Report on formative activities

Lorenzo Cioni

Dottorato in "Matematica per le Decisioni Economiche"

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Dipartimento di Informatica, Università di Pisa

e-mail: lcioni@di.unipi.it

Abstract

The present report is a short survey of the formative activities i carried out during the months of June, July and September 2005: a Doctoral Course, a Conference and an International Workshop. The report contains a section with loose notes on the topic of my intended PhD thesis with some links to the formative activities.

It also contains a short description of the courses that i am going to attend from October to December 2005 or i have the will to attend in a very near future (anyway before the end of summer 2006).

1 Introduction

The present report is a short survey of the formative activities in which i have been engaged during the months of June, July and September 2005 and also contains a personal proposal of some courses i would like to attend at least during the first semester of the second year of my PhD studies and anyway before the end of summer 2006. The report contains a section with loose notes on the topic of my intended PhD thesis with some links to the formative activities.

1.1 Doctoral Course

1. **Title**: Parallel Computing in Combinatorial Optimization

2. **Teacher**: Prof. Bernard Gendron

3. **Period**: from June 15 to June 29

4. **Place**: "Dipartimento di Informatica" of "Università di Pisa"

The course consisted of a series of theoretical lessons (twice a week, three hours each time) and ended with a two stages evaluation.
Outline of the course.
The main objectives of the course were the presentation of the current research on the design of parallel algorithms and software tools for solving combinatorial optimization problems. Both heuristic and exact methods have been reviewed, including tabu search, simulated annealing, variable neighborhood search, genetic algorithms, ant systems, branch-and-bound algorithms, and constraint programming methods. The implementation of these algorithms on various parallel and distributed computing systems has been studied, including shared-memory systems, message-passing environments, networks of heterogeneous workstations and grid computing environments. Classical problems, such as the Traveling Salesman Problem (TSP), the Vehicle Routing Problem (VRP) and the Quadratic Assignment Problem (QAP), as well as difficult network design problems arising from applications in the fields of transportation and telecommunications have been considered. **Calendar of the lessons**.

1. Lesson 1 (3h):

   - Overview of parallel computing
   - Overview of combinatorial optimization

- A prototype parallel tabu search algorithm
- A prototype parallel branch-and-bound algorithm

2. Lesson 2 (3h):

   - Overview of metaheuristics in combinatorial optimization
   - Parallel metaheuristics: design issues and implementation
   - Parallel metaheuristics: software tools
   - Parallel metaheuristics: applications

3. Lesson 3 (3h):

   - Overview of integer programming (IP), relaxation and decomposition
   - Parallel branch-and-bound: design issues and implementation
   - Parallel branch-and-bound: software tools
   - Parallel branch-and-bound: applications

4. Lesson 4 (3h):

   - Overview of constraint programming (CP)
   - Hybrid methods: algorithms combining metaheuristics, IP and CP
   - Parallel hybrid methods: applications

5. Lesson 5 (3h):

   - Parallel algorithms for classical problems: TSP, VRP, QAP
   - Parallel algorithms for network design problems

Evaluation.
The **first stage** took place on June 30 and consisted of the oral presentation of a paper to be chosen, in accordance with the teacher, from a list of proposed papers. For the oral presentation i chose a paper on Ant Systems (precisely the paper written by Bernd Bullnheimer, Gabriele Kotsis and Christine Strauβ, "Parallelization Strategies for the Ant System", Report Series, Report n^0 8, October 1997, University of Economics and Business Administration, Vienna) and prepared a PowerPoint presentation to highlight the main characteristics of the Ant System metaheuristic and two algorithms for its parallel execution whose main aim is a gain in speedup of

the execution with respect to a sequential execution.

The **second stage** ended on August 1 with the delivery of a survey or research paper on a topic to be agreed on with the teacher. In accordance with the teacher i chose to go deeper into the topic of the oral presentation and to write a survey paper whose title was "Some strategies for parallelizing Ant Systems".

So to allow a minimal understanding of the nature and structure of such a paper i quote here both the introductory and the closing sections.

"The present paper contains a short and partial survey of some of the parallelization strategies of the Ant Systems (AS) meta-heuristic with regard to the typical application of AS i.e. the Traveling Salesperson Problem (TSP). AS have been introduced as Ant Colony Optimization by Dorigo and, since then, have undergone many changes (we cite here *Rank based Ant System Max-Min Ant System* and *Ant Colony system*) and have been successfully applied in solving different optimization problems such as: traveling salesperson, quadratic assignment, vehicle routing, job-shop scheduling, sequential ordering, shortest common supersequence, graph coloring and frequency assignment, bin packing, constraint satisfaction, set covering and partitioning, spatial databases and telecommunication routing among the others.

So to make the paper as self-contained as possible, in the next sections we present some general concepts on metaheuristics and parallel processing then we introduce AS as a paradigm or a metaheuristic. After that we describe the TSP from the AS perspective then we describe AS in its sequential form to end with some parallel versions. As we will see shortly, AS are a population based metaheuristics and therefore are naturally suited for parallel processing though many possibilities of exploiting parallelism exist. Such possibilities depend on the the nature of the problem at hand and on the type of available hardware. This is the main reason we focus, in this paper, on the application of AS to TSP: this allows us to put on a common ground different proposals with the aim of comparing their results."

