Intelligent Decision Support Systems

(Case Study 5 – SUSTAINABLE ACTION PLANNING)

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CASE STUDY 3 – SUSTAINABLE ACTION PLANNING
Scenario (1)

- All responsible cities in the world are worried about designing and implementing sustainable plans to improve the sustainability.

- Sustainability issues involves three connected dimensions:
  - The social dimension has some goals like:
    - Improving the quality of life
    - Improving the education level of society
    - To get equal opportunities for the citizens
  - The environmental dimension is oriented to:
    - Improve the environmental protection
    - The resource management
    - The preservation of the habitat reducing the contamination levels of air, water and land
  - The economic dimension is worried about:
    - A smart growth of society
    - To reduce the cost of living in a city
    - Fostering the cost savings in general
Scenario (2)

● The problem:
  ■ In the sustainable city named INTELLICITY, its major and the corresponding local municipality government is wondering about:
    ◆ Which would be the best possible actions to be taken in their municipality to improve the sustainability degree of the city, and the general satisfaction of their citizens?
Problem Analysis (1)

- Planning the *best sustainable action plans* to be taken in a city is not an easy task.
- There *a lot of features* involved and interrelated.
- There are several *social agents* in a city who want to influence in the decisions of a local municipal government:
  - The citizens
  - The political parties
  - The huge companies
  - The government members
  - ...
Problem Analysis (2)

- It is very difficult to assess *which are the best alternatives or options* due to many reasons:
  - *The consequences and effects* of one decision are not easily forecasted
  - And can have *more consequences* which are not envisioned.
  - The *cause-effect relationships* are not easy to be made explicit, especially because the *cause-effect chains* can be long.
  - For instance: even though the municipality government thinks that *introducing or increasing a car sustainability tax* could be a good measure, they are not sure about possible negative consequences of this decision.
Goal

- To build an IDSS that given:
  - A set of possible sustainable actions to be taken into account
- Can help them to:
  - Decide which are the best possible action plans to be made according to the possible good or bad consequences of candidate actions to increase the degree of sustainability of INTELLICITY
  - And to increase the satisfaction degree of the citizens
Decisions involved

- Main decision is:
  - To select which are the best possible actions to be done given:
    - The constraints in budget
    - Other considerations that the municipality has regarding the sustainable management of the city

- There are several possible actions that can be done like:
  - Invest or not in renewable energies
  - Invest or not in water drinking and treatment systems
  - Invest or not in waste and recycling management
  - Invest or not in education
  - Introduce/increase or not a car sustainable tax
  - ...
Requirements

- The IDSS to be deployed must be able to satisfy the functional requirements:
  - The user of the IDSS must be able to input to the system possible candidate sustainable actions.
  - The IDSS must be able to assess how other variables will evolve, taking into account several cause-effect relationships originated by the initial sustainable actions.
Data and Expert Knowledge Availability

- Data
  - No available dataset with related information because sustainable actions have not been regularly implemented in INTELLICITY

- Expert Knowledge
  - There was not a theory available, because the sustainability field is not a classic subject with well-established principles
  - In INTELLICITY there was a reduced set of enthusiastic Sustainability Master’s students recently graduated:
    - They had acquired a lot of expert knowledge
    - They were recently hired by the municipality
    - They were keen to analyse and study the possible consequences of some actions under the sustainability view
    - They know cause-effect knowledge that could be used to build up some model incorporating these cause-effect relationships
A possible solution (1)

- It became to be clear that an IDSS using some kind of *qualitative model* would be a good solution.
- In a *qualitative model*, it would be easier to model the *cause-effect relationships* between two variables $A$ and $B$, because there is a *qualitative relationship* like:
  - if the variable $A$ increases, then the variable $B$ will increase too
- **Type of IDSS:** a static IDSS, to be used from time to time
- **Kind of tasks:** This IDSS mainly involves a basic task which is the *prognosis of the different possible sustainable actions*
Model Selection (1)

- To implement the *prognosis task*, the Sustainability Technicians proposed to use *Causal Loop Diagrams (CLDs)* technique.
- The *Causal Loop Diagram* concept was first proposed by [Jay Forester, 1961] and further elaborated by other researchers such as [Meadows *et al.*, 1972; Rosnay 1979; Richardson and Pugh, 1981; Senge, 1990; Sterman, 2000]
Model Selection (2)

