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The Analytic Hierarchy Process (AHP)

**Faculty of organization and informatics
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Business decision making course

The AHP

- The Analytic Hierarchy Process (AHP) (Saaty, 1980) is well known multi-criteria decision making method

- The AHP is a powerful and flexible decision making method which helps people to set priorities and make the best decision when both qualitative and quantitative aspects of a decision need to be considered.

- The AHP deals with intangible factors and derives measurements for them by using judgments and pair-wise comparisons with the participation of many people who provide the judgments individually.

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The AHP

- AHP is one of the most widely exploited decision making methods in cases when the decision (the selection of given alternatives and their prioritising) is based on several criteria (sub-criteria).

- Complex decision problem solving, which this method uses, is based on the problem decomposition into a hierarchy structure which consists of the goal, the criteria, sub-criteria and the alternatives.

- The AHP can combine judgments into a single representative judgment for the group and also including the importance of the individuals themselves.

The AHP applications

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NASA's IT Portfolio Management Takes Off With Expert Choice

CASE STUDY

Challenge — Develop a collaborative process to prioritize IT investments and bring about trust and buy-in across the agency.

Action — Implemented EC11.5 to structure and synthesize critical information about priorities and preferences in the organization.

Results — Aligned priorities to resources and delivery solutions that helped the organization achieve objectives across all scenarios.

Project & Product Management

America Online

CASE STUDY

Challenge — AOL enjoyed rapid growth in the 1990's but began to outgrow many of its project-based processes. PPM was one specific area that AOL wanted to improve.

Action — After establishing guidelines and objectives, AOL evaluated tools to complement its methodology and selected Expert Choice as the best solution for their PPM needs.

Results — AOL reduced requested project hours by 40%; met a 2004 timeline for a cross-prioritized project list; and improved overall project portfolio ROI.

Strategic Planning & Budgeting

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National Institutes of Health (NIH) Selects Decision Lens to Prioritize Cancer Antigens

National Cancer Institute Leads New, Innovative Approach to Research Funding

Arlington, VA. - August 7, 2009 — Decision Lens, a leading provider of desktop and Web-based decision support software for enterprise resource allocation and planning, is partnering with The National Institutes of Health National Cancer Institute (NCI) to identify specific cancer vaccine target antigens for accelerated research.

Using Decision Lens software, NCI developed a list of "ideal" cancer antigen criteria/characteristics and evaluated numerous representative antigens against those criteria for potential accelerated funding. Decision Lens enabled NCI to capture input from academia, industry and government in an un-biased and structured way.

Medicine

The Green Bay Packers Select Decision Lens for Business Planning, Player Selection

**NFL Team Partners with Leader in Decision Software**

Arlington, VA. - August 19, 2009 — Decision Lens, a leading provider of decision making software solutions, announced today that the Green Bay Packers of the National Football League (NFL) has selected Decision Lens for business planning and player selection. The Green Bay Packers, one of the most successful and storied teams in the league is using Decision Lens advanced group-enabled software platforms and optimization capabilities for a range of decisions across the organization. The investment was made in Decision Lens to deliver the most strategic and financial value to the Packers organization in the future.

"We look forward to working with the Packers to build their organization and continue their track record of success" said John Saaty, chief executive officer of Decision Lens.

Sport

The AHP – four steps

- The method application can be explained in four steps:

