Real-Life Examples of MADM Applications

Aims:
- To get a feeling for MADM models
- To see the potential of MADM in practice

Some Application Areas

1. INFORMATION TECHNOLOGY
   - evaluation of computers
   - evaluation of software systems
   - evaluation of Web portals
2. PROJECTS
   - evaluation of products
   - evaluation of proposal and/or evaluation teams
   - pre-R&D R&D evaluation
3. COMA-Y EES
   - benchmarking
   - evaluation of companies
4. PERSONNEL MANAGEMENT
   - personnel evaluation
   - selection and assignment of teams
5. MEDICINE and HEALTHCARE
   - diagnosis and treatment
   - evaluation of hospital applications
6. OTHER AREAS
   - assessment of technologies
   - assessment of risk and environment
   - granting personal and corporate loans

Allocation of Housing Loans

- Housing Fund of the Republic of Slovenia: Allocation of housing loans to citizens and nonprofit organizations
- Since 1991-21 completed 5 loans for citizens (social benefit problem)
- Decision support system for housing loan allocation
- Evaluation of loan priority: qualitative multi-attribute decision models (DEA)
- 2/3 of housing loans in Slovenia are allocated in this way

Evaluation of R&D Projects

Evaluation of projects in 1992
516 projects: 1094 reviews contributed by 90 reviewers

Medicine:
Breast Cancer Risk Assessment

An Example of Decision Rules

<table>
<thead>
<tr>
<th>Facility duration</th>
<th>Menstrual cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reg. and stab. of menstruation</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>average</td>
</tr>
<tr>
<td>2</td>
<td>long</td>
</tr>
<tr>
<td>3</td>
<td>long</td>
</tr>
<tr>
<td>4</td>
<td>short</td>
</tr>
<tr>
<td>5</td>
<td>short</td>
</tr>
<tr>
<td>6</td>
<td>average</td>
</tr>
<tr>
<td>7</td>
<td>short</td>
</tr>
<tr>
<td>8</td>
<td>average</td>
</tr>
</tbody>
</table>
Average Importance of Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Regression</th>
<th>Logistic</th>
<th>OR Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Menstrual cycle</td>
<td>122</td>
<td>125</td>
<td>1.39</td>
</tr>
<tr>
<td>Family duration</td>
<td>122</td>
<td>125</td>
<td>1.39</td>
</tr>
<tr>
<td>Age</td>
<td>75</td>
<td>79</td>
<td>1.20</td>
</tr>
<tr>
<td>First delivery</td>
<td>145</td>
<td>128</td>
<td>1.17</td>
</tr>
<tr>
<td>Oral contraceptives</td>
<td>54</td>
<td>27</td>
<td>3.00</td>
</tr>
<tr>
<td>Personal characteristics</td>
<td>100</td>
<td>100</td>
<td>1.00</td>
</tr>
<tr>
<td>Quetel's index</td>
<td>20</td>
<td>9</td>
<td>3.20</td>
</tr>
<tr>
<td>Family history</td>
<td>107</td>
<td>103</td>
<td>1.13</td>
</tr>
<tr>
<td>Menopause</td>
<td>74</td>
<td>112</td>
<td>0.67</td>
</tr>
<tr>
<td>Other</td>
<td>105</td>
<td>16</td>
<td>3.50</td>
</tr>
<tr>
<td>Physical factors</td>
<td>160</td>
<td>160</td>
<td>1.00</td>
</tr>
<tr>
<td>Chemical factors</td>
<td>40</td>
<td>34</td>
<td>1.20</td>
</tr>
<tr>
<td>Demographical circumstances</td>
<td>100</td>
<td>100</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Evaluation and Analysis of Options

