</math> is at least as good as <math>b</math></p>	$a \succeq b$

### Critical Questions

1. list of criteria: Are the criteria of equal importance?
2. majority aggregation: Is the simple majority threshold relevant for the current decision problem?



# Arguments in Multi-criteria context





## Arguments in Multi-criteria context

### Scheme for pairwise evaluation multicriteria

<b>Premises</b>	an action	$a$
	an action	$b$
	a set of criteria	$\{h_1, h_2, \dots, h_n\}$
	there are enough supportive reasons according to	$\mathcal{R}_P$
	there are no sufficiently strong reasons to oppose it	$\mathcal{R}_N$
<b>Conclusion</b>	$a$ is at least as good as $b$	$a \succeq b$

### Critical Questions

- list of criteria: (i) Is this criteria relevant?, (ii) Should we introduce a new criteria?, (iii) Are these two criteria are in fact the same?
- positive reasons: (i) Are there enough positive reasons to support the claim? (ii) Is the aggregation technique relevant ?



## Example

### Decision problem

- choice problem;
- $h_1 \succeq h_2 \succeq \dots \succeq h_5$

	$h_1$	$h_2$	$h_3$	$h_4$	$h_5$
$a$	7.5	6	2	3	5
$b$	7	4	8	4	7

## Example

	$h_1$	$h_2$	$h_3$	$h_4$	$h_5$
$a$	7.5	6	2	3	5
$b$	7	4	8	4	7

### Dialogue

1. System: Given your informations,  $a$  is at least as good as  $b$ . [Recommendation]

2. User: Why? [Challenge]

3. System: The most important criteria according to you defend this claim, so by comparing actions on the basis of criteria of decreasing importance,  $a$  should be preferred to  $b$  [**Justified Recommendation**]  
(although the majority of arguments defend the opposite claim [**Gen. counter-arguments**])

### AS/CQ

Turn 3:

**Justification**: Argument of the PR-AG(lexicographical) scheme;

**Counter-argument**: relaxing some information (criteria have different importance).

## Example

	$h_1$	$h_2$	$h_3$	$h_4$	$h_5$
$a$	7.5	6	2	3	5
$b$	7	4	8	4	7

### Dialogue

3. System: The most important criteria according to you defend this claim, so by comparing actions on the basis of criteria of decreasing importance,  $a$  should be preferred to  $b$  [**Justified Recommendation**] (although the majority of arguments defend the opposite claim [**Gen. counter-arguments**])

4. User: I still think that  $h_1$  is the most important criterion so the majority makes little sense. [**Reject counter-argument**] however, now I see that the difference between  $a$  and  $b$  is not **significant enough**...

### AS/CQ

Turn 3:

**Justification:** Argument of the PR-AG(lex) scheme;

**Counter-argument:** relaxing some information (criteria have different importance).

Turn 4:

**Critical Question:** relevance of the preference relation of the Argument scheme UC-PW-EV.



## Example

	$h_1$	$h_2$	$h_3$	$h_4$	$h_5$
$a$	7.5	6	2	3	5
$b$	7	4	8	4	7

### Dialogue

4. User: I still think that  $h_1$  is the most important criterion so the majority makes little sense.

[Reject counter-argument]

however, now I see that the difference between  $a$  and  $b$  is not significant enough...

The system update the information

5. System: My recommendation remains the same because  $a$  is preferred to  $b$  on the second most important criterion

6. User: I agree but still  $a$  cannot be acceptable.

### AS/CQ

Turn 4:

**Critical Question**: relevance of the preference relation of the Argument scheme UC-PW-EV.



## Example

	$h_1$	$h_2$	$h_3$	$h_4$	$h_5$
$a$	7.5	6	2	3	5
$b$	7	4	8	4	7

### Dialogue

6. User: I agree but still  $a$  cannot be acceptable.

7. System: Why? [Burden of proof shift]

8. User:  $b$  is way better than  $a$  on  $h_3$ , I could not justify this choice... [Argument Scheme for Relative acceptability]

9. System: Ok. [Revise the recommendation]  
But beware that applying this scheme for acceptability may have the following consequences... [Inform of consequences of this revision]

### AS/CQ

Turn 8:  
an attack on the ground of negative reasons



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## Conclusion

1. a first approach to represent the steps of a multi-criteria evaluation model by means of argument scheme;
2. we identified a hierarchical structure of argument schemes and their associated critical questions;
3. we considered the restricting case of the comparison of two actions;
4. we give the very basic ingredients of the dialectical system (justify a recommendation, inform the user of the consequences of its modifications, potentially propose automatically generated argument).



## Currently

1. extend the model to take into account a large set of alternatives;
2. extend the model to take into account different decision problems (ranking, sorting,...);
3. allow the selection or the questioning of the aggregation procedure, by using critical questions built on the basis of the characterisation of this procedure;
4. specify in a more formal way the dialectical system;