1. The AHP enables decision makers to structure decisions hierarchically. The overall goal of the decision is at the top of the model, evaluation criteria in the middle levels, and alternative choices at the bottom.
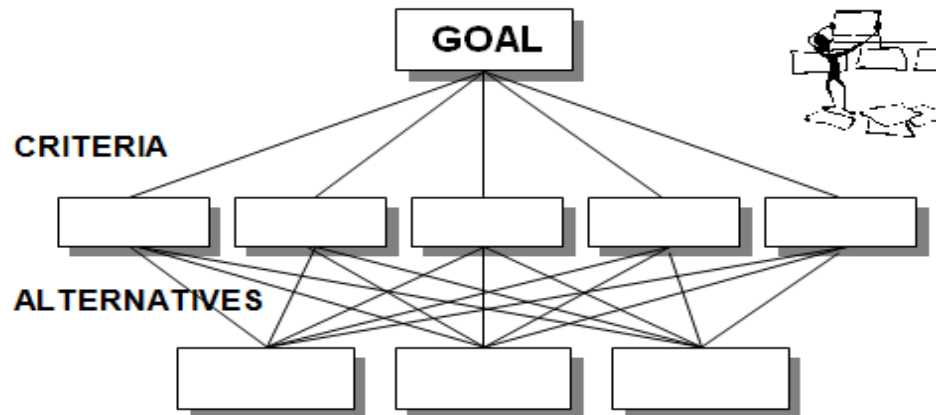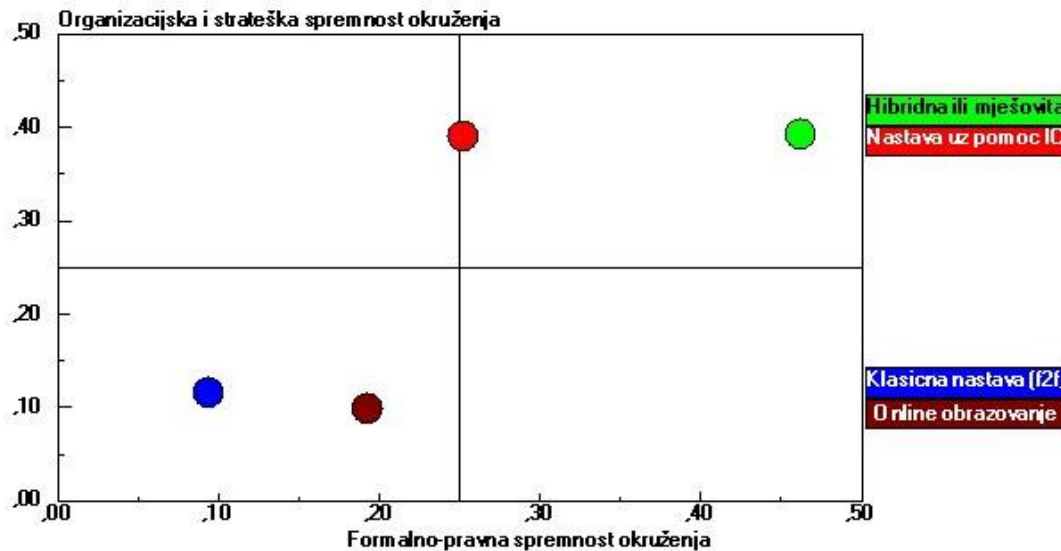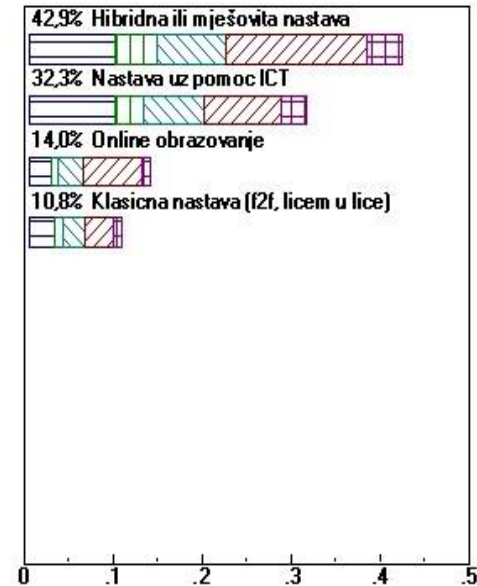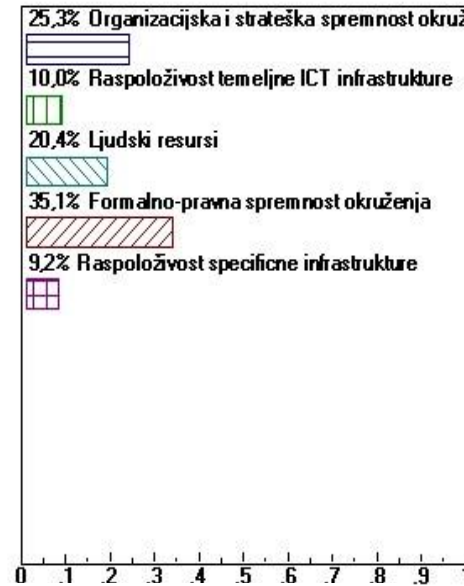
The AHP – four steps

2. Decision makers begin the procedure of pair-wise comparisons on each hierarchy structure level in order to determine the relative importance of elements on each level (*Saaty-es fundamental scale of absolute numbers*).

3. On the basis of the pair-wise comparisons, relative significance (weights) of elements of the hierarchy structure are calculated (calculation of relative priorities for criteria), which are eventually synthesized into an overall priority list of alternatives.

Decision maker is allowed to change preferences and to test the results if the inconsistency level is very high. In cases where inconsistency is above 10% it is recommended that the criteria and judgments be revisited (inconsistency ratio < 0,10).

