Simple Networking Applications

ORLAB - Operations Research Laboratory

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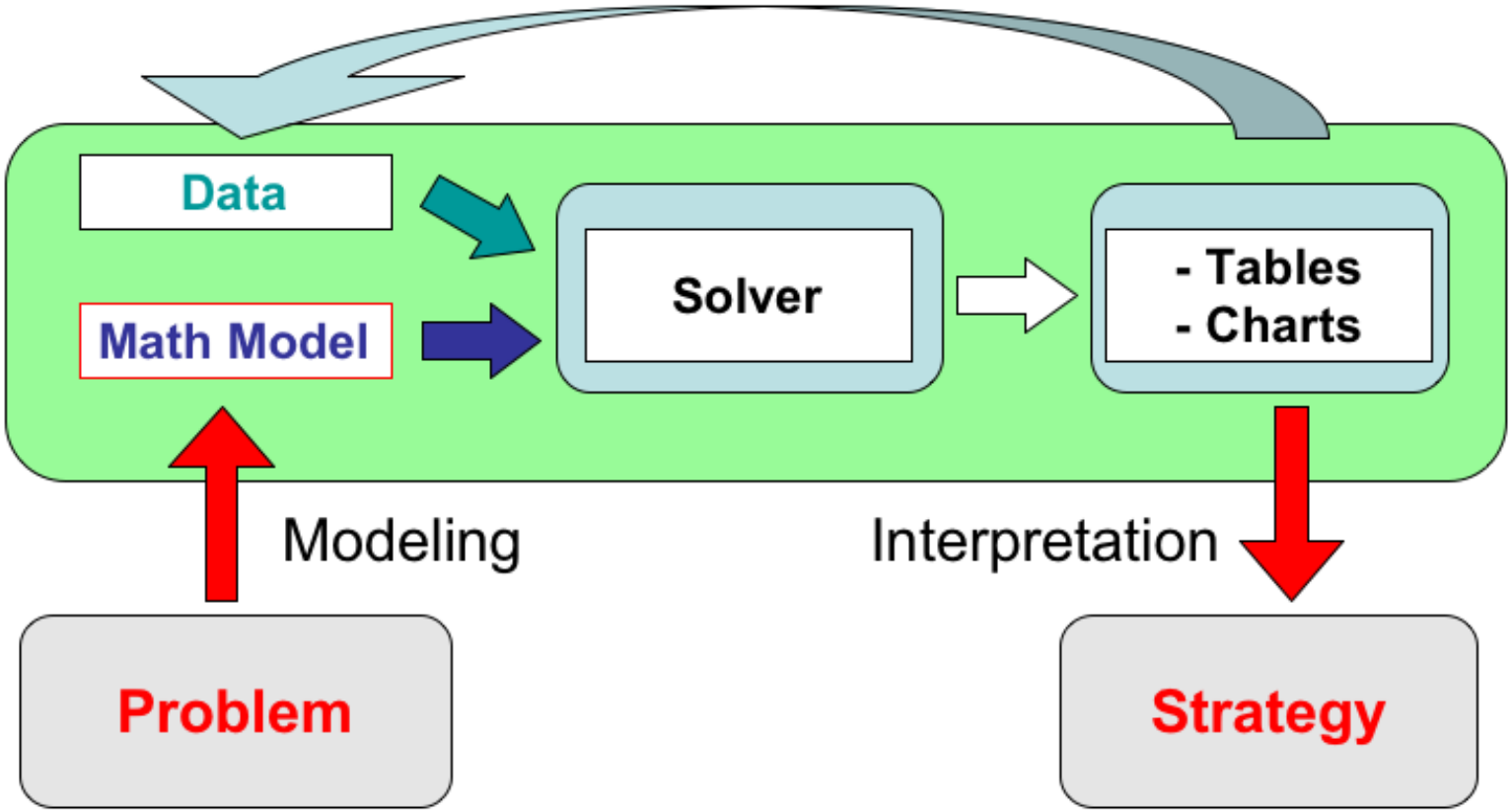
What you do during lab sessions



What you do during lab sessions

Check this out: http://challenge.roadef.org/2010/sujet.en.htm!!!

