

# Research report for the STSM of Patrick Maillé

## Host: FTW Vienna, Austria (Peter Reichl)

Following the previous STSMs to FTW:

- of Patrick Maillé in December 2008, devoted to discussions with security specialists and elaboration of a state-of-the-art document,
- and of Bruno Tuffin (INRIA, France) in early 2010, igniting the mathematical modeling of a non-cooperative game among security providers,

the present STSM has been devoted to joint research on security issues in telecommunication networks using the framework and tools of non-cooperative game theory.

We based our work on the preliminary models that had been defined during Bruno Tuffin's STSM, where users are assumed to selfishly choose the cheapest security provider in terms of a price-performance tradeoff that encompasses the fact that more popular systems attract more attackers. Under that framework, a pricing competition game among providers had been defined.

In this STSM, we went further in the modeling of demand, by introducing heterogeneity among users. Users are now assumed to differ in terms of their *valuation*, that represents the value they associate to the protection of their data, or in other terms, the price they are willing to pay to prevent their data from being stolen or damaged. We therefore assume that the valuations among users are given by some distribution over the set of positive real numbers.

Under that framework, the counterpart of the "more popular systems attract more attackers" assumption now includes the value of the data protected by some security system, and can therefore be formulated as "systems protecting more valuable data attract more attackers".

A general model for that 2-level (provider and customer level) interaction has been defined during the STSM, and we began studying it mathematically.

- The lower level consists in customers playing a non-cooperative game when choosing their security provider. Here the externalities that appear are negative: when choosing a provider, a customer adds his own valuation to the total value of the data protected by that provider, thus increasing the attractiveness of the system, and decreasing the interest of the provider. Using tools from Game Theory, we managed to prove some existence and uniqueness results for a Nash equilibrium of that game, under some general assumptions.
- The upper level of the game is the competition played on prices that should take as an input the user equilibrium described above. The mathematical analysis of the user equilibrium has not yielded a closed-form expression of that equilibrium, and we did not manage so far to obtain very general results for that upper level game among providers. For that reason, we will continue the work on that model through some specific examples, assuming some particular forms of the user valuation distribution. We expect to be able to derive some analytical results; otherwise we might have to go to numerical analysis to get some insights about the influence of competition in the network security market.

That ongoing work is jointly carried out by the three researchers Bruno Tuffin, Peter Reichl and Patrick Maillé.