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Baseline</th>
<th>Missing data</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Menstrual cycle</td>
<td>moderate risk</td>
<td>moderate risk</td>
<td>moderate risk</td>
</tr>
<tr>
<td>Family duration</td>
<td>average</td>
<td>average</td>
<td>average</td>
</tr>
<tr>
<td>Age</td>
<td>over 40</td>
<td>over 40</td>
<td>over 40</td>
</tr>
<tr>
<td>First delivery</td>
<td>29 or younger</td>
<td>29 or younger</td>
<td>29 or younger</td>
</tr>
<tr>
<td>Personal characteristics</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Quetel's index</td>
<td>29+</td>
<td>29+</td>
<td>29+</td>
</tr>
<tr>
<td>Family history</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Menopause</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Other</td>
<td>high risk</td>
<td>high risk</td>
<td>moderate risk</td>
</tr>
<tr>
<td>Cancerogenic exposure</td>
<td>high risk</td>
<td>high risk</td>
<td>high risk</td>
</tr>
<tr>
<td>Physical factors</td>
<td>higher</td>
<td>higher</td>
<td>lower</td>
</tr>
<tr>
<td>Chemical factors</td>
<td>high risk</td>
<td>high risk</td>
<td>moderate risk</td>
</tr>
<tr>
<td>Demographical circumstances</td>
<td>high risk</td>
<td>high risk</td>
<td>moderate risk</td>
</tr>
</tbody>
</table>

Selective Explanation of Options

<table>
<thead>
<tr>
<th>Reason/CF (Higher risk)</th>
<th>Baseline Frequency</th>
<th>Baseline Frequency</th>
<th>Baseline Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancer-related factors</td>
<td>Family history</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Cancerogenic exposure</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Physical factors</td>
<td>high risk</td>
<td>high risk</td>
<td>high risk</td>
</tr>
<tr>
<td>Demographical circumst.</td>
<td>high risk</td>
<td>high risk</td>
<td>high risk</td>
</tr>
</tbody>
</table>
Diabetic Foot Risk Assessment

Who:
- General Hospital Novo Mesto, Slovenia
- US
- InforNet, d.o.o.

Why:
- Reduce the number of amputations
- Improve the risk assessment methodology
- Improve the DSS model of clinical information system

How:
- Develop multi-attribute risk assessment model
- Evaluate it on patient data (about 3400 patients)
- Integrate into the clinical information system

Legend:
1 Bukovnik
2 Margetnca
3 Existing clay-pit
4 Okroglica
Brick factory

Environmental: Clay-Pit Location
Advising Children in Choosing Sports

Talent:

- A knowledge-based computer program
- for advising children in choosing sports
- in primary and secondary schools

Database of Measurements

<table>
<thead>
<tr>
<th>GENERAL DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
</tr>
<tr>
<td>Gender</td>
</tr>
<tr>
<td>Date of measurement</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MORPHOLOGICAL TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH (body height)</td>
</tr>
<tr>
<td>BW (body weight)</td>
</tr>
<tr>
<td>UF (upper arm)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MOTORIC TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAP (taping)</td>
</tr>
<tr>
<td>JJ (jumping)</td>
</tr>
<tr>
<td>PB (progress)</td>
</tr>
<tr>
<td>SVG (sit up)</td>
</tr>
<tr>
<td>DB (deep bend)</td>
</tr>
<tr>
<td>BAH (barhanging)</td>
</tr>
<tr>
<td>600m (600m run)</td>
</tr>
</tbody>
</table>

Talent: Basics

23 disciplines:
- athletics (5 disciplines)
- swimming (4)
- skiing (3)
- baseball
- volleyball
- handball
- tennis
- badminton

“SPORTS-CARD” MEASUREMENT
- 3 morphological and 8 motoric tests
Decision Problem: Housing (1/2)

Client: 
The Housing Fund of the Municipality of Ljubljana

Task: 
Support a lender for renovating old demofunctionalized blocks of flats in Ljubljana

Problem characteristics: 
- one-time problem

Decision Problem: Housing (2/2)

Earmarked financial resources: 
600 M € (~1.5 M £)

Timing: December 1999 – September 2000

Phases of the project: 
1. application gathering
2. (in)completeness notification
3. application completion
4. loan approval and allocation
5. notifying applicants
6. handling complaints

DEX Application Ranking Model:
Model Structure
**DEX Application Ranking Model:**