WARNINGS

- **Warning 1**: Lab sessions complement exercise sessions
- **Warning 2**: read carefully the error messages!
- Common pitfalls:
  - unbounded variables
  - missing constraints
  - missunderstood constraints
  - wrong quantification in the summation of constraints
  - wrong objective function

A short introduction to AMPL

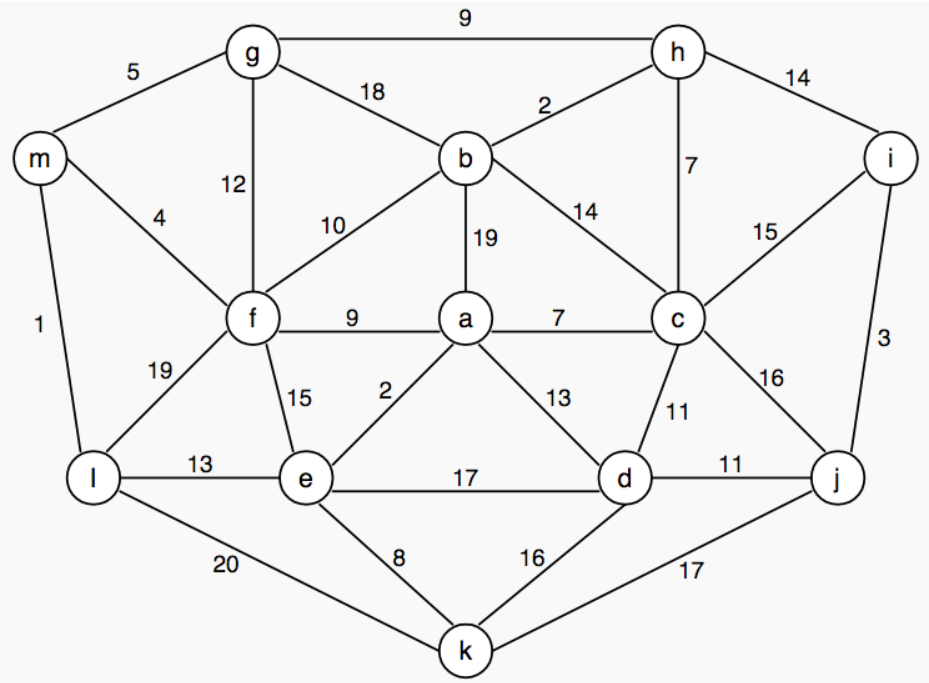
- You write two separate text (ASCII) files:
  - *FILENAME*.**mod**: it contains the model of the problem, i.e., variables, constraints, and objective function;
  - *FILENAME*.**dat**: it contains the data specifing an instance of the problem, i.e., the coefficients of the constraints and objective function
- Useful AMPL keywords (syntax sugar):
  - `set`: defines set of elements;
  - `param`: defines constant parameters like constants, vectors, or matrices; `default` is used to give default values to parameters;
  - `var`: defines continuous variables. They can be defined also as `integer` and `binary`;
  - `sum`: defines a linear sum;
  - `subject to`: defines a family of constraints;
  - `minimize` or `maximize`: defines the objective function;
  - `symbolic`: defines a parameter equal to an element of a set;