"When i started planning this paper my intention was to examine (and compare amongst themselves) as many parallel implementations of AS as i could find in literature. After only a few searches i found that mine was a "mission impossible": too many papers in too many areas of application in a too short time. Therefore, having as a starting point, i decided to confine myself to parallel implementations of AS for TSP. I, then, started a new search (not a really completely new one) and began finding some materials among which i selected the papers that have been discussed here. My inten-

tion, as i stated in the *Introduction* was to "to put on a common ground different proposals with the aim of comparing their results". Unfortunately, as it has been shown in this same paper, such intention has remained unfulfilled simply because, as an even superficial examination reveals, the results cannot be compared amongst themselves either because they have been obtained using ad hoc problem instances or because they have been obtained by using different and disjoint generally available and typical data sets for TSP. The paper is, therefore, simply a partial survey of some parallel implementations of AS for TSP whereas it is not clear if the original intention deserves further investigations or not, but time is a gentleman."

The draft of the paper took me up till the end of July. The final outcome was a 26 pages paper which i submitted to the teacher gaining his approval. I got through the two stages evaluation with a final mark of 16/20.

1.2   XXXVI AIRO Conference

1. **Title**: XXXVI Conference of the Italian Association of Operations Research (*AIRO* 2005)

2. **Period**: from September 6 to September 9

3. **Place**: Camerino (Macerata)

The program of the Conference was very rich with plenary, semiplenary and parallel sessions. During the four days of the conference i attended talks on the following topics:

1. graphs algorithms and problems;

2. game theory;

3. combinatorial and global optimization;

4. network optimization;

5. competitive electric markets;

6. scheduling;

7. city logistics;

8. location and routing problems, transportation problems, network design problems;

9. distributed decision making.

My main goal was to cover a wide spectrum of topics from those more linked to "traditional" Operations Research to topics with a more or less strong "economic flavour".
If we imagine to put the talks on a scale from such two extreme points at one end of the scale we can find talks such as the followings:

1. graph algorithms

   (a) The robust traveling salesman problem with interval data (R. Montemanni J. Barta L. Bianchi L.M. Gambardella): a new extension of the traveling salesman problem where travel times are specified as ranges of possible values.

   (b) The Stack Loading and Unloading Problem (D. Pretolani F. Malucelli S. Pallottino): stack ordering strategies aiming at minimizing the number of pop and push operations during the search for an item. Three types of reordering strategies: when unloading the stack, when loading it or in both phases.

   (c) Metaheuristics for the pickup and delivery traveling salesman problem with LIFO loading constraint (F. Carrabs J.F. Cordeau G. Laporte): another variation of the traveling salesman problem with pickup and delivery in which loading and unloading operations are executed in a LIFO order. Metaheuristics such as tabu search and variable neighborhood search evaluated on instances from TSPLIB.

2. network optimization

   (a) The Shortest Path Tour Problem (P. Festa): SPTP consists of finding the shortest path from a given origin node to a given destination node under the constraints that it passes through nodes belonging to sets T_i. The complexity class of the problem is proved and some techniques to solve it are presented.

   (b) Approximation algorithms for the Min Cost Network Containment Problem (F. Reinald R. Descent): given two directed graphs with the same set of nodes and with costs on the arcs of the first graph and assigned capacities on those of the second graph the Min Cost Network Containment Problem consists of finding a minimum cost capacity vector for the arcs of the first graph with certain properties on the cuts. New approximate algorithms for the problem are presented and some results are illustrated.

(c) Network Design for Electric Power Systems (D. Barnstorm S. Maia): the electric power transmission system is studied so to develop models and algorithms to improve the robustness of the transmission network.

(d) A bicriteria network flow problem to minimize energy consumption and maximize link stability in ad hoc networks (F. De Rango F. Guerriero S. Marano E. Bruno): a bicriteria (energy consumption and network stability) network flow model is used to address the problem of selecting the paths that represent the best compromise between minimizing energy consumption and maximizing links stability in case of mobile nodes.

3. scheduling

(a) A job shop problem with two classes of resource (M. Flamini A. Agnetis G. Nicosia A. Pacifici): a special job shop problem is presented wit a set of machines and a set of operators that assist each machine during jobs' operation processing. We have machines, operators and jobs: each job is defined by a sequence of operations, each operation can be processed by a given machine and requires a given processing time. The scheduling of the jobs must be decided under a set of constraints. The objective is to minimize the makespan. The complexity of the problem is analyzed and several algorithms are given.

(b) An Optimization Model for the Short-term Hydrothermal Unit Commitment Problem (C. Arbib M. Lizzi F. Marinelli): a new model for the unit commitment problem is proposed. Such a model takes into account minimum up-time and down-time constraints and start-up and shut-down costs.

