Discrete Optimization 1 - CS 566

Integer Programming vs. Expert Systems

Maxime Chambreuil

McGill ID: 260067572

maxime.chambreuil@mail.mcgill.ca

Plan

- Start
- Plan
- Article
- Problem
- IP Formulation
- IP Implementation
- Conclusion
- Questions

- The article : title, authors, date, theme.
- The Problem
- The IP formulation :
  - Subscripts
  - Variables
  - Coefficients
  - Constraints
  - Objective function
- The IP implementation
  - Process
  - Performance
- Conclusion - References
- Questions

The article

- Start
- Plan
- Article
- Problem
- IP Formulation
- IP Implementation
- Conclusion
- Questions

- Title: Integer Programming vs. Expert Systems: An Experimental Comparison.
- Authors :
  - Vasant Dhar: Associate professor in Information Systems at the Leonard N.School of Business, New York University.
  - Nicky Ranganathan: PhD student of Information Systems at the Leonard N.School of Business, New York University.
- Date: March 1990
- Theme: Comparison between 2 formulations and implementations of the problem.

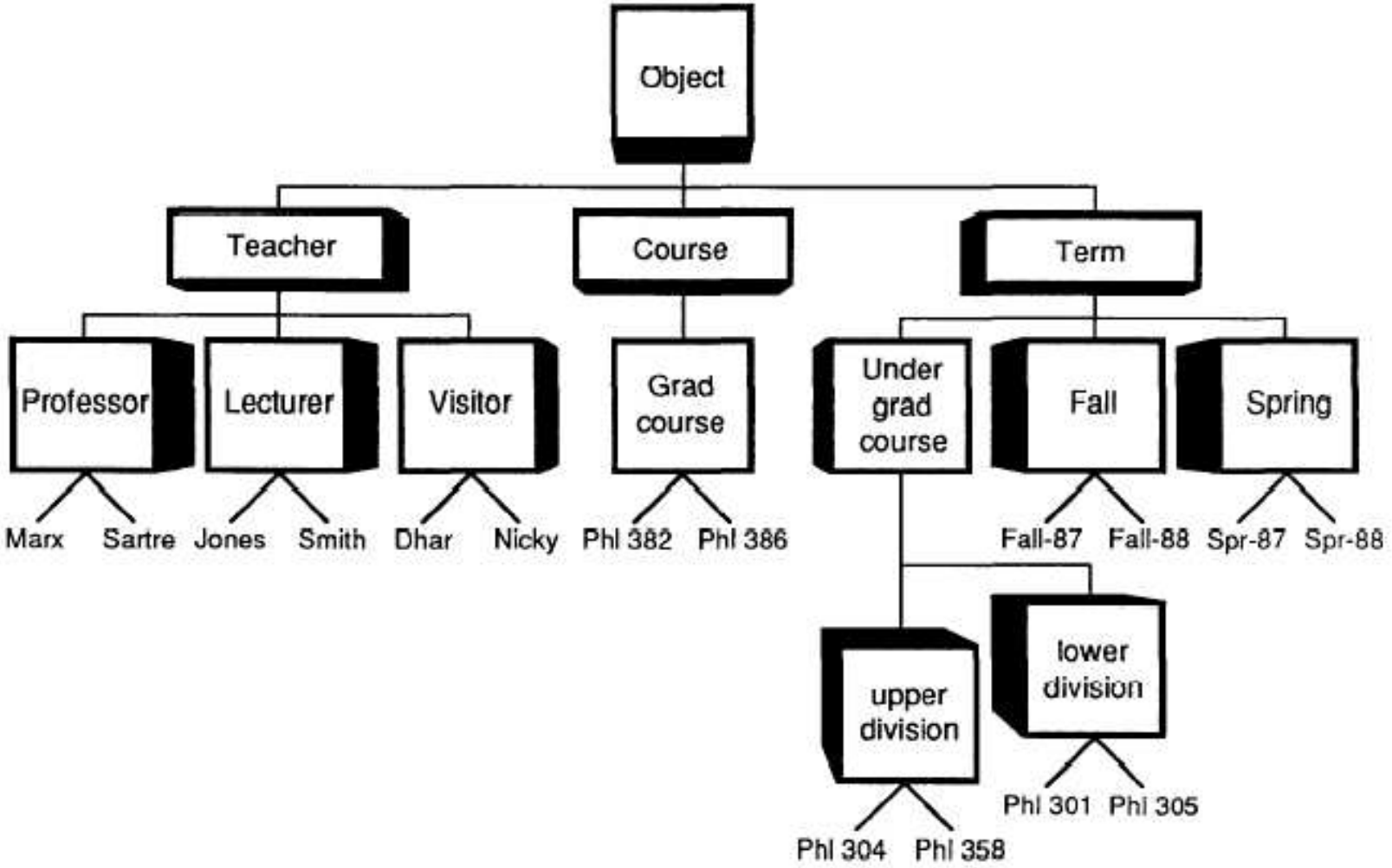
The problem

- Start
- Plan
- Article
- Problem
- IP Formulation
- IP Implementation
- Conclusion
- Questions

- Planing the assignment of faculty to courses and revising plans as assumptions change (not covered).
- Current solution: the Expert Systems.
- New solution: the IP ???

