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Methodology template for acquiring user preferences and decision-making based on hierarchically organized criteria

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Agenda

- Problem
- Assumptions
- Methodology (user point of view)
- Nucleolar solution concept
- Conclusions – Advantages

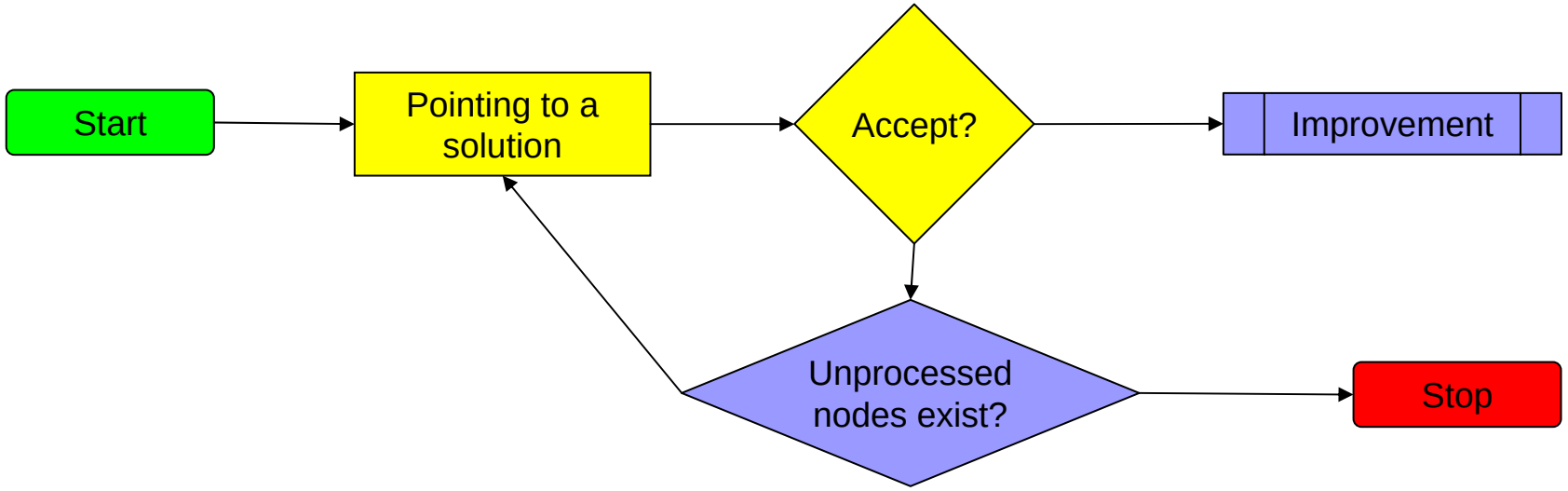
Problem

- Preference indentification
- Large number of criteria
- Structure (tree) of criteria (indicators corresponding to the lowest level of criteria)
- Large number of alternatives (for problems with discrete set of alternatives)

Assumptions

- Cooperation of user and the methodology underlying user interface software
- Single-criteria optimization on the indicators' level
- Bottom-up approach (from the indicators' level to the zero-level criterion)
- At every node user focuses only on a few outcome vectors presented
- Direction of improvement is assessed from user
- Failure of the linear weighting aggregations (AHP etc)