At the other end of the scale we can find talks such as the followings:

1. game theory

(a) On cooperative games arising from deterministic auction situations (V. Fragnelli R. Branzei A. Meca S. Tijs): a market situation with a single seller of one object and more than one buyer of the object. The valuation of the object for the different buyers is common knowledge. Three cooperative games are presented: market game (in which the seller acts as a big boss), buyer ring games (in which some buyers plot against the seller so to reduce the price to

be paid for the object) and mixed ring games (in which the seller with the help of some buyers tries to increase the selling price).

(b) Statistical analysis of the Shapley value for microarray games (S. Moretti): statistical techniques and procedures within the frame of a game in co-operative form applied to analysis of genes.

(c) A Strategic Solution for Cooperative Games (G. Gambarelli): a technique to represent games in characteristic function form as games in strategic form so to allow the former to exploit the concepts and solutions of the latter.

(d) Allocating indivisible objects: Integer Linear Programming in Fair Division (M. Dell'Aglio R. Mosca): a fair allocation of indivisible goods between two players (that express their subjective evaluations on the items with positive integers) without side payments. No proportional or fair partition may exist. An algorithm that yields an efficient allocation and that differs from the classical algorithm is presented.

2. competitive electrical markets

(a) A model for the hourly bidding of an Independent Power Producer in a competitive electricity market (M. Innorta M.T. Vespucci): a procedure for the "hourly bidding"of an Independent power producer that aims at maximizing his own profit in a competitive context is presented. Basic assumptions: the total energy demand is price independent, the market operator must accept the cheapest offers taking into account the network security constraints and the structure of the competitor bids can be estimated.

(b) Modellazione e risoluzione del problema dello unit commitment per un produttore di energia elettrica (F. Calabrò G.M. Casolino A. Losi M. Russo): unit commitment falls within the short term management and covers a day splitted in hours and plays an important role in the participation of an electric energy producer to the so called market of the day before and market of settlement. On the forecast of the price of electricity production levels are determined so to optimize the choice of the production units to be used during the day, taking into account their physical characteristics. A model of such a problem is presented.

Between these extremes we can find talks such as the followings:

1. city logistics

(a) Analysis of Practical Policies for a Single Link Distribution System (L. Bertazzi L.M.A. Chan M.G. Speranza)

(b) A Tabu Search Algorithm for the Capacitated Traveling Purchaser Problem (R. Mansini M. Pelizzari R. Saccomandi)

(c) EVE-OPT: Memetic Algorithm for the Capability Vehicle Routing Problem (S. Palamara G. Perboli R. Tadei)

(d) Un modello di generazione dei movimenti di merci in ambito urbano (D. Vigo G. Gentile)

2. location and routing problems

(a) A fleet assignment location-routing problem (D. Ambrosino A. Sciomachen M.G. Scutellà)

(b) A flexible approach to locate extensive facilities on trees (J. Puerto)

(c) Extensive Facility Location Problems on Networks with Equity Measures (A. Scozzari J. Puerto F. Ricca)

(d) A polynomial algorithm for assigning units to centers in a tree to minimize flat service costs (N. Apollonio I. Lari F. Ricca B. Simeone)

1.3   International Workshop

1. **Title**: International Workshop on "Mathematics and Democracy. Voting Systems and Collective Choice"

2. **Period**: from September 19 to September 23

3. **Place**: Erice (Trapani)

The scope of the Workshop was the study of both voting systems and collective choice mechanisms from the point of view of both social and quantitative sciences: social sciences emphasize the diachronic aspects of electoral systems (changing needs and political structures of the societies) underlying both their development and their evolution whereas quantitative sciences try to formalize the electoral mechanisms so to assure that a set of basic and universal principles (among which i mention equity, representativity, stability and consistency) are satisfied.
The aim of the Workshop was a deep scrutiny of the many electoral systems that have been devised in the past and that are in use at the present, the

mixture of the different viewpoints and the stress of the role of mathematics to gain a deeper understanding, a rational assessment and a sound design of voting procedures. One of the main goals was the presentation of quantitative tools that allow the detection of inconsistencies or poor performances in actual systems. During the talks a lot of attention has been payed also to real-life situations ranging from the elections and voting systems of many countries to the problems associated to the elections of committees.

The program consisted of five days of lectures and problem discussion sessions. Broadly speaking the main thematic areas that characterized the workshop are the followings:

1. voting systems (majority, proportional, ranking systems (Borda, Condorcet and the like), approval voting, committee election);

2. district design;

3. representation and apportionment;

4. formalization, the role of mathematics and statistics;

5. electronic voting.

Among the examined topics i found very interesting the followings (cf. sections 2.1 and 2.2):

1. applications of Arrow's impossibility theorem to voting systems;

2. apportionment methods;

3. approval voting and election of committees;

4. characteristics, problems and paradoxes of "traditional" voting systems.