4. The sensitivity analysis. Sensitivity analysis is used to determine how the priorities of the alternatives change with respect to the importance of the criteria.
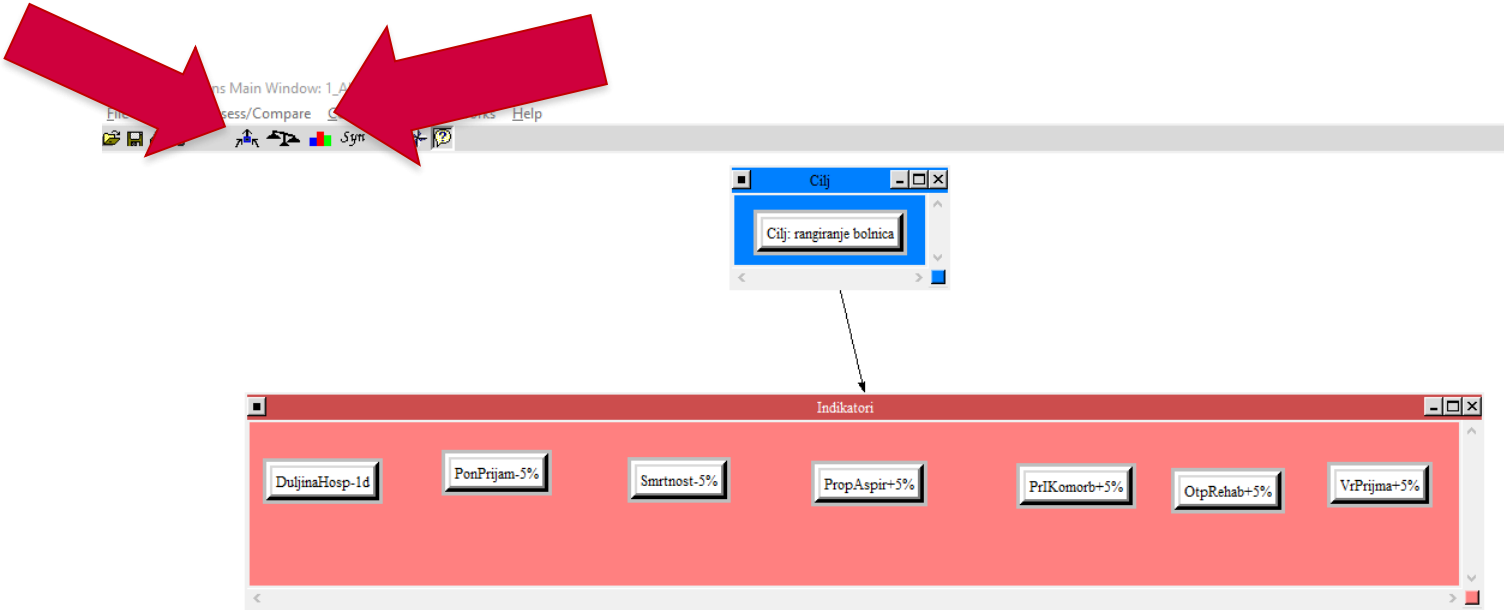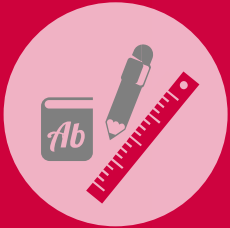
Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
2	Weak	
3	Moderate importance	Experience and judgment slightly favor one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgment strongly favor one activity over another
6	Strong plus	
7	Very strong demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
Reciprocals ob above	If activity i has one of the above nonzero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	A reasonable assumption
Rationals	Ratios arising from the scale	If consistency were to be forced by obtaining n numerical values to span the matrix
Decimals values 1.1 – 1.9	For tied activities	For elements which are close to each other, the judgments like 1.1, 1.2, 1.3, …1.9, can be used to make finer distinctions

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Program tools - AHP

- The AHP is implemented in the program tools:
- Decision Lens software - http://www.decisionlens.com/
- Super Decisions software - http:// www.superdecisions.com/
- Expert Choice software - http://www.expertchoice.com/

- EC and DecisionLens in versions for individual and group decision making.

Software DECISION LENS

https://www.decisionlens.com

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| 1 Build Model | 2 Compare Criteria | 3 Evaluate Alternatives | 4 Allocate Resources | 5 Reporting |

Pairwise Comparison

Compare Criteria Steps

- Pairwise Comparison
- Priorities Graph
- Inconsistency Analysis

Process Tip

Enter judgments with the mouse or keypads for each voter, then click next vote to move to the next comparison in the set. Click Calculate to

Keypads Active

Decision Goal: Odabir najbc
- Kvaliteta postojećeg kur ...
- Interes studenata za po ...
- Usklađenost studija s p ...
- Potrebe zanimanja bud ...
- Procedure prihvaćanja ...
- Raspoloživost materijal

Zoom: [+] [-] Calculate Previous Vote Next Vote

Evaluate: With respect to Decision Goal: Odabir najbolje alternative za provedbu inovacije studijskih programa which of the following pair is more important?

