Société de Calcul Mathématique SA
Tools for decision help

Fédération Française des
Jeux Mathématiques

Mathematical Competitive Game 2015-2016

False Alarms in a Sensor Network

Fédération Française des Jeux Mathématiques
(French Federation of Mathematical Games)

and

Société de Calcul Mathématique SA

in partnership with

IRSN

(Institut de Radioprotection et de Sûreté Nucléaire)

Results and remarks, by Bernard Beauzamy

I. Participation

There were fewer participants this year than during the previous years ; only 5 this time (2 individuals and 3 groups). This is perhaps due to the fact that the problem contained many "imprecisions" left to the participants. It was certainly far from an academic presentation, but certainly closer to reality ! The networks described in the problem exist in reality, and the governments have to solve this type of question (where to put the sensors, and how many), with less information than what was provided in the problem.

II. Results

For Individuals, no prize was given

For Groups :

No first prize

Second prize : Ecole Polytechnique de Montréal, Classe du cours MTH6311 - Optimisation combinatoire, Professeur Alain Hertz. Etudiants : Ait Mehdi Meriem, Attia Dalia, Bancel Lucas, Bécotte-Boutin Hélène-Sarah, Bouallagui Lotfi, Brika Zayneb, Delaite Antoine, Graille Raphaël, Pinon Olivier, Saadi Cherifa, Spleit Michael, Tanneau Mathieu, Trudeau Rémi.

Second prize ex aequo : Delft University of Technology, Faculty of Electrical Engineering, Mathematics and Computer Science. Supervisor: Drs. A. T. Hensbergen. Students : Massimo Achterberg, Jorn Hoofwijk, Roel Vos and Mike Zoutendijk.

Third prize : TU Delft, Faculty of Electrical Engineering, Mathematics and Computer Science, BSc program Applied Mathematics. Students : Rick Hegeman, Carlos Hermans, Marco Rozendaal, Pieter Verstraten.

III. Approaching real world problems

Academia clearly has difficulties in approaching real-world problems. The solutions which are given (and this is typically the case here) are of the following form: let us make some assumptions on the various parts of the problem (what we would call "model assumptions") and when this is done, we will solve the problem, using our usual tools. Such an approach is clearly inappropriate here.

I would say that it is useless to build precise mathematical models, for instance about the way a cloud moves, because the law of physics are quite complicated and we do not have an information which is precise enough (speed and direction of winds, rain or not, and so on). So a rough description of the size of the cloud, based upon the IRSN model after the Tchernobyl accident, will be sufficient. But, on the other hand, a radioactive cloud coming from an accident is not a bomb, so the comparison with Hiroshima is not valid.

IV. Important parameters

The timeliness of the detection is certainly an important parameter; it will be considered as satisfactory if it occurs within one or two hours; 6 hours is certainly too slow.

Quite clearly, the cost of false alarms is quite important. The easiest way to reduce it is to group the sensors by 2; grouping by 4 (as some participants did) seems to be an excessive precaution.

V. The approach we suggest

The general approach we would suggest is as follows:

First, put 20 sensors in the same pixel as the nuclear plants; these sensors do not need to be doubled, since the plants have other means of surveillance, as the text indicates.

Second, put enough sensors (by groups of 2) on the Eastern border. Since the probability of a cloud from the East is ten times larger than the probability of a terrorist attack, we might decide for instance to put 10 times more sensors on the border than in the inside. But the probability of a terrorist attack, using a "dirty bomb", is very empirical, because we never saw such a thing on the French territory. So let us take a ratio of 5 to 1, which is high enough. Let us say for instance that we put 150 sensors on the border, then 30 remain for the inside (in the case of a 200 sensors network). We would put these 150 sensors at equally spaced places, by groups of 2, on the border.

Then, for the remaining 30 sensors, we put them inside the territory, by groups of 2. The aim is here to minimize the distance to a sensor. Each point of the territory should be as close as possible to one of the sensors (taking into account, of course, those which are near the nuclear plants and those which are on the border).

All participants find that the final benefit is negative: the network costs a lot of money, no matter how costs are computed, brings a lot of trouble, and does not work well in practice. From our contracts with IRSN about the Teleray network, we showed that it is almost impossible in practice to maintain a network which, on a permanent basis, sees nothing. Such a network will need constant maintenance, in the unlikely event that it is needed some day.

VI. Our suggestion for the network

So, our suggestion to IRSN was: let us build a much smaller network, consisting in sensors which are much more robust, and, if something is detected, we will send mobile units in order to confirm the detection and make it more precise. This recommendation is based upon what is done for fires. There is no such thing as a permanent network, all over the French territory, in order to fight against fires ; there are detection means, and, if some fire is detected, mobile units are sent (the firemen brigades).

But, in fact, permanent sensors near the nuclear plants already exist and are permanently monitored for proper work. Permanent sensors on any border do not need to be installed, because if any accident in a nuclear plant abroad occurs, it will be detected immediately, as previous situations showed. So, in a case of a radioactive cloud, only mobile units are needed.