Methodology (overview) (1)
Node Process

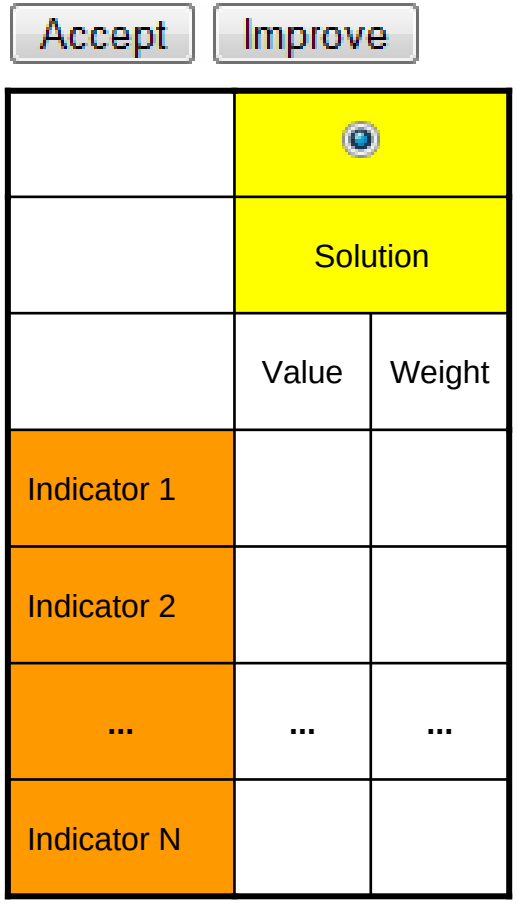


Methodology (user point of view) (1)

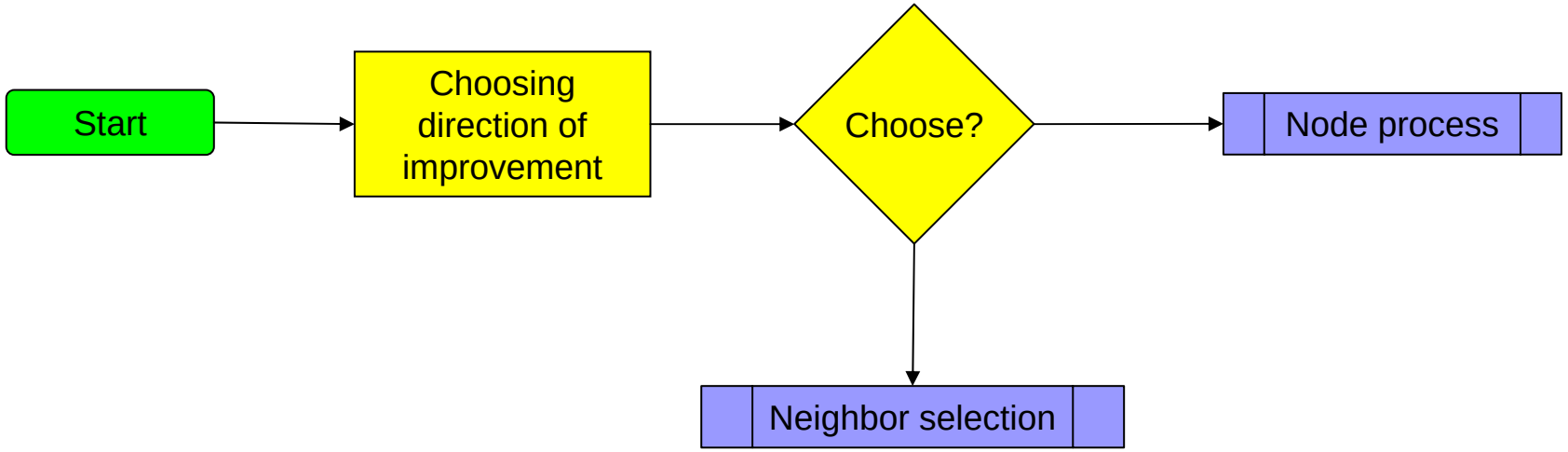
1. The user is presented with a solution, i.e. he/she sees values (or other properties) of all those lowest level criteria which are subordinate to the considered criterion. Each of the subordinate criteria must be either a lowest level criterion or must have been visited by the user before.
2. For all criteria the first solution (values for the corresponding subset of the lowest level criteria) is generated by the application itself. The following solutions are generated with user cooperation.
3. When a new solution is generated for the criterion, the user is prompted to select from all those generated so far: either a final solution for the criterion or a solution for improvement (at the beginning of the criterion processing the set of solutions includes one solution only). The selection of the final solution ends the processing of the criterion (the selected set of values/properties of the lowest level criteria matches the best user preferences).