Data hierarchy (Source: article)

- Start
- Plan
- Article
- Problem
- IP Formulation
- IP Implementation
- Conclusion
- Questions



IP Formulation (1)

- Start
- Plan
- Article
- Problem
- IP Formulation
- IP Implementation
- Conclusion
- Questions

Subscripts:

- i = 1, 2, . . . , n instructors
- j = 1, 2, . . . , m courses
- t = 1, 2 terms (fall or spring)
- k = 1, 2, . . . , p categories of courses (for balancing curriculum)

IP Formulation (2)

- Start
- Plan
- Article
- Problem
- IP Formulation
- IP Implementation
- Conclusion
- Questions

Variables:

$$x_{ijt} = \begin{cases} 1 & \text{if faculty i is assigned to course j in term t} \\ 0 & \text{otherwise} \end{cases}$$

IP Formulation (3)

- Start
- Plan
- Article
- Problem
- IP Formulation
- IP Implementation
- Conclusion
- Questions

Coefficients:

- ρ_j = load of course j depending on its size and type
- T_i = teaching load requirement for teacher i
- c_{ijt} = cost of assigning teacher i to course j in a term t
- $g_j = \begin{cases} 1 & \text{if j is a graduate level course} \\ 0 & \text{otherwise} \end{cases}$
- $w_j = \begin{cases} 1 & \text{if j is an writing course} \\ 0 & \text{otherwise} \end{cases}$
- $t_{ijt} =$
  $\begin{cases} 1 & \text{if course j is proposed as a tutorial by i in term t} \\ 0 & \text{otherwise} \end{cases}$

IP Formulation (4)

- Start
- Plan
- Article
- Problem
- IP Formulation
- IP Implementation
- Conclusion
- Questions

Constraints:

- The number of teachers assigned to a course in each term should be between the lower and upper bounds on the number of sections of that course :

$$lb_{jt} \leq \sum_{i=1}^{n} x_{ijt} \leq ub_{jt}$$

- Each teacher must satisfy some minimal teaching load:

$$\sum_{t=1}^{m} \rho_j x_{ijt} \geq T_i$$

IP Formulation (5)

- Start
- Plan
- Article
- Problem
- IP Formulation
- IP Implementation
- Conclusion
- Questions

Constraints:

- Only professors can teach graduate courses:

$$x_{ijt} \leq 1 - (1 - f_i)g_j$$

- No professor can teach more than G graduate courses per year:

$$\sum_{j=1}^{m} \sum_{t=1}^{2} x_{ijt} g_j \leq G$$

IP Formulation (6)

- Start
- Plan
- Article
- Problem
- IP Formulation
- IP Implementation
- Conclusion
- Questions

- Objective function:

$$\text{Minimize } z = \sum_{i=1}^{n} \sum_{j=1}^{m} \sum_{t=1}^{2} c_{ijt} x_{ijt}$$

- IP Formulation =

700 binary variables
300 constraints

IP Implementation (1)

- Start
- Plan
- Article
- Problem
- IP Formulation
- IP Implementation
- Conclusion
- Questions

In 1990:

- Problem solved with ZOOM/XMP, Fortran library for linear and integer programming
- ZOOM: Zero-One Optimization Model, no more documentation
- XMP: eXtensible Metadata Platform, based on XML, still in use by Adobe

ZOOM process:

- Find a solution to the LP relaxation
- Use an heuristic procedure, called Pivot and Complement (E. Balas and Martin C. H.) to find a feasible integer solution
- Improve the solution by flipping variables to the opposite bounds

IP Implementation (2)

- Start
- Plan
- Article
- Problem
- IP Formulation
- IP Implementation
- Conclusion
- Questions

Performance

- Few minutes to few days to get a solution (with a SUN-3 workstation)
- In general, the IP solution is similar at 75% to the Expert System, because of:
  - the single objective limitations
  - the compiled knowledge limitations
  - the global optimization limitations

Conclusion

- Start
- Plan
- Article
- Problem
- IP Formulation
- IP Implementation
- Conclusion
- Questions

- Using the IP is possible, even if the user interface requires a lot of work.
- Expert Systems is prefered because of his flexibility, his possibility to give partial solution and indicate holes, etc. . .
- New tools to use IP: SAS/OR Software

References

- Start
- Plan
- Article
- Problem
- IP Formulation
- IP Implementation
- Conclusion
- Questions

- Vasant Dhar: vdhar@stern.nyu.edu
- ZOOM/XMP: http://cadswes.colorado.edu/directory/Tim_Magee.html
- XMP: http://www.adobe.com/products/xmp/main.html
- SAS/OR Software: http://support.sas.com/rnd/app/or.html
- E. Balas, C. H. Martin: Pivot and Complement – a Heuristic for 0–1 Programming, Management Science 26(1), 1980.

Questions

- Start
- Plan
- Article
- Problem
- IP Formulation
- IP Implementation
- Conclusion
- Questions

Any questions ???