Using AMPL

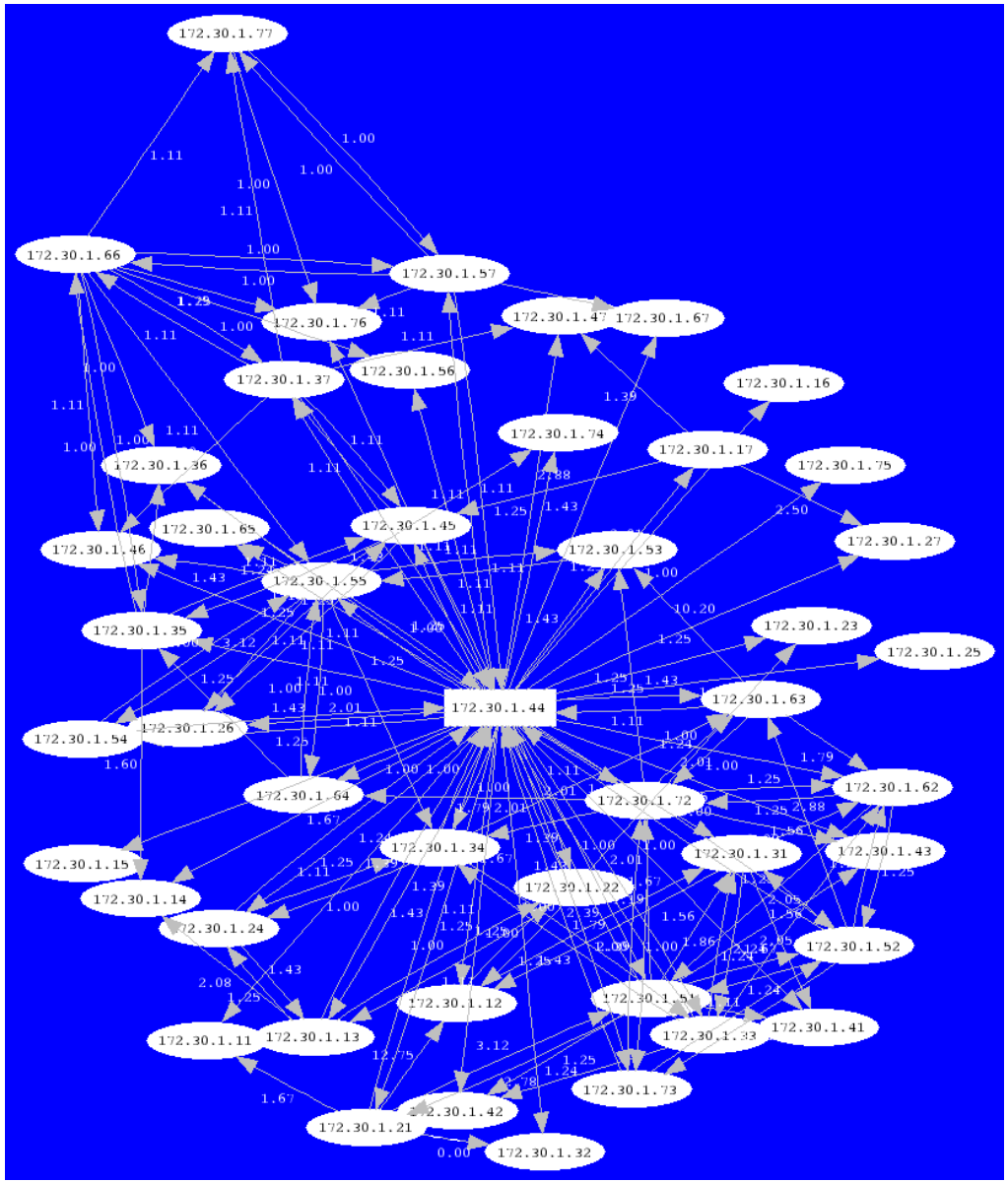
1. select the solver you want to use (CPLEX):
   `% option solver cplex;`
   or: `% option solver gurobi;`
2. write/load the model (.mod) and data (.dat) files
3. solve the problem
4. if you get (syntax) errors, check your files and try again
5. if you get a solution, look it:
   `% display x;`
6. in any case, inspect how AMPL interpret your .mod file:
   `% expand Cost;`
   `% expand MatrixConstraints;`

