Solution to HW. 1

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Optimization

As a reminder:

- **Objective** is a goal you would like to achieve, the way you evaluate the goodness of a solution, and a yardstick against which to measure alternative solutions.
- **Constraint** is what you must achieve without fail.

The question that usually you want to give an answer is: "*What should I do, given these constraints, for a more effective (or less costly) objective ?*".

An important aspect to be considered is that an optimization model can be formulated in different possible ways, emphasizing different aspects of the same problem.

Problems Solution

1-2.
Objectives

- Maximizing the number of students that attend classes.
- Minimizing the number of "gaps" with no lessons for students.
- Minimizing the number of "gaps" with no lessons for teachers.
- Smooth distribution of hours along the week.
  (e.g. If a class has to be taught 6 hours a week it does not make sense to place it for 6 hours in a row for only one day.)
- Minimize distance between locations of back-to-back courses for a given student.

Constraints

- Room Size.
- Conflicts in terms of size (Two classes of 45 students cannot be taught at the same time if there is only one room for 45 available).
- Conflicts in terms of course requirements (Don't teach math and physics at the same time if both courses are required for graduation.).
- Instructors may not teach more than one class at a time.
- The same class meets always in the same room.
- Course material (A chemistry class should be taught in a room where a a periodical table is available).
- Fixed number of hours per week for a given subject.
- No classes after 5 PM.
- No classes on Saturdays and Sundays.
- ...

Many constraints can be found and some objectives can be integrated in the problem as constraints. For example the minimization of the gaps can become a constraint: No gaps at all.

1-4.
Objectives

1. Minimizing the costs (e.g. construction and maintenance).
2. Minimizing the maximum time to reach every household.
3. Minimizing the acoustic and traffic disturbance.
4. Maximizing the fraction of "happy" citizens after decision. (e.g. If it is built near a business district all the shops owners will complain, if it is built near your house only you will complain).
5. Minimizing the construction ugliness (e.g. Think about of a fire station building near a nice and old monument.)

Constraints

- Not close to certain areas such as elementary schools (Children after school usually run in every direction ...).

- Not too far from business districts such as a mall (If something happen in a mall many people can get injured in a very short time, if instead my house burns, only me and my family will get injured).

The priority list is of course subjective:

- Mayor: $4, 1, 5, 3, 2$.
- Chamber of Commerce: $1, 3, 5, 4, 2$.
- Residents: $2, 4, 5, 1, 3$.
- Realtors: $3, 5, 4, 2, 1$.
- Merchants: $3, 5, 1, 4, 2$

Also in this case some of the objectives can become constraints of the problem. In real world situation the different group will argue not only on the different priorities to be met but also on the "weight" of every single constraint (e.g. The constraint not far from a mall more than 5 minutes or half an hour can make a big difference in decisions and consequences.)

1-7.
(a) Constraints:

- Total amount of children.
- Maximum capacity for each school.
- Some schools have to remain open in a low income area.
- "Good" social and economic mixing in each school.
- School that remain open should be located near public transport stations.
- Students living more than N miles from school must be bussed.
- ...

(b) Objectives:

- Minimizing the overlap in spatial coverage.
- Minimizing displacement of students.
- Maximizing total revenues.
- Minimize the variance in distances traveled by walking students (equity).
- ...

(c): Information needed for these problem are demographic mostly but not only:

- Spatial distribution of children.
- Spatial distribution of household income.
- Spatial distribution of minorities.
- Transportation network.
- Maintenance costs for each school.
- Revenues per student for each school.
- Capacities for each school.
- Long term demographic data.

(d) Complaints:
For this problem you try to optimize more than one objective. Every solution will emphasize only a certain aspect of the problem producing complaints from the people that are not really satisfied. As an engineer you will rigorously formulate the problem and get the set of different results. It is to the decision makers (e.g. the city council) the hard task to decide which one of the different solutions is really "optimal" for the community.