- A *Causal Loop Diagram* (CLD) is a directed graph formed by a set of nodes or vertices and a set of edges connecting the nodes in a directed way.
  - The *nodes* represent the *relevant variables* describing the problem at hand
  - The *edges* linking two nodes represent the *relation between two variables*.
  - The relationships between two variables can be of two types:
    - A positive relation
    - A negative relation
Model Selection (3)

- For the deployment of the CLD model the technicians obtained the following variables:
  - Invest or not in renewable energies
  - Invest or not in water drinking and treatment systems
  - Invest or not in waste and recycling management
  - Invest or not in education
  - Introduce/increase or not a car sustainable tax
  - Budget available
  - Health cost
  - Public health
  - Water diseases
  - Drinking water quality
  - City cleanliness
Model Selection (4)

- Renewable energies use
- Conventional Energies use
- Energy cost
- Private car transport
- Sustainable public transport
- Greenhouse gas emissions
- Tourism income
- Equal opportunity
- Citizen economic satisfaction
- Citizen environmental satisfaction
- Citizen social satisfaction
- Citizen global satisfaction
Functional Architecture of the INTELLICITY IDSS

- Expert Knowledge
- CLD MODEL
- Alternative Action Plans
- Qualitative Reasoning
- Qualitative Simulation
- Future evolution of the system
- End User

Invest in Water: Drinking & Treatment Systems
Invest in Waste & Recycling Management
Invest in Biodiversity & Biodiversity
Invest in Natural Environment
Invest in Economic Satisfaction
Invest in Technological Innovation
Implementation (1)
Implementation (2)

- The implementation of the IDSS relay on implementing those three functionalities for the CLD model:
  - **Building of the CLD model** by the experts:
    - The interface allowed to *create nodes* and *cause-effect relations* between nodes
    - The *feedback loops* could be automatically detected and marked in the CLD.
  - **Qualitative simulation of the evolution of the CLD model**:
    - Given information about the *trend* or *variation* of one variable (*cause*), the system was able to *propagate the cause-effect relationships* and compute the *final trends (effects)* of several variables along several cause-effect paths.
  - **Reverse propagation on a path in the CLD model**:
    - Given a *concrete trend* in one variable (*effect*), the system could automatically analyse which are the *necessary trends/ variations* (causes) in the related variables through the *reverse propagation* of the cause-effect paths.
Results and Evaluation (1)

- The assessment of the system was based on the *evaluation of the cause-effect paths* (associations) and the *final evolution of the model* for different initial scenarios.
- The initial scenarios were the different possible sustainable action alternatives for the municipality of INTELLICTY.
- Those actions were to invest or not in several sustainable actions like:
  - Invest or not in renewable energies
  - Invest or not in water drinking and treatment systems
  - Invest or not in waste and recycling management
  - Invest or not in education
  - Introduce/increase or not a car sustainable tax
Results and Evaluation (2)

- Municipality makes an increase in “Invest in renewable energies”
Results and Evaluation (3)

- Municipality increases or creates a “Car sustainable tax”
Results and Evaluation (4)

- **Accuracy and efficiency**
  - The experts’ evaluations were *very satisfactory*:
    - The cause-effect paths were meaningful
    - The final effects of some variations in the value of some variables were computed in a very accurate way.
  - The CLD model implemented was *very efficient*:
    - The computations of final path variations were *very fast*.
    - The computational cost of the other secondary and derived paths was not very high, because the *ramification factor* in the exploration was a *very low number*.

- **Response time**
  - The response time of the IDSS for computing *the final trends* of the different cause-effect was very short:
    - The *main path exploration* is proportional to the length of the path (*linear time*).
    - The other *secondary paths* usually are just a few and very short, and thus, the *final response time* of the system was very good.
Results and Evaluation (5)

- **Quality of the output generated (alternatives, support given)**
  - The quality of the IDSS was very accurate and valuable:
    - For a given possible sustainable action, the system computed *the possible trends in several related variables* through a cause-effect chains of reasoning.
  - In addition, the *reverse path propagation* functionality was very nice to support the municipality government:
    - To decide which should be the variations needed *to obtain a given desired trend* in a concrete variable of interest, like “Citizen social satisfaction”
Conclusions

- The Municipality of INTELLICITY evaluated the IDSS very positively:
  - The system produced a great *sustainable benefit* for the municipality
  - Costs can be reduced not making wrong actions
  - The IDSS could be reused, with minor modifications, by other similar municipalities:
    - Some extra business opportunities for INTELLICITY could appear with the licensing or similar economic agreement with other municipalities
- *Qualitative models, and especially CLD models* are really useful
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