Arrow's impossibility theorem represents the reference frame of voting systems and states that if the number of candidates is at least three there is no aggregation method (i.e. no voting system) that satisfies simultaneously a set of basic properties such as

1. **universal domain**: an aggregation method must be applicable in all cases,

2. **transitivity**: the result of an aggregation must always be a ranking maybe with ties in which preferences satisfy transitivity,

3. **unanimity** (or Pareto condition): if all voters rank one candidate before another then the first candidate must be ranked before the other in the overall preference,

4. **independence** of irrelevant alternatives: the relative position of two candidates in the overall ranking depends only on their relative positions in the individual's preferences,

5. **non-dictatorship**: none of the voters can impose systematically his/her preferences on those of the others, in other words it should not be possible that the overall ranking is always identical to the preference ranking of a given voter.

Such a theorem can be used to check on which property a voting system fails. If we have a given voting system that is known to satisfy only four on five properties then it is assured that it must fail on the fifth. Starting with such a theorem it is easy to imagine that things go even worse if we broaden the set of the properties by adding required properties such as:

1. **separability**: a voting system is said separable is the result of an election in two areas (e. g. districts) coincides with the result of a global election,

2. **monotonicity**: a voting system must be such that an improvement of a candidate's position in some of the voters' preferences cannot turn into a deterioration of his/her position after the aggregation,

3. **non-manipulability**: a voting system must be robust against insincere vote.

Arrow's impossibility theorem represents a major obstacle to the design of a fair voting system and many attempts have been made to overcome it. A promising and worth exploring path seems to be the following: Arrow's theorem bases itself on Arrow's theory that is strictly ordinal and from which cardinal aggregation of preferences have been explicitly rejected. Voting methods, on the other hand, are cardinals and so out of the reach of Arrow's theorem. The underlaying theory is a cardinal theory of collective choice based mainly on the work of Harsanyi. Such a path has been (to my knowledge) traced by Claude Hillinger in his paper "Utilitarian collective choice and voting".
Other topics that interested me are those about apportionment methods (and so the methods by which votes are turned into seats), approval voting and the mechanisms for the election of committees.

As to approval voting (AV), it is based on the fact that the set of candidates is seen by each voter as composed of approved and refused candidates and we can think that the ones receives a weight equal to one and the others a weight equal to zero. AV is a non-rank, scoring method of voting. Under this method a voter can vote for as many alternatives as he wishes with the restriction that each alternative can receive at most one vote. All votes count equally and the alternative receiving the highest number of votes is chosen to be the winner. I think worth doing a comparison between such voting systems and the voting systems based on ranking without ties of the candidates. To the ranking systems family belong both the Condorcet method (according to which candidates are compared pairwise so that the winner is the candidate who gets the higher number of ranking votes) and the Borda method (according to which in each voter's preferences each candidate has a rank and to each rank corresponds a score. The method requires the evaluation of the Borda's score as the sum for all voters of that candidate's rank and the election of the candidate with the lowest score) and their numerous variants. In this case we can have ties and such candidates are considered as equivalent. AV with some added constraints can be used also for the elections of the members of various committees. Constraints can be used so that the elected members of a committee warrant the representation of certain cultural, racial, social or economical categories.

2   Relevance of the topics

I am deeply convinced that the topics i faced with during these months are important and significant by themselves both from a formative and from a methodological point of view (in this case essentially i refer to the Doctoral Course, cf. section 4).
From a formative point of view since (in order of events):

1. i became acquainted with the current research on the design of parallel algorithms and software tools for solving combinatorial optimization problems (cf. section 1.1);

2. i had the opportunity to deepen my knowledge of basic principles of Operations Research and to become acquainted with a very huge and broad set of applications of OR to many areas (cf. section 1.2);

3. i had the opportunity to meet the main experts in the field of voting systems and collective choice and to follow a very deep and interesting debate on both practical and theoretical aspects of such topics (cf. section 1.3).

At this point i would like to frame the subject of my future PhD thesis so to underline the links with such topics.
The main topic of my thesis should be: mediated modeling and systems dynamics for facing environmental problem/issues, modeling them and maybe solving them through the building of a strong consensus among the stakeholders.
During the AIRO Conference and during the International Workshop i had the possibility to examine more deeply than i have ever done before theoretic and modeling tools from that point of view. In what follows i simply summarize some remarks divided in two main sections: **evaluation and decision models** and **mediated modeling**. It should be clear that the first section owes much to the International Workshop whereas the second section has been conceived during the days of AIRO Conference.

2.1   Evaluation and decision models

I give here only few loose notes. The topic is complex and covers many interdisciplinary areas. Some links are highlighted but many others can be found (and will be found and well framed during the draft of the thesis).
I note that

1. taking decisions (in complex situations) is a complex and difficult task;

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2. it is possible to use decision support techniques (either formal or not): cost-benefit analysis, multiple criteria decision analysis, decision trees and so on;

3. some tools available are grades, indicators, voting procedures.

Explicit and well-defined rules to collect, assess and process information so to make recommendations in a decision and/or evaluation process.

Formal models look scientific but they are not granted to be neither well-founded nor free from any logical flaw or suffer limitations.