Exercise 6: Networking

Consider the network topology given below. Each node represents a router connected to a wireless network and each edge represent a bidirectional link between routers. For each link is given the capacity. Formulate and solve the problem of finding the maximum flow from node c to node f.



http://wirelessafrica.meraka.org.za (49-nodes mesh)



Questions

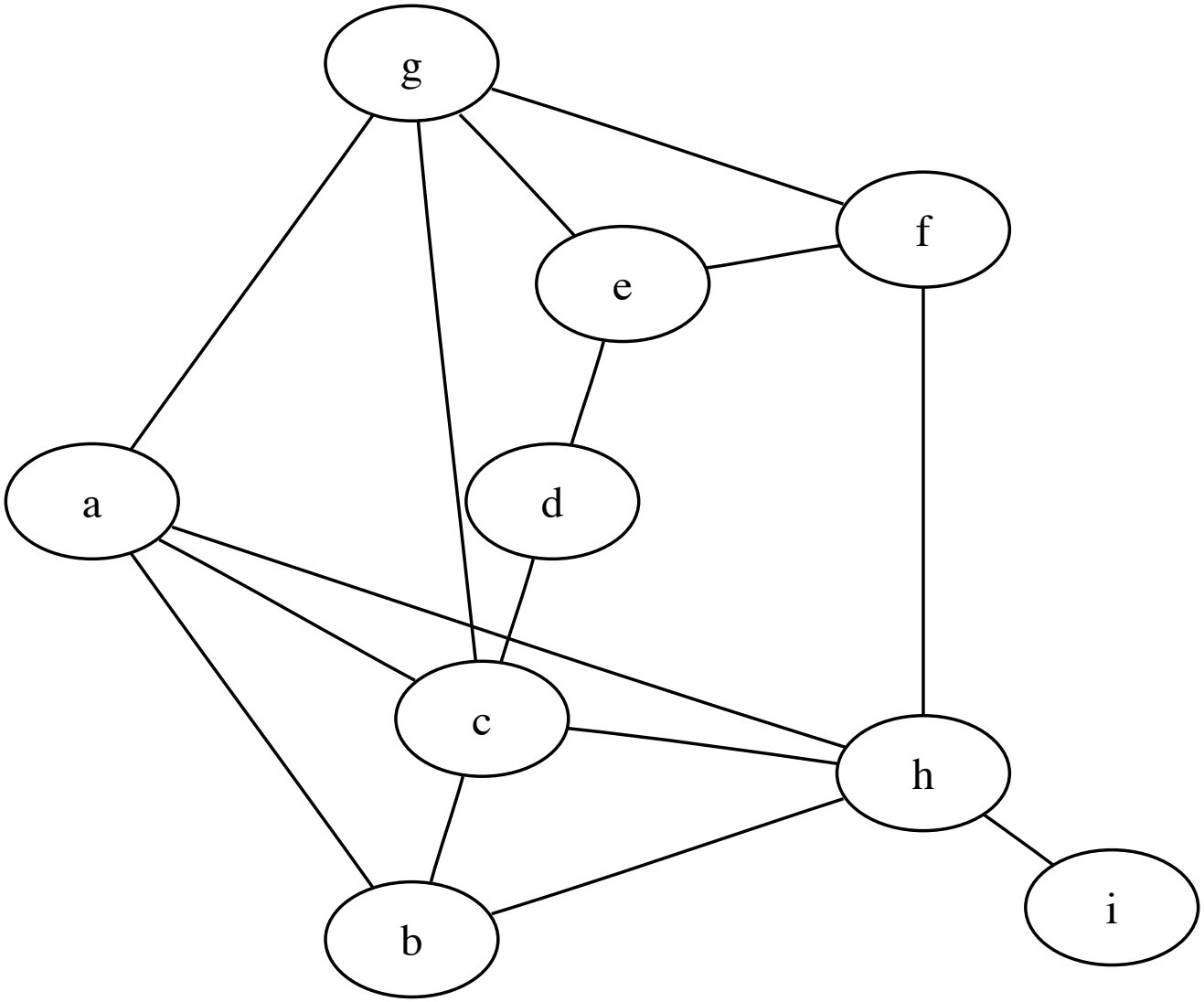
1. write the AMPL model file and solve with the .dat file presents on the web site
2. check the solution (it should be =62)
3. try to solve node the sam problem with source b and destination d. What does it change?
4. solve both version by using first `cplex` and then `gurobi`. Which are the differeces (if any)?
5. suppose you have a limited budget to improve the maximum flow from b to d. On which link you should improve the capacity? Why? How can AMPL help you to solve this problem?
6. you should have to solve real-life max-flow problem, how do you do? Which algorithm would use? Why?