Methodology (user point of view) (2)

Pointing to a solution



Methodology (overview) (2)
Improvement



Methodology (user point of view) (3)

4. If the user has selected a solution for improvement he/she is presented with a table which has the current criterion's subordinate criteria in rows and a single column corresponding to the selected solution. He/she is asked for a direction of improvement via pointing to a lowest level criterion which should be upgraded. If no criterion is selected the current solution for the processed criterion is regarded as its default and the application comes to point 3.

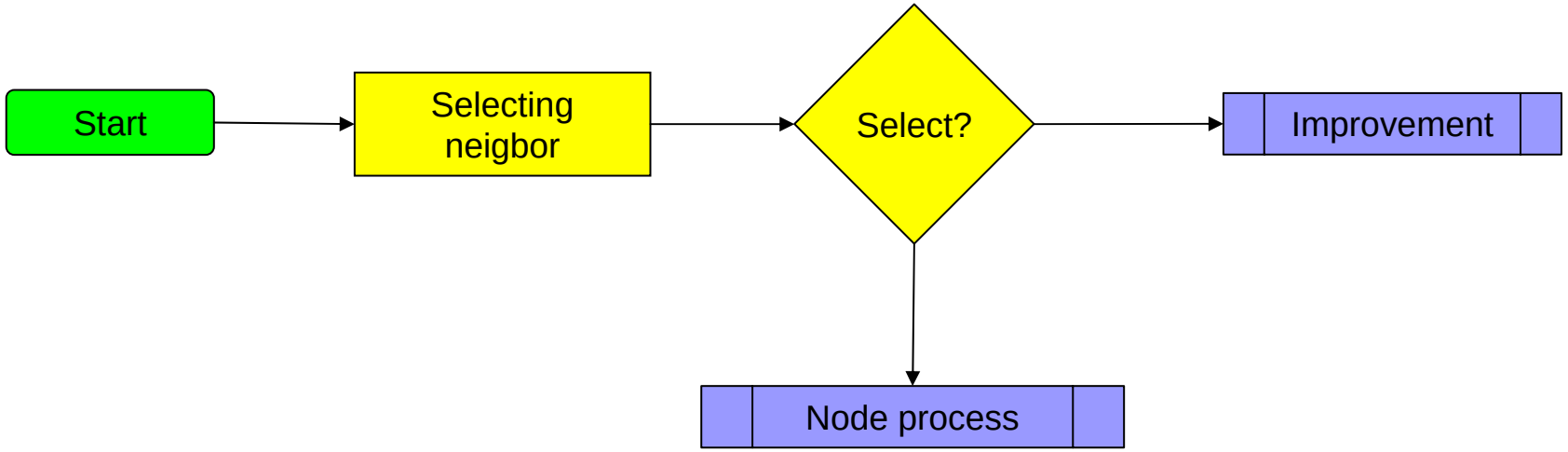
Methodology (user point of view) (4)

Choosing indicator to improve

Cancel improvement | Choose

		Solution	
		Value	Weight
○	Indicator 1		
◉	Indicator 2		
...	...	...	...
○	Indicator N		

Methodology (overview) (3)
Improvement



Methodology (user point of view) (5)

5. If the lowest level criterion has been pointed to, the application generates the number of neighbors, i.e. new solutions. Neighbors have better properties of the selected lowest level criterion (and worse for (some) other lowest level criteria) than did the basic solution. Next, the user is prompted to point to the neighbor which best matches his/her preferences. The chosen neighbor is treated as a new generated solution. If the user selects the solution (not a neighbor), then this solution is regarded as the default solution for the processed criterion and the application comes to point 3.

Methodology (user point of view) (6)

Selecting a neighbor

Cancel Select

			◉		○		...		○	
	Solution		Neighbor 1		Neighbor 2		...		Neighbor N	
	Value	Weight	Value	Weight	Value	Weight	...	...	Value	Weight
Indicator 1							...	...		
Indicator 2							...	...		
...	...	...	...	...	...	...	...	...	...	...
Indicator N							...	...		