Formal models (decision and evaluation models) characteristics:

1. explicit and unambiguous representation of a given problem;

2. common language for communicating about a problem;

3. facilitate communication among the stakeholders (actors) involved in a given problem;

4. require a deep understanding of a problem in order to structure it (both as perception and as representation);

5. formal model implies formal techniques to draw conclusions from the model.

Problem of voting:

1. voting methods and related problems;

2. modeling voter's preferences;

3. selection of the voters and of the candidates.

Marks or grades:

1. assessment of elements (people, projects, proposals . . .);

2. performance evaluation and aggregation of evaluations.

Indicators:

1. problems and difficulties;

2. indicators have many and not always well defined roles (measures and tools for control and management).

Cost-benefit analysis:

1. projects evaluation;

2. difficulties;

3. underlying hypotheses and their relevance in the decision aiding process.

Multi-criteria systems:

1. different viewpoints;

2. rank or choose from a set of alternatives;

3. aggregation methods that give a value function on the set of alternatives;

4. can be used on not very rich or precise data;

5. can provide not very rich results: non clear-cut conclusions.

Automatic decision systems:

1. repetitive decision tasks;

2. more or less explicit decision rules that reflect decision policy of humans;

3. explicit or implicit decision rules.

Modeling of uncertainty:

1. decision trees;

2. expected utility approach.

Decision aiding is not number crunching:

1. actors (stakeholders) participating the process (possible link to mediated modeling);

2. problem formulation (possible link with system dynamics);

3. construction of the evaluation criteria;

4. aggregation process.

2.1.1 Single topics in short.

Voting systems and procedures.

Voting systems:

1. uninominal election, principles, types (single stage, two stages), para-doxes and properties (manipulability, monotonicity, participation, sep-arability, influence of agenda);

2. rankings (Condorcet and Borda methods);

3. theoretic results (Arrow's theorem, Gibbard-Satterthwaite's theorem);

4. approval voting (to be examined in details: committees election, selec-tion of proposals, alternatives, projects and so on).

Preferences of the voters:

1. rankings (with or without ties);

2. partial rankings (poor information, conflicting or confidential informa-tion), semiorders;

3. rankings with fuzzy relations (risk or uncertainty).

The voting process:

1. defining the set of candidates;

2. defining the set of voters.

Social choice and multiple criteria decision support.

Grading of elements (building and aggregating evaluations)

Elements can be either persons (members of committees, workgroups and so on) or objects such as proposals, goals, tools, plans and so on. Problems: mixing grades and compensation.

Indicators

Indicators as objective and faithful representations of a reality. An indicator, in effect, only accounts for some aspects of a reality. Examples:

1. human development index;

2. air quality index;

3. decathlon score.

Multiple roles of the indicators: normative, descriptive, rankings, performance measures, improvement measures over time, monitoring tool.

Open problems:

1. superindexes as a combination (weighted average?) of indexes;

2. scale normalization;

3. compensation among indexes;

4. dimension independence;

5. scale construction;

6. statistical aspects;

7. properties: monotonicity, non compensation and meaningfulness.

During a decision aiding process a decision-maker wants to rank the available alternatives according to a set of criteria (criterion = dimension) that are relevant with respect to the problem at hand. The tool used is a multi-criteria decision aiding tool that allows the ranking of the alternatives with respect to the preferences of the decision-maker. Indicators, too, aim at aggregating multi-dimensional information about a set of objects.
Indicators, however, assume no decision problem or decision-maker or preferences (one possibility is to consider the preferences of the potential users of an indicator (or index).

Measurement theory

Measurement is the way in which we assign numbers to objects or how we measure them. Measures reflect relations among objects (usually expressible in terms of greater, greater or equal, equal and so on). Open problem: assigning numbers to people or alternatives so to measures non physical properties such as expertise, experience, validity, feasibility and so on.
Decision support: it is often necessary to measure "objects" with respect to

the relation "is preferred to" since handling numbers is an easy task.

Basic assumption: a preference relation over the alternatives exists as an a-priori but is not known and must be discovered examining the objects or preferences can emerge and evolve dynamically during the decision process even if some of its characteristics are defined a-priori.

Many indexes either assume no preference relation over the items or don't try to reflect a pre-existing relation so to claim to be "pure" measures.

Indicators (indexes) and reality

Main points:

1. an index is not an aid to uncover reality;

2. an index institutes or settle a reality;

3. an index is an efficient way to synthesize reality;

4. an index can present flaws since it doesn't reflect any reality even if this is not necessarily a flaw;

5. an index, in some cases, doesn't reflect only reality;

6. an index is a kind of language (is based on conventions and allows the communication about different topics and the execution of different tasks);

7. an index is characterized by ambiguities and contradictions that should be kept at a minimum (or avoided at all) in case of decision-making.

Decision aiding processes relate often to a decision problem (more or less precisely defined) so that some elements of preferences are present and then measurement theory can be used to assure that the model being built do not contradict such preferences.