Exercise 8: Frequency Assignment Problem

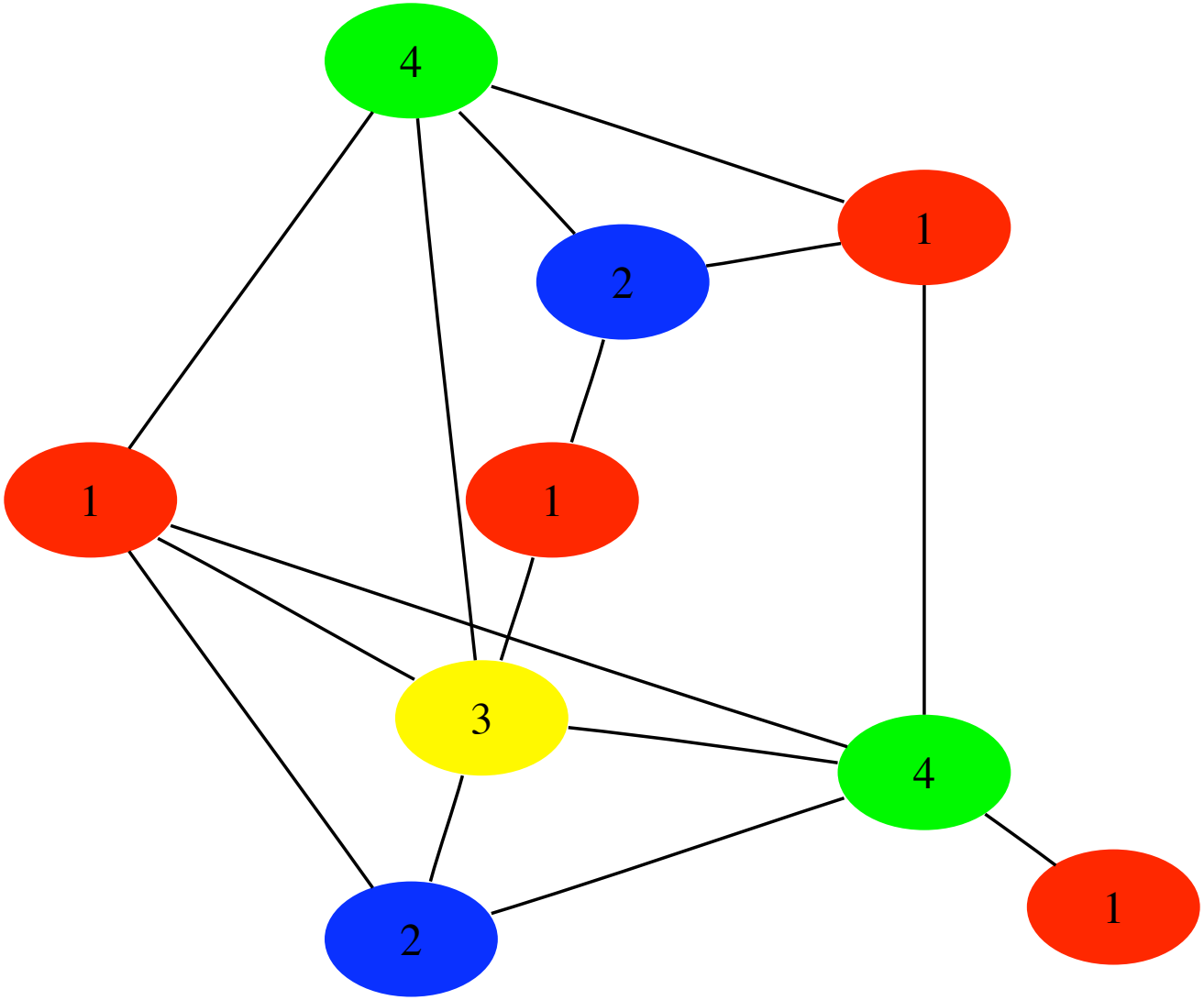
In a wireless network, a given city is covered by a number of antenna. Each antenna cover a given area (a cell). The cells overlap in such a way that the whole city is covered by at least an antenna. If two cells overlap, then the corresponding two antenna interfere. Let $F = \{1, \ldots, f\}$ be the set of frequencies available. Formulate the problem of assigning to each antenna a frequency in such a way that no two antenna interfere each other, while minimizing the number of frequencies used.