Full Screen
Hide Votes
Show Definitions

	Kvaliteta postojećeg kurikuluma								**Interes studenata za postojeće studije**						
	extreme	very strong		strong		moderate		equal	moderate		strong		very strong	
	(9)	(8)	(7)	(6)	(5)	(4)	(3)	(2)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Average								■							
Participant 1						■	■	■							
Participant 2										■					
Participant 3							■	■							

Software SUPERDECISIONS

https://www.superdecisions.com

- Hierarchy tree

- Pair-wise comparisons

- Criteria weights, Alternative priorities

- Sensitivity analysis

Decision Goal: selection of candidates for the vacancy of Assistant Professor at HEI

0.421		Scientific work
	0.081	Conducting and participating at scientific and development projects
	0.184	Scientific recognisability
	0.06	Publications in acclaimed journals and conferences
	0.042	Professional development at acclaimed institutions
	0.033	Networking with scientists outside of the institution
	0.023	Reviewer in journals and at conferences
	0.026	Invited lectures at conferences
	0.156	Doctorate field
0.396		Teaching activities
	0.041	Opinion of the Quality Committee on the student survey results
	0.059	Contribution to the development of courses
	0.059	Edited and published student materials: university coursebooks, reviewed materials for e-learning
	0.027	Evaluation by a fellow lecturer, peer assessment
	0.038	Assessment of the contribution to e-learning
	0.078	Teaching performance
	0.032	Mentoring final and graduate papers
	0.036	Mentoring students at competitions
	0.027	Pedagogical-psychological training
0.182		Contribution to institution/ society
	0.045	Work on projects, cooperation with the business, local and public administration
	0.045	Participation in the work of the committees, boards, associations on institutional, university and national level
	0.037	Membership in organizational boards of journals and at conferences
	0.034	Chairing, active membership in associations or committees important for the institution
	0.021	Populariztion of science

Pairwise Comparison

Zoom: [+] [-] Calculate Previous Vote Next Vote

Evaluate: With respect to Decision Goal: selection of candidates for the vacancy of Assistant Professor at HEI which of the following pair is more important?

Full Screen
Hide Votes
Show Definitions

	extreme		very strong		strong		moderate		equal	moderate		strong	
	(9)	(8)	(7)	(6)	(5)	(4)	(3)	(2)	(1)	(2)	(3)	(4)	
Average													
Chair of the study program													
Faculty board member 01													
Faculty board member 02													
Assistant 01													
Assistant 02													

Group decision making using keypads supported by *Decision Lens*

- The group decision making with keypads **is a newer but proven pair-wise comparison process**.

- Decision Lens is a tool designed to support the AHP group decision making and it enables:
  - the process of accepting the judgments from stakeholders (using wireless keypads) that are at the same time at the same place or remote decision making,
  - it synthesizes judgments from multiple stakeholders,
  - tracks each team member's judgments,
  - weights team members and
  - evaluates outcomes based on team member characteristics.

- The Response-Key keypads allow the members of a group to respond to posted questions and express preferences by pressing one of fifteen keys which present the intensity of importance on the Fundamental scale.

- After each individual provide his/her own judgment, members' final judgments are combined by taking the **geometric mean** (Aczel & Saaty).

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Group decision making using keypads supported by *Decision Lens*

- Group decision making using keypads supported by Decision Lens uses two highly effective techniques to help groups come to the best decisions:
  - First, it improves individual decision-making skills of each participant, leading them through structured process of decision making and eliminates the complex nature of decision making. Pair-wise comparisons enable the participant to focus on the relative importance of a particular element on a decision.
  - Secondly, it enhances group collaboration by bringing together participants from various areas of expertise.

- The AHP based group decision making with keypads encourages full participation by collecting input from all the participants throughout the entire process. They are sharing responsibility and getting better results.

Group decision making using keypads supported by *Decision Lens*

- **Critical factor** is a good organization of a group decision making event.

- **Some of the central points are:**
  - identification of right number and accurate expertise of participants,
  - identification of skilled facilitator,
  - modeling of decision hierarchy on a way that the number of criteria on any level should be limited to no more than nine since studies have shown that humans are unable to deal with more than nine factors at one time (Saaty, 1980).
  - comprehension and motivation of participants
  - securing an adequate infrastructure
  - to assemble the right number of participants to represent stakeholder positions and provide required expertise (for productive discussion not more than 15-20 participants).

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Group decision making using keypads supported by *Decision Lens*

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The strengths of the proposed approach include the following:

- It generates better decision making through consensus and consistency.
- The application combines a easy-to-use interface with an advanced, proven analytics engine to ensure that participants are making better decisions faster.
- It is ideal for individual or group settings.
- It is the simplest method for collecting and immediately reporting group response.
- Decision makers can personally indicate their opinions but system synthesize judgments from multiple stakeholders but also report and analyze each team member's judgments.
- System can weight team members and evaluates outcomes based on team member characteristics.
- The results of the group decision making with keypads incorporates knowledge of all stakeholders in the process of group decision making, and we must take in account that a group can generate a higher number of ideas and usually know more than an individual does.
- System setup typically involves handing a keypad to every participant which allows fast, reliable, safe and attractive installation.

- In the AHP based group decision making we can conclude that:

advantages of group decision making surpass its disadvantages.