Cost-benefit analysis

Decision making as a way to allocate scarce resources to some (competing) alternatives, projects, courses of action rather than to others or evaluate them. Cost-benefit analysis (CBA).

Core point: a project should be undertaken when its "benefits" outweigh its "costs". Open problems:

1. how to identify both "benefits" and "costs" in real world problems;

2. how to transform them in monetary or other comparable terms;

3. how to evaluate and compare "benefits" and "costs" (using weights? simply summing?).

Decisions are complex with a huge variety of consequences.

Main points:

1. principles underlying CBA;

2. practical applications of such principles;

3. scope and limitations of CBA.

2.2 Mediated Modeling (MedMod in short)

Again only loose notes. The topic is the core of the thesis and strongly relates with system dynamics and simulation tools. The right approach is system thinking, a sort of holistic approach to real world problems analysis and modeling.

MedMod, indeed, represents a set of tools centered on system dynamics whose aim is the building of a general consensus around environmental issues. MedMod is based on system dynamics but it also requires the involvement of all stakeholders within a learning process of analysis of a complex system form a dynamical point of view. It usually works on longer time scales than those usually used by policymakers.

Environmental problems: hard problems due to

1. complexity,

2. interrelatedness (causal loops, feedbacks),

3. dynamic behavior.

Traditional approaches:

1. equilibrium centered,

2. command and control,

Time scales:

1. short term (politicians),

2. medium and long term (environmental professionals, industry leaders and academic),

Central issues:

1. alternative use of (scarce) resources,

2. complexity (more and more actors involved in a problem),

3. uncertainty (with associated risk depends on the perspective of stakeholders and their attitudes: risk-adverse, risk-neutral, risk-seeking).

Tools:

1. modeling (representations of reality or of real problems),

2. simulation (stimulation of a model with ad hoc perturbations so to validate it and use it for forecasts of real behaviors) from system dynamics (how systems change over time: building blocks, feedback loops and time lags)).

Problems ("structural" problems)

1. bounded rationality (we are limited by a lack of full information and cannot process all we have, we are not able to take into account time lags and feedback loops),

2. decision making (fragmentation into economic, environmental and sociocultural spheres and integration from different sciences and scales),

3. participation of stakeholders at the appropriate scale,

4. understanding of the evolution in time (past, present and future).

Major problem: compartmentalization of competences and scientific approaches.

Main point of view: integration of ecology and economics from the start to get a process of decision making that is more multidimensional, dynamic and interactive.

Quantitative model structures with economical and ecological aspects included in a quantitative model structure: conversion of units so to make meaningful confronts.

Expression of economic and ecological values in monetary terms (the second ones are much more difficult to express in such a way): expressing ecological services (to be detailed) in monetary terms.

MedMod provides a structured process to include the most important aspects of a problem in a simple but elegant simulation model.

2.2.1 Experts (and scientists) as a source of knowledge

Experts are traditionally seen as those who can give the right answer to any scientific problem by looking at the right level of detail. Two order of problems arise:

1. compartmentalization of science,

2. greater emphasis on analysis (the art of splitting a problem in more and more simple subproblems) than in synthesis (the art of building the whole from its composing elements).

Opinion of scientists as a partisan support of different and contrasting claims in absence of a general scientific consensus. Experts and scientists are seen within MedMod on the same level as the other stakeholders since they:

1. can provide pieces of information to the other stakeholder as they need it,

2. can help to keep discussion on a rational ground and dynamically connect pieces of information together.

Adaptive research so to allow adaptive managers and policymakers to be more responsive.

2.2.2 Participation of stakeholders

Traditionally stakeholders (all people potentially affected by the problem at hand and by its possible solutions) can be involved in the decision process by experts and scientists at various levels:

1. at the highest level experts and scientists consult individual stakeholders to carry out their studies and to develop their models,

2. at the lowest level experts and scientists perform studied and develop models about the stakeholders.

After the execution of such studies and the definition of the models decision makers confront their results with the society's needs or their political agenda. A consequence is that very often stakeholders do not accept the results of such studies and models since:

1. they don't understand or agree with the results of the studies or models since they either don't understand or agree with the underlying assumptions,

2. they don't agree with the structure of the model,

3. they refuse to accept the outcome since they feel excluded from the decision making process.

Owing to all these reasons conflicts are likely to arise during the implementation phase.

Broader and deeper participation of stakeholders if on one side is more expensive on the other hand can make the whole decision process more effective and less expensive in the implementation phase since it should reduce the passive resistance of the stakeholders.

Main points:

1. early involvement of stakeholder groups,

2. definition of groups of stakeholders (government, municipalities, industry, environmental nongovernmental organizations, groups of associated citizens),

3. common goals,

4. consensus.

Main aim: reducing conflicts and costs at the implementation phase.

Open question: dissent, is dissent a simple complement of consensus? various levels of dissent from passive resistance (posing difficulties in implementing decisions taken by others) to active rejection of those decisions (from appeals to legal authorities to sabotages), how to measure dissent and how to deal with it.

