Optimization techniques for e-health applications

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Knowledge Acceleration and ICT:

Towards a Tuscany agenda for the European ICT research

Health Care Services

In Health Care scenarios:

- the ever increasing average age of population
- the desire to improve the quality of the service
- the limited economic resources

affect Health Care operations management, at a strategical, tactical and operational level

Health Care Services

During the last decade

the Health Care Service industry experienced significant growth in many European countries, due to:

- governmental pressure to reduce healthcare costs
- demographic changes
- development of new services and technologies

Decision-making in Health Care

To take into account such challenges, Health Care decision problems have been solved for:

- Hospital services
- Home Care services

by rigorous methodologies involving operations research and computer science techniques

Health Care applications I

Specifically, scientific results have been obtained for:

- Surgery planning and scheduling problems: an efficient operating room planning allows one to reduce
  - staff workload
  - patient waiting time
  - surgery cancellations

Health Care applications II

- Home Care problems

By providing care to patients in their home, we can

- reduce the hospitalisation costs
- improve the patient quality of life (so, social impact in addition to economic advantage)

Health Care policies

The basic orientation of Health Care policies, at national and regional level, is thus to address decision problems in Health Care by

- exploiting the ICT innovations: e.g. ICT-assisted protocols for remote rehabilitation
- but also optimizing the use of Health Care resources via advanced optimization models and methods: e.g. MILP models, decomposition approaches ....

Strong synergy: optimization is fundamental to be able to exploit the new technologies in a clever way!

A case study: Home Care

Given:

- a *planning horizon* W (usually a week)
- a set of *patients* with an associated *care plan*, i.e. weekly requests characterized by a *skill* (e.g. ordinary and palliative)
- a set of *operators*, also characterized by a *skill*

The Home Care Problem (*HCP*)

HCP requires to:

- schedule the patient requests during the week (care plan scheduling)
- assign the operators to the patients (operator assignment)
- determine the tour of the operators for each day of the week (routing decisions)

Some QoS requisites

- Skill constraints: the patient requests can be assigned only to operators of "adequate" skill
- Continuity of care: "a few" operators for each patient
- Maximum daily workload: the workload of each operator in each day, i.e. sum of service times and traveling times, can not exceed the duration of the operator workday

Optimizing resources in Home Care

Typical objectives to be pursued:

- minimization of operating costs
- balancing of the operator workload (e.g. in public stakeholders)

Some Home Care results

- MILP formulations to *HCP*:
  - based on patterns to combine scheduling, assignment and routing decisions
  - with the aim of balancing the operator workload
- Computational results: validation on real instances

Patterns: a new modelling device

Services are offered through a priori given patterns, which provide alternatives to schedule the care plan visits

- e.g. the care plan $= (3, 1)$ can be operated according to pattern (1, 2, 0, 1, 1):
  - ordinary visits on Monday, Thursday and Friday
  - palliative visit on Tuesday
  - no visit on Wednesday

Pattern generation policies

We designed and tested:

- Heur: a greedy heuristic based on frequency of request types
- Provider: the procedure implementing the scheduling strategy of the reference Home Care Provider
- FB: a multicommodity flow based model (on an auxiliary layered network)

The data

- Real data (palliative care and terminal patients)
- Main data characteristics:
  - Selected medical area: Merate (Lombardia)
  - 2 skills: ordinary and palliative
  - Care Profile: 4123 patients in [2004 - 2008]
    - Selected weeks: January 2006 and April 2007
      (more than 100 patients in each week, so very large instances!)

The impact of pattern generation policies: just a hint

	Heur	Provider	FB
January 2006	1.02	0.66	0.07
April 2007	0.48	0.41	0.17

- Percentage optimality gap: by solver CPLEX 12.4
- Achieved result: improved optimality gap w.r.t. the one of the Provider = better balancing of operator workload = more equity (positive social impact)
- Notice: other objectives have been investigated to improve cost efficiency, e.g. shorter total traveling time

More in ....

More details can be found in

- P. Cappanera, M.G. Scutellà "Joint assignment, scheduling and routing models to Home Care optimization: a pattern based approach", TR 13-05, Dipartimento di Informatica, Università di Pisa, 2013 (submitted)
- P. Cappanera, M.G. Scutellà "Home Care optimization: impact of pattern generation policies on scheduling and routing decisions", Electronic Notes in Discrete Mathematics, 41, 53 - 60, 2013
- P. Cappanera, M.G. Scutellà, F. Visintin "Home Care Services delivery: equity versus efficiency in optimization models", to appear in Springer Proceedings in Mathematics & Statistics, 2013

Notice that ....

The pattern approach is related to column generation, a technique also used in:

- Logistics
- Telecommunications
- Transportation
- Financial optimization

in fact: methodologies for one problem can be used for others ...

- Thanks for the attention!