**Decision Rules**

<table>
<thead>
<tr>
<th>Investment part</th>
<th>Years in Ljubljana</th>
<th>APPLICANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) 40-50</td>
<td>(1) less than 10</td>
<td>(1) normal</td>
</tr>
<tr>
<td>(2,3) 50-100</td>
<td>(1) less than 10</td>
<td>(2) priority</td>
</tr>
<tr>
<td>(1) 40-50</td>
<td>(2) 10-30</td>
<td>(3) priority</td>
</tr>
<tr>
<td>(2) 50-50</td>
<td>(2,3) over 10</td>
<td>(4) high priority</td>
</tr>
<tr>
<td>(1,2) 40-60</td>
<td>(3) over 20</td>
<td>(5) high priority</td>
</tr>
<tr>
<td>(3) over 60</td>
<td>(2,3) over 10</td>
<td>(6) highest priority</td>
</tr>
</tbody>
</table>

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**Decision Support System**

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**Project Characteristics**

- **Business sector:** Housing, Investments, Funding
- **Decision problem type:** one-time vs. recurring; two-time
- **Problem structure:** structured vs. unstructured; semi-structured
- **Problem definition:** medium
- **Organizational level:** Topical/Strategic, Management involved
- **Methods used:** modeling, qualitative and quantitative models
- **Computational models:** data, models
- **Primary DS elements:** data, models
- **Group decision problem:** no two different interests
- **Group members:** project owner; 3 members; decision analyst 2
- **Time spent:** 9 months
- **Models:** 2
  - A: 17 attributes; 10 basic, 7 aggregates; 5 ranks
  - B: 10 attributes; 6 basic, 4 aggregates; 5 ranks
- **Options:** 109 + 256 = 367
Banks @ SI Housing Schema

Who:
- Slovenian Housing Fund
- US
- Temida

What:
- Evaluate and select banks for SHS
- Distribute rights for loan allocation to banks

Why:
- Difficult and sensitive decision problem

How:
- Combined quantitative/qualitative modelling

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Assessment of Governmental Life-Event Portals

<table>
<thead>
<tr>
<th>State/Land Province/City</th>
<th>Internet Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td></td>
</tr>
<tr>
<td>- Italy: <a href="http://www.italia.gov.it">http://www.italia.gov.it</a></td>
<td></td>
</tr>
<tr>
<td>- Spain: <a href="http://www.administracion.es">http://www.administracion.es</a></td>
<td></td>
</tr>
<tr>
<td>- Great Britain: UKonline</td>
<td><a href="http://www.ukonline.gov.uk">http://www.ukonline.gov.uk</a></td>
</tr>
<tr>
<td>- Austria: Internet Service HELP</td>
<td><a href="http://www.help.gv.at">http://www.help.gv.at</a></td>
</tr>
<tr>
<td>- The city of Bremen (Germany): Bremer-online-service</td>
<td><a href="http://www.bremer-online-service.de">http://www.bremer-online-service.de</a></td>
</tr>
</tbody>
</table>

---
Life-Event Portals
Structure of Models

- PORTAL
  - LE 1
  - LE 2
  - LE n

Qualitative models for assessing life-event portals at three levels

Evaluation of LE portals as a whole
Evaluation of life-events
Evaluation of e-services

Life-Event Portals
Model for Assessment of E-Services

Attribute | Description | Attribute scale
--- | --- | ---
Information Clarity | How clear the LE is presented to the user | inadequate, unsuitable, acceptable, good, very suitable
Use of LE | Level of services' design standardisation within LE | inadequate, unsuitable, acceptable, good, very suitable
Maturity | Level of services' coordination within LE | inadequate, unsuitable, acceptable, good, very suitable
Documents Accessability | How well the LE is covered with additional services | inadequate, unsuitable, acceptable, good, very suitable
E-guide | Intelligent electronic guide through life-event | inadequate, unsuitable, acceptable, good, very suitable
Access to Services | How well the LE is covered with vital services | inadequate, unsuitable, acceptable, good, very suitable
Scope of LE | How well the LE is covered with services | inadequate, unsuitable, acceptable, good, very suitable
Vital Scope | How well the LE is covered with vital services | inadequate, unsuitable, acceptable, good, very suitable
Check List | List and description of key-steps within LE | inadequate, unsuitable, acceptable, good, very suitable
Key Steps | List and description of key-steps within LE | inadequate, unsuitable, acceptable, good, very suitable
Interactive document handling | Additional features of electronic case handling | inadequate, unsuitable, acceptable, good, very suitable
Assessment of document handling | Level of service's online sophistication (higher than inf.) | inadequate, unsuitable, acceptable, good, very suitable
E-service Type | Type of e-service | inadequate, unsuitable, acceptable, good, very suitable
Interactive Forms | Available on-line forms | inadequate, unsuitable, acceptable, good, very suitable
Send Documents | Documents can be sent by e-mail | inadequate, unsuitable, acceptable, good, very suitable
Attachments | Documents can be attached to interactive forms | inadequate, unsuitable, acceptable, good, very suitable
E-payment | Electronic payment for service is provided | inadequate, unsuitable, acceptable, good, very suitable
Notifying | Notifying about e-service progress in electronic way | inadequate, unsuitable, acceptable, good, very suitable
Authentication | Authentication of e-documents | inadequate, unsuitable, acceptable, good, very suitable
Life-Event Portals
Model for Assessment of Portals