Principles of involvement of the stakeholders at the relevant levels (anyway before the final decisions have been taken):

1. openness and so active communication, common languages and increasing confidence,

2. participation throughout the decision process,

3. accountability and so clearer goals and greater responsibility.

2.2.3 Adaptive (environmental) management (AdMan)

Ecosystem management approach in which a range of different stakeholders are included.

Goal: to improve decision making for a sustainable development (i. e. to

allow the satisfaction of today's needs guaranteeing the rights of future generations).
Tools to:

1. facilitate common goal development,

2. test alternative scenarios.

Such tools should be able to communicate both the complexity and the associated uncertainties of the decisions and to allow for a broader participation of the stakeholders.
Support of the decision making process.
AdMan assumes a dynamic perspective centered on the behavior of ecological systems.
According to this approach policymaking is seen as an experiment since a policy is monitored for its intended and unintended effects (keeping control so to change policy if we the one we chose prove having too many unintended effects).
Caution: definition of intended/unintended effects as an a priori or during the course of the process, tools to modify or reverse any decision that proves to have unintended effects (degree of unintended effects against intended ones or a yes/no decision?).
Actions:

1. abandonment of a policy if it "proves wrong",

2. adjustment of a policy in the attempt to avoid its unintended effects (if not too many or too serious),

3. fine tuning of a policy to correct it in face of the intended goals.

AdMan gains strength from:

1. a process-oriented approach,

2. a team learning perspective that emphasizes collaborative learning.

Open question: who takes decisions? only one or few persons or stakeholders too? and in this case how many and who of them?

2.2.4   Side stream: voting systems and methods

Voting sets: selections of members of committees and commissions, selections among proposals, alternatives, and distinct courses of action, selections

among distinct agendas.

Main problems: correlation between successive elections, variable electoral body or base (set of voters), electoral base non fully representative of all the categories of stakeholders.

Open question: single answers to a problem or a range of answers in face of a intrinsic uncertainty?

Open question: answers from a single discipline or from a multidisciplinary perspective?

2.2.5 The building of environmental consensus

Environmental conflicts depends very often on values of individuals and groups and on contrasting beliefs about the distribution of costs and benefits of the different stakeholders.

Main problem: lack of general scientific consensus (science used to justify opposing points of view), focus mainly on legal (or economical) aspects and arguments.

"Tool": mediation with the aid of computer modeling.

Addressing complex environmental problems requires the building (or establishing) of the consensus.

Consensus: a process aiming at the attainment of an agreement. It involves:

1. good faith effort to meet the interests of all stakeholders (stake holding parties),

2. framing a proposal (or a set of proposals) after the hearing of every stakeholder's concerns,

3. the fact that none of the stakeholders must undermine his/her interests,

4. the responsibility of proposing solutions that will meet the interests of all stakeholders.

Topmost outcome: unanimous consensus.

Various degrees, from weak to strong consensus:

1. strong consensus means that no stakeholder has dropped out during the process owing to reasons associated to the process itself,

2. weak consensus means that stakeholders have dropped out owing to strategic reasons,

3. a strong consensus is reflected in the approval and support of the resulting recommendations, action plans or proposals to resolve a conflict,

4. a strong consensus is considered a constraint by all the stakeholders,

5. a weak consensus is seen as not constraining but as a sort of environmental conditions with whom to live with (and that can be violated).

Degree of consensus:

1. all stakeholders stay involved,

2. only a critical mass of stakeholders stay involved,

3. only stakeholders from a few groups (organizations and/or administrations) stay involved,

but there may be more combinations.

Strong consensus usually represents a strong basis for the implementation of a course of actions or any other decisions taken by the (appropriate) stakeholders. It is important to broaden as much as possible the attained consensus to those parties that are lagging in the process.

Weak (or partisan) consensus is a relatively fragile basis for implementation.

2.2.6 The role of MedMod

Framing of proposals for the building of consensus in small increments:

1. common ground for the goal of a model,

2. construction of a simulation model,

3. evaluation of the model using various scenarios (=> design of scenarios: plausibility, compatibility, worse cases, respect of historical data).

Proposal drafting is a collaborative process based on the sharing of information about the system and its dynamics.

Main points:

1. status quo of the system/world (under concern),

2. more desirable (from what point of view?) future state,

3. path from the two states.

A MedMod process appreciates any improvement or insight in a complex situation.
Original thinking and learning.
MedMod aims at avoiding:

1. linear thinking (so a way of modeling without feedback and loops),

2. compartmentalized decision making (no cooperation at all),

3. non participatory (or authoritative) decision making.

MedMod aims at obtaining:

1. a collaborative team learning experience,

2. a broad (quantitative) and deep (qualitative) consensus.

Practical tools: system dynamics and simulation software. Models to increase the understanding of the involved dynamics.
Modeling process. End products:

1. learning of the group,

2. a set of consensus-based conclusions.

The model is more a by-product.
The process of model construction:

1. structures both discussion and thinking (it represents a focus),

2. fosters team learning (since there is a goal to be attained).