- Group decision making using keypads:
  - speeds up the process of making a decision,
  - it prevents imposing opinion of an authoritative member, because every decision maker brings in his/her own judgment, and
  - contributes to decrease of conflicts because conflicts are possible only in discussion but that does not influence individual judgments.

Case study "*Ranking of means of state support for international projects*"

- Decision Lens for **11 participants** and **top down structuring** with numerical judgments mode were used.
- Group decision making was lead and supervised by the **facilitator**, who was the only one with the access to the central computer.
- The facilitator entered participants' names and demographic information about each participant and optional passwords and **coordinated the process of group decision making**.

Identify Participants

Prioritize Participants   Back Next

Add Participant   Delete
☐ Select All

| Delete	Name	Priority	KeyPad	Active
☐	Participant 1	0.09	1	Yes
☐	Participant 2	0.09	2	Yes
☐	Participant 3	0.09	3	Yes
☐	Participant 4	0.09	4	Yes
☐	Participant 5	0.09	5	Yes
☐	Participant 6	0.09	6	Yes
☐	Participant 7	0.09	7	Yes
☐	Participant 8	0.09	8	Yes
☐	Participant 9	0.09	9	Yes
☐	Participant 10	0.09	10	Yes
☐	Participant 11	0.09	11	Yes

Case study "*Ranking of means of state support for international projects*"

- The whole procedure of group decision making consisted of **two parts.**

- In first session participants were trained in fundamentals of methodology and technical facilities.

- Then the second part was used to consider the problem that had to be solved and to do "real" decision making using keypads.

- The whole exercise took **approximately 2.5 hours.**

Build Model → Compare Criteria → Evaluate Alternatives → Allocate Resources → Reporting
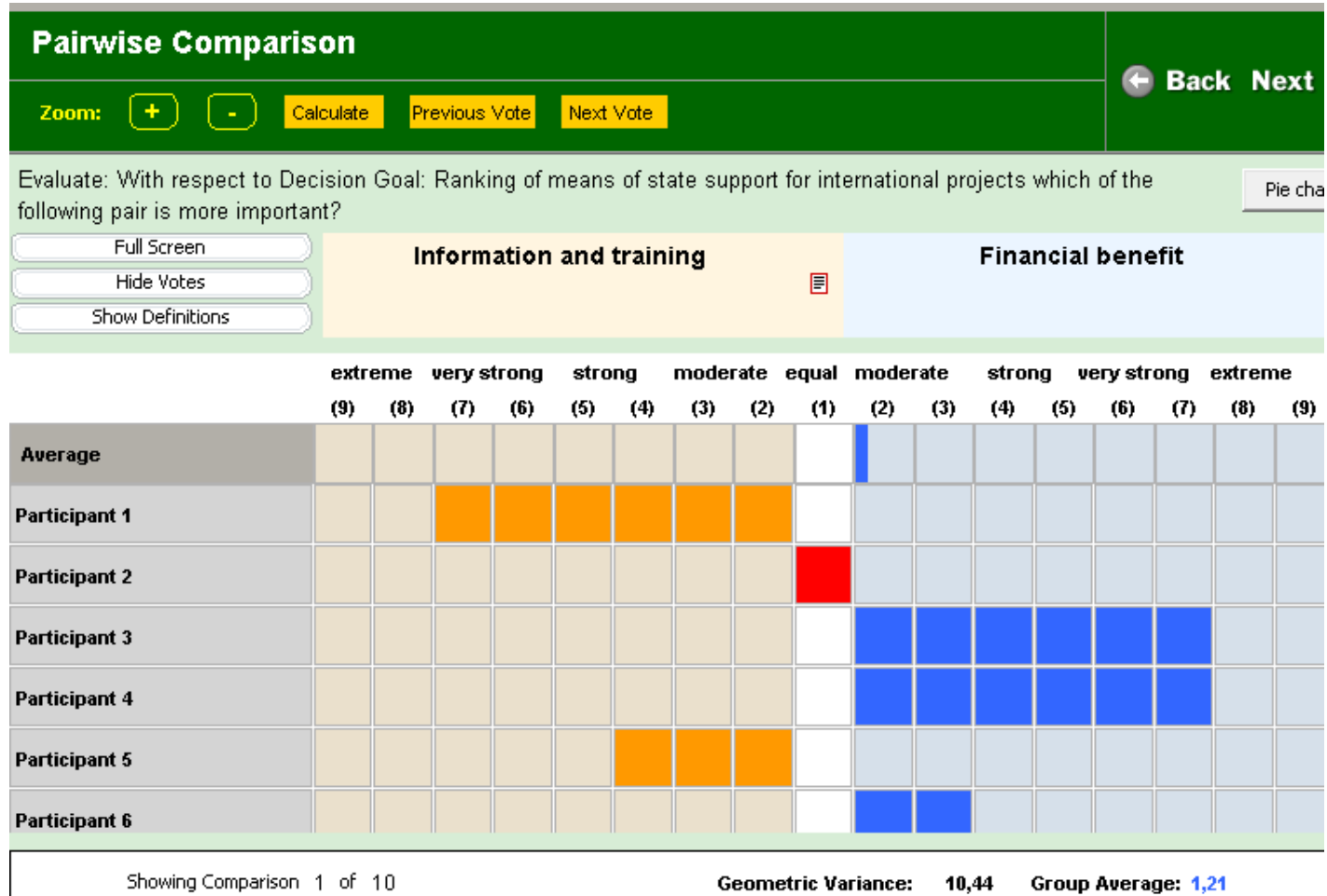
Iterate As Necessary
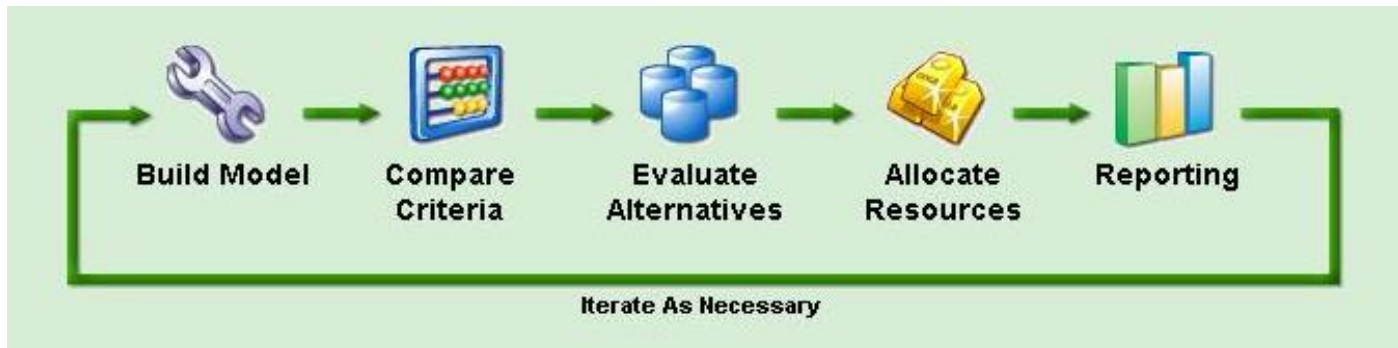
Case study - Results