Variant: Consider now a different model in which two antennas that overlap does not interfere each other if the frequency they get assigned is *sufficiently* different. For instance, if the frequencies are numbered from 1 to f, we say that two frequencies interfere if the absolute value of their difference is less or equal to k. Formulate the new problem and solve with $k = 2$.

Exercise 8: Interference Graph [.dat file]

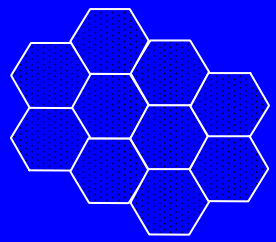


Exercise 8: Solution with 4 frequencies



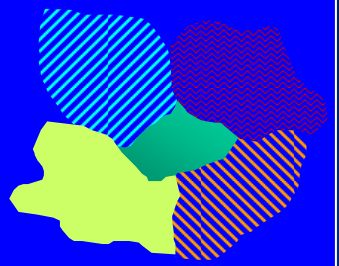
Cell Models

Hexagon Cell Model



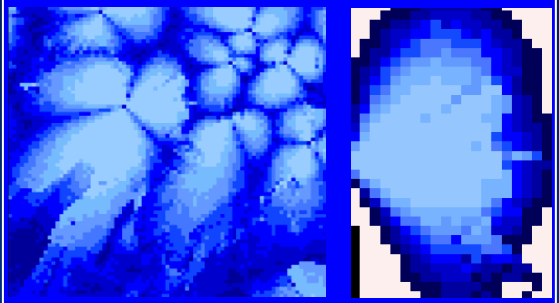
- sites on regular grid
- isotropic propagation conditions
- no cell-overlapping