Three stages of a modeling process:

1. first stage, answers to preliminary questions about the dynamics of the system,

2. second stage and third stage rely on the first stage,

3. second stage, research stage, full definition of the model with as much details as possible,

4. third stage, management of the model, scenarios and refinements.

Topics of future and deeper investigations:

1. role of MedMod and comparison with other tools, inspiring disciplines,

2. general characteristics and context of the MedMod process,

3. the MedMod process as a guideline with variations.

Participatory modeling means participation in the modeling process.
Two points.

1. More levels (a continuum?) of participation from the lowest level
   (stakeholders are consulted individually to provide inputs to the mod-
   eling process) to the highest (stakeholders, or a group of them, has
   a complete control of the type of modeling and of the content of the
   model). MedMod is positioned at this highest level where the model
   is a by-product of the team learning process than the only and final
   product of the process.

2. Timing of the modeling process (another continuum?) at which partic-
   ipation can take place: form late to early invitation of the stakeholders
   to the modeling process. In the former case stakeholders can have a low
   influence on the modeling process to change the course of the process;
   in the latter case stakeholders can contribute at shaping the model from
   the very beginning.

Two dimensions:

1. degree of participation, from low to high;

2. timing of participation, from early to late.

Two dimensional space in which to position various kinds of modeling pro-
cesses. We can think of four "cardinal points" as extreme points:

1. low participation, late involvement: experts design the model and use
   stakeholders only to get a feedback,

2. low participation, early involvement: experts use individual stakehold-
   ers viewpoints to design the model,

3. high participation, late involvement: stakeholders refine the model that
   experts have framed,

4. high participation, early involvement: stakeholders design the model
   with the support of the experts.

Obviously MedMod aims at gaining the last "cardinal point".

3   Second year personal proposal

My proposed formative program for the end of 2005 and the beginning of 2006 covers substantially the following thematic areas:

1. system dynamics, evaluation and decision models and voting systems applied to both economic modeling and to decisions in conditions of complexity and conflict;

2. mediation and conciliation;

3. game theory as a tool for conflict modeling;

4. economics with a strong stress on co-operation, local development, environmental and ecological aspects and problems.

So to study in depth such topics i planned to attend a bunch of university courses both at the "Centro Interdipartimentale di Scienze per la Pace" and at the "Corso di laurea in economia del territorio e dell'ambiente" of Università di Pisa and any interesting and suitable cycles of seminars on those topics to be held during the aforesaid period (cf. the sections 3.1 and 3.2).

3.1   University courses

1. Decisioni in sistuazioni di complessità e conflitto, "Centro Interdipartimentale di Scienze per la Pace", first semester, teacher: professor Giorgio Gallo;

2. Mediazione e conciliazione, basic and advanced courses, "Centro Interdipartimentale di Scienze per la Pace", first semester, teacher: professor Paolo S. Nicosia;

3. Cooperazione decentrata e internazionale, aspetti economici, "Centro Interdipartimentale di Scienze per la Pace", first semester, teacher: professor Stefano Sanna;

4. Economia ecologica, first and second module, "Corso di laurea in economia del territorio e dell'ambiente", second semester, teacher: professor Paola Meoli.

3.2   Doctoral course

1. **Title**: An Introduction to Dynamical Systems

2. **Teacher**: Prof. Frederico Oliveira-Pinto, Universidade Independente, Lisbona

3. **Period**: October 2005

4. **Place**: "Dipartimento di Informatica" of "Università di Pisa"

Aim o the course: A comparative study of discrete and continuous dynamical systems and of their stability.
Contents:

1. Discrete systems:

   (a) Introduction

   (b) Recurrence & difference equations

   (c) General solutions of discrete systems

   (d) Equilibrium values

   (e) Dynamical stability

   (f) Examples of linear systems with exponential growth and known general solutions

   (g) Analytical solutions of discrete linear versus continuous linear growth models

   (h) Quadratic dynamical systems

   (i) Discrete quadratic versus logistic systems

   (j) Closed-form solutions for discrete quadratic and discrete cubic dynamical systems with "chaotic" behavior

   (k) Study of their intrinsic instability

2. Continuous systems:

   (a) Volterra-type predator-prey systems

   (b) Military fighting models

4   Closing remarks

I would like to underline that the formative activities i attended are of basic importance for the following reasons:

1. from a formative point of view, all of them gave me the occasion to examine more closely many basic and advanced topics both in operations research area, in economics and social choice and in algorithmics;

2. from a methodological point of view, the attendance to the doctoral course gave me the chance to prepare a talk on a research topic and to draft a survey paper and to have them both evaluated.

Last but not least i note that i planned to cover the area "game theory as a tool for conflict modeling" either with some university course (second semester) or with a summer school (summer 2006).

5 Enclosed documents

1. Doctoral Course: text of the oral presentation;

2. Doctoral Course: text of the survey paper;

3. Doctoral Course: final certificate;

4. Airo Conference: certificate of attendance;

5. International Workshop: certificate of attendance;

6. programs of the university courses (cf. section 3.1)

7. program of the doctoral course (cf. section 3.2).