- Results of group decision making in Decision Lens: objective's relative significance, gained by judgment synthesis of participants included in decision making
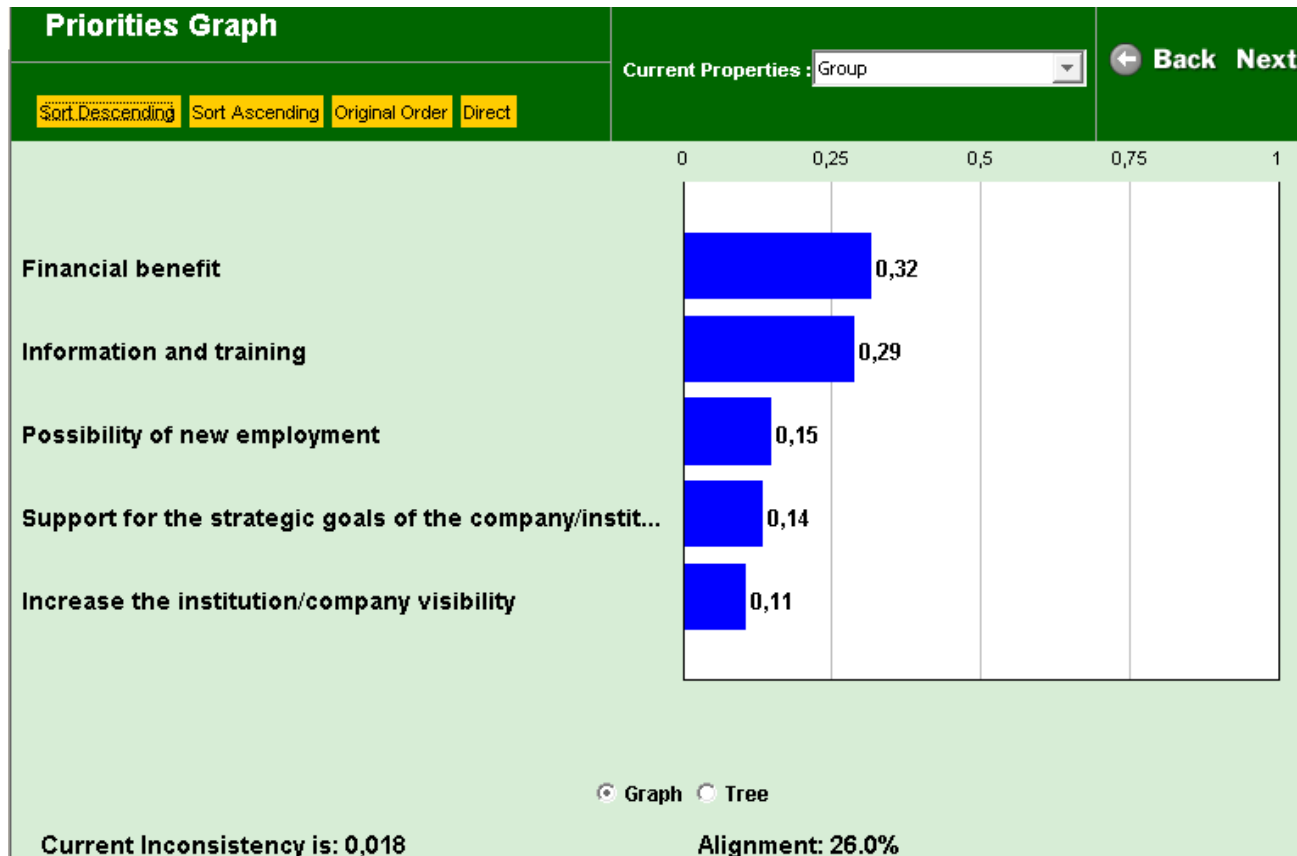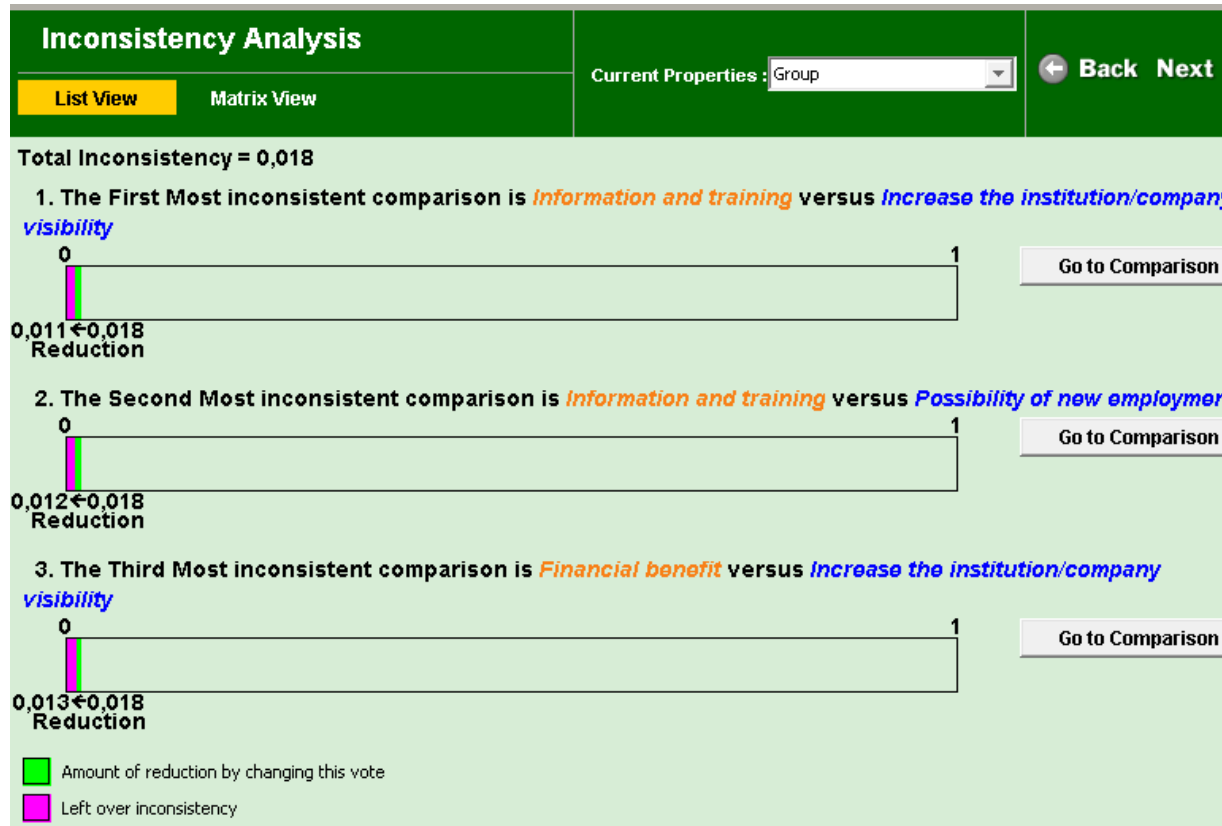
Case study - Results