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Attribute scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of LEP</td>
<td>Scope of LEP</td>
<td>Standardisation of LE level of LEP design standardisation on portal</td>
</tr>
<tr>
<td>Handling of LE</td>
<td>The way in which life-events (LE) are handled</td>
<td>Search engine is offered to find a particular LE on portal</td>
</tr>
<tr>
<td>Topics Scope</td>
<td>How well LEP is covered with topics</td>
<td>Different instruments leading to particular LE on portal</td>
</tr>
<tr>
<td>LE Scope</td>
<td>How well LEP is covered with life-events</td>
<td>Different elements of LE portal usage</td>
</tr>
<tr>
<td>Search Engine</td>
<td>Life-events are identified through the hierarchy of topics</td>
<td>Level of covering different problems</td>
</tr>
<tr>
<td>List of LE</td>
<td>List of life-events</td>
<td></td>
</tr>
</tbody>
</table>
ECOGEN and SIGMEA Models

1. “Grignon” model
   Economic and ecological assessment of GM maize cropping systems
2. ESQ1: ECOGEN Soil Quality Model
   Assessing the impact of cropping systems on soil quality
3. SMAC Advisor: SIGMEA Maize Coexistence
   Decision support software
   Assessing maize coexistence

“Grignon” Model
Model Output: Topmost Levels
Soil Quality Model
Assessment of ECOGEN Data

• All the options have the same soil quality value of 3.
• The use of tillage intensity positively affects soil function by raising biodiversity (when using nutrients uptake).
• Minimum tillage positively affects 
  – Root uptake of nutrients and, consequently, 
  – Phosphorus biomass, leading to better activity.
• Minimum reduces phosphorus biomass, but 
  – Intensiﬁes communication due to Arable 

Soil Quality Model
ECOI Web Page

http://ai.ijs.si/MarkoBohanec/ESQI/ESQI.php

SMAC Advisor
Decision Problem

Project:
Can GM maize be grown in close proximity with plants on other fields?

Criteria:
Genetic inferences (Adverse effects, Precision)

Type II error of 0.9%

Factors:
pollen flow, volunteers, seedlings, mixing during harvesting, 
wind, sport strategy and processing buffer error, rodents...
SMAC Advisor

Decision support software that assesses the achievable AP given:
- relation between field distance, relative size, wind direction, etc
- type and characteristics of used seeds
- environmental characteristics (e.g., background GM pollen pressure),
- use of machinery (e.g., sharing with other farmers)
- target AP

... and gives recommendations:
- farming allowed
- farming disallowed
- assess risks (coexistence is possibly achievable)
- assess additional measures (coexistence achievable by small change)

SMAC Advisor Architecture

1. SMAC Advisor Wizard
   - User Interface
2. Co-Existence
   - Multi-Attribute DEXi Model
3. Simulation Results

SMAC Advisor Level 2: DEXi Model

Qualitative Multi-Attribute Model

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SMAC Advisor Level 2: DEXi Model

SMAC Advisor Level 1: User Interface

SMAC Advisor Level 1: User Interface
Summary

1. Loan Allocation
2. Evaluation/Selection of Projects
3. Medicine: Risk Assessment
4. Evaluation/Selection of Locations
5. Advising in Sports
6. Application ranking (in Housing)
7. Business partner selection (in Housing)
8. Assessment of Life-Event Portals

Other areas:
- evaluation of technology (cars, computers, software, Web pages and services, ...)
- evaluation of investment proposals, tenders
- production portfolio evaluation
- performance evaluation of companies
- personnel management
- ...