Best Server Model



- realistic propagation conditions
- arbitrary cell shapes
- no cell-overlapping

Cell Assignment Probability Model



- realistic propagation conditions
- arbitrary cell shapes
- cell-overlapping

Source: **E-Plus Mobilfunk, Germany**

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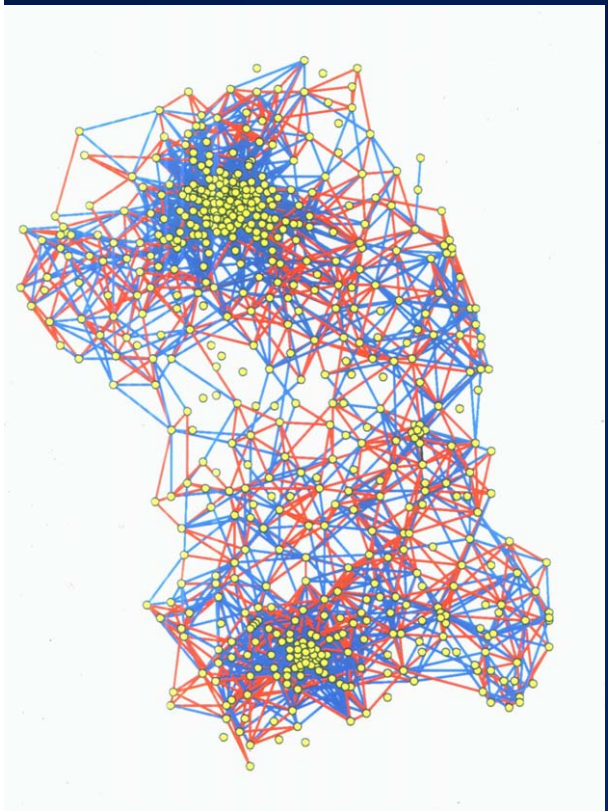
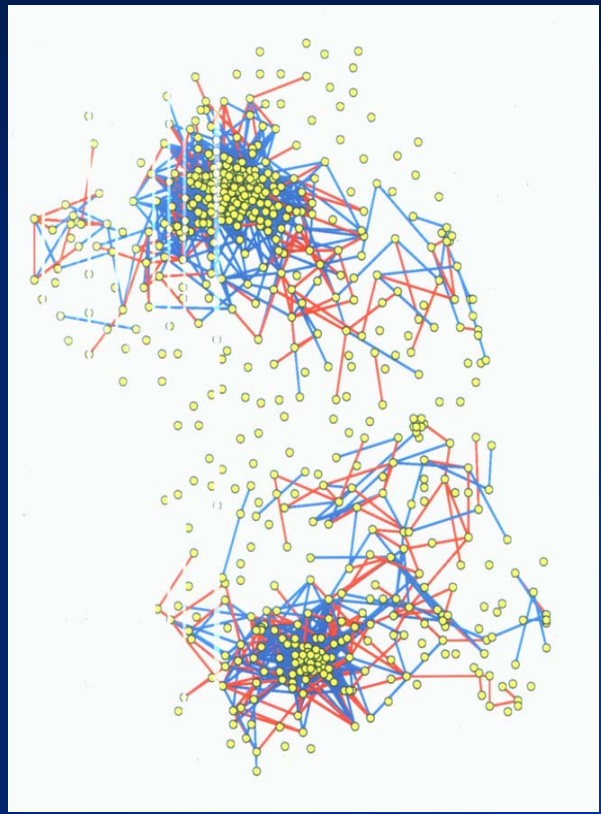
Region Berlin - Dresden





2877
carriers

50 channels

Interference
reduction:
83.6%

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Radio Interface: OR & Optimization Challenges

- Location of sites/base stations
  - was investgated in the OR literature („dead subject")
  - has become „hot" again
    - UMTS: massive investments around the world
    - GSM: still significant roll-outs
    - special issue: mergers
- antenna configurations at base stations
  - GSM: coverage based planning
  - UMTS: coverage & capacity considerations
- radio resource allocation
  - GSM: frequency assignment
  - UMTS: ? (open: real time/online resource management)



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Challenge 2: Sudoku

Sudoku, also known as Number Place, is a logic-based placement puzzle. The aim of the canonical puzzle is to enter a numerical digit from 1 through 9 in each cell of a 9x9 grid made up of 3x3 subgrids (called "regions"), starting with various digits given in some cells (the "givens"). Each row, column, and region must contain only one instance of each numeral.
(From Wikipedia, the free encyclopedia.)

5			1			8		
3					6	7		
	1	7	3	5	8			
1		5						
	4						6	
						9		2
			4	8	7	1	3	
		3	9					8
		1			3			7

Daily SuDoku: Wed 15-Nov-2006 hard

Links and email

- Lab sessions web site:
  http://home.dei.polimi.it/gualandi/FRO-D
- E-mail:
  gualandi_at_elet.polimi.it
- La Fabbrica dei modelli:
  http://home.dei.polimi.it/gualandi/FRO-D
- Reference Guide to AMPL
  http://.../FRO-D/ampl_examples.pdf