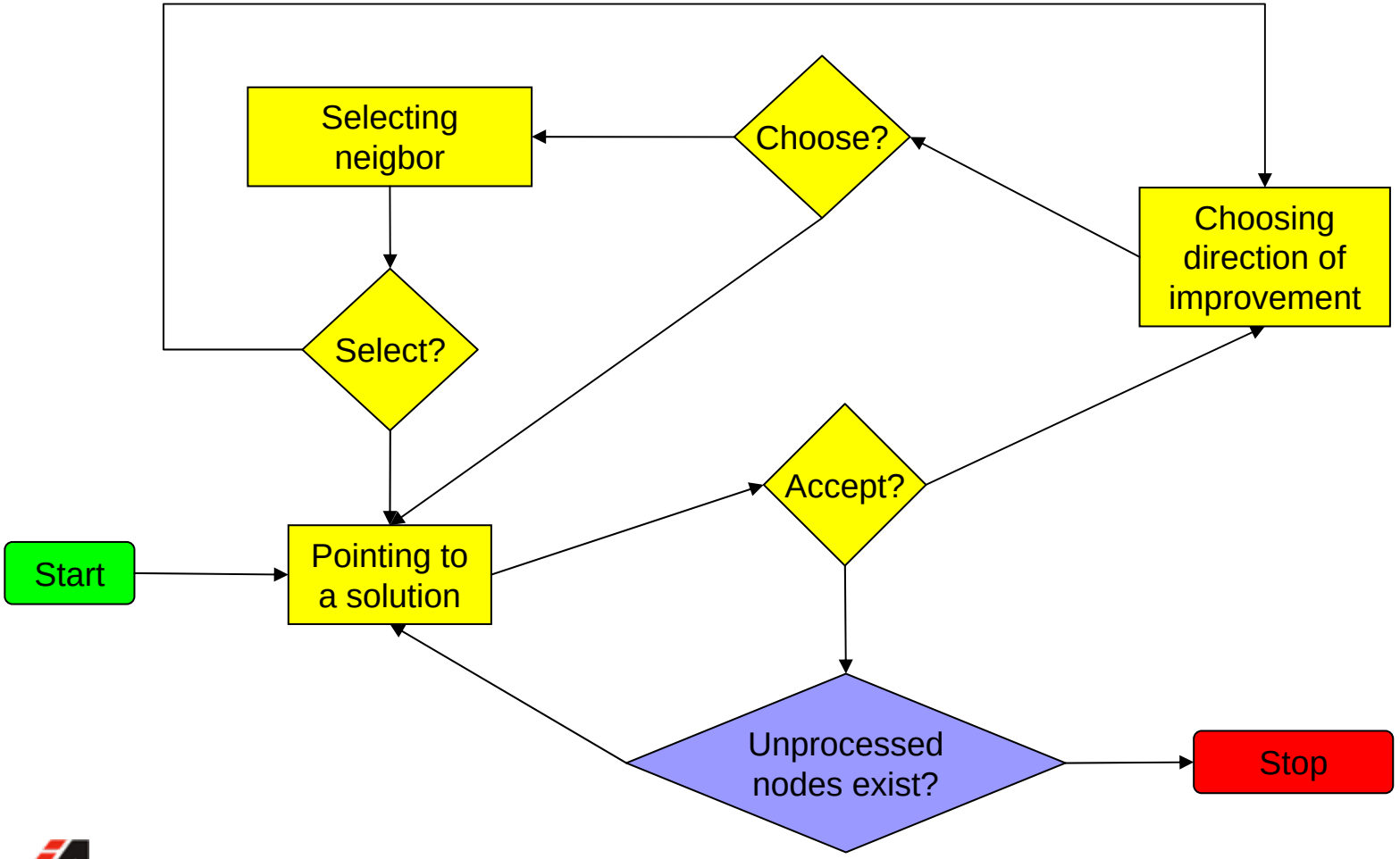
Methodology (user point of view) (7)