- The pair-wise comparisons of the criteria based on the Fundamental scale of absolute numbers

Case study - Results

- Inconsistency analysis, which consists of the three most inconsistent comparisons. It can be seen that the total inconsistency is 0.018 which approves consistency of the obtained results because the inconsistency index is lower then 0.1.

Case study - Results

- Results of group decision making: alternative's priorities.
- After performing dynamic sensitivity analysis, we have proved the stability of the obtained ranking. If we change the priority of each criterion for ±5% and rank of the alternatives remains unchanged, the ranking of alternatives is stable.
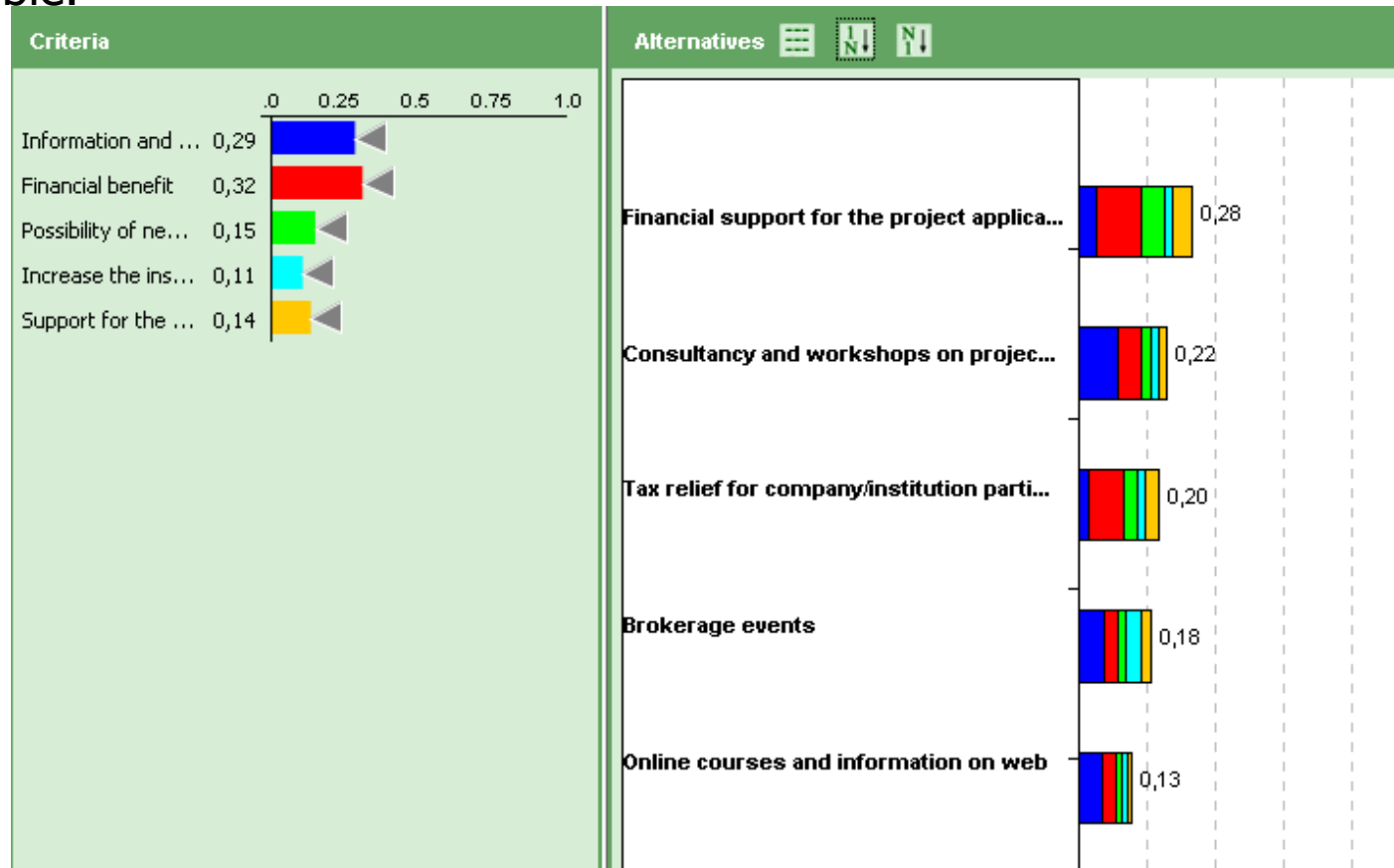
Advantages of the AHP group DM

- Such a group decision making enables:

  - multi-criteria analysis,

  - increases and systemizes knowledge on the problem,

  - motivates decision makers,

  - leads to more analytical results,

  - captures and incorporates diverse viewpoints,

  - speeds up the decision-making process.

- **The AHP based group decision making allows the decision makers to make critical decisions faster and more effectively in a way that truly captures their priorities.**

Task – homework – 2 members of team (20 points)

1. To identify the problem – description (business DM, IT problems, project management, investments, project management, allocation of resources, etc.)

2. To structure problem – goal, criteria, sub-criteria, alternatives (description)

3. To define decision makers – expertise, weight of their judgements (description)

4. To develop the AHP model (SuperDecision or Excel)

5. To do pairwise-comparisons

6. Interpretation of individual and group results

7. Interpretation of results (weights of criteria, priorities of alternatives)

8. Inconsistency analysis

9. Sensitivity analysis

Thank you!

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