Pointing to a solution (2)

Accept | Improve

	○		○	
	Solution 1		Solution 2	
	Value	Weight	Value	Weight
Indicator 1				
Indicator 2				
...	...	...	...	...
Indicator N				

Methodology (overview) (4)
Global



Methodology (user point of view) (8)

6. The algorithm ends when all criteria have been visited by the user.

Algorithm

- Mark all criteria as not processed
- Select such criteria, which child are indicators.
- For every selected criterion:
  - Select appropriate indicator (child)
  - Calculate maximum of the indicator value, which is possible to be reached on the set of alternatives.
  - Create indicator subset of alternatives, i.e. such alternatives, for which the indicator value is equal to above maximum
  - Set correcting coefficient of this criterion equal to 1.
  - Mark the criterion as processed
- Limit set of alternatives by removing these alternatives which do not belong to any indicator subsets

Algorithm (2)

- While exist ready criteria (marked as not processed and having all „child” criteria processed)
  - Process ready criterion (next page)
  - Mark the criterion as processed
  - Set subset of indicators which affect the criterion (indirect children)
  - For all indicators belonging to above subset set its value and correcting coefficient by taking appropriate values from child criterion.
  - Do SOLVE procedure to calculate first solution

Algorithm (3)

- If procedure SOLVE does not change values of indicators
  - Accept generated solution as final for currently processed criterion

  in other case
  - Present (to user) all generated solutions for the criterion
  - Until user does not point final solution (from presented)
    - Prompt user to select the solution and next the indicator for improvement
    - In lexicographically ordered indicators (considering multiplication of indicators and its coefficients values) calculate the lowest position on which selected indicator could be improved

Algorithm (4)

- If new position is different then previous: (Calculate neighbors of pointed solution):
  - Set number of neighbors of selected solution.
  - For every neighbor do:

    * set correcting coefficient of pointed indicator to such value, that multiplication this value and value of the indicator could move the indicator to the recently calculated position.

    * do SOLVE procedure to generate next neighbor of solution pointed by user

    * accordingly to numbers of neighbors find the position for next neighbor
  - Present to user pointed solution and all neighbors. Selected by user neighbor consider as next solution for currently processed criterion

Algorithm (5)

other case

- Value of selected indicator can not be improved (preceding indicators do not limit the value of selected indicator) - inform the user

- *End of the criterion processing :*

  In final solution linearly convert correcting coefficients in such way that coefficient of the first from lexicographically ordered indicators is equal to 1. (Mark the criterion as processed).

Nucleolar solution concept

- Let us consider
  - set of solutions D (for example set of alternatives),
  - indicators $f_i : D \rightarrow R$, $i \epsilon \mathbf{I}=\{1,2,...,I\}$ (maximization of indicator values is assumed),
  - ordering function $F: D \rightarrow R^I$, in such way that

$$F(z) =< f_{j_1}(z), f_{j_2}(z),...., f_{j_i}(z),...., f_{j_I}(z) > \quad j_i \in \boldsymbol{I} \quad \bigcup_{i=1}^{I} j_i = \boldsymbol{I}$$

    and for each $i<I$ condition

$$f_{j_{i-1}}(z) \leq f_{j_i}(z)$$

    is satisfied

- Find such $z^* \epsilon D$ that for every $z \epsilon D$ condition

$$F(z^*) \geq^L F(z)$$

  is satisfied

Conclusions – Advantages

- Allows application of various approaches on a single-node (criterion) level: ‘objective’ (utopia, variability statistics, fair point, etc.) or clearly subjective (aspiration) for the node
- Gradually familiarizes user with criteria and their inter-dependencies while broadening their range
- Bases on selection from a small set of partial vectors of criteria values
- Enables adjustment of preferences by a reference outcomes comming from previous setting
- Enforces correction of user preferences due to necessity of consideration of an increasing number of criteria

Thank you for
your attention!