Mathematical modeling of pricing schemes under competition, and network security economics

Current and planned specific research interests

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In general

Current: Competition among providers

Inter-domain issues: pricing evolution and resources planning

Network security economics

Quality of Experience and Pricing

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General interests

- All aspects of network economics that deal with
  - mathematical modelling
  - performance evaluation
  - game theory
- For instance, currently working on a simple model with refund when QoS is not met.

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Current: Competition among providers

- Additionally to designing (mathematical) pricing schemes for specific network technologies,
- We currently have an activity on the impact of competition among providers on those schemes.
- Even if efficient for a monopoly, how do they behave in case of an oligopoly (direct competition for customers)?
- This induces an upper-level of non-cooperative game. Is there a Nash equilibrium? Is it unique?
- Initial model: the one presented in Sevilla:
  - I providers in competition at an access point; for provider i
    - Own capacity C_i, per-packet (or per-unit) price p_i (received or not).
    - total demand d_i, each packet served with probability $\min(C_i/d_i, 1)$.
  - Customer repartition following Wardrop's principle
  - Price war for providers: there exists a unique Nash equilibrium.

Competition among providers: perspectives

We want to look at the following extensions to our model, but it could be applied to other competition models as well (which ones to be discussed).

- What happens if providers partially share demand?
  - We currently have an answer: if a small provider has a coverage area included in the bigger provider (ex: wifi against wimax). Unique Nash equilibrium, but two situations possible!
  - Another modeling situation (MVNOs...) could be imagined.
- What happens if providers partially share their capacities? Typical case: wifi.
- What if providers can also play on capacities along with prices? Or before playing with prices?
- What about the multiclass case?
- What about the dynamics of the model? How to drive to the equilibrium?

Inter-domain issues

- PhD thesis will likely start in collaboration with Alcatel-Lucent.
- Here not a direct competition for customers, but providers have to pay other domains for forarding their traffic and ensure end-to-end delivery (similar problems arise in ad hoc networks).
- We want to focus on optimal strategies of operators, in order to propose the best investments, in terms of:
  1. Investment on capacity : bandwidth for a domain or mobile network...
  2. Investment on products : new services.
  3. Investment on technology : new link between two domains, new base station, new WiFi hotspot...
- The idea is to combine game theory, simulation, optimisation, optimal control, etc., to study the profit expectation and equilibrium situations.
- Each operator can play simultaneously with resources and prices, or in two steps.

Network security economics

- Network security: actors with conflicting interests. Game theory appears as an appropriate set of tools to study the interactions among those actors.
- Goal: to propose tools taking into account the interactions of agents.
- Possible games:
  - To determine the equilibrium situations characterizing the optimal strategies of networks attacks and defences. Then investigating the parameters allowing to better control that equilibrium.
  - Game between the service provider and users when, given the likelihood of attacks, each one is trying to miximize his own utility, represented by the revenue minus financial cost for providing security measures for the provider, while each user tries to minimize the the infection risk plus the service cost.
  - Impact of previous items on worms' spreading in the network could be investigated. This can de realized via epidemiologic models.

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Quality of Experience (QoE) and Pricing

- Utility function in pricing models (representing valuation for the provided service) often chosen arbitrarily.
- QoE represents very well in practice users' perception of quality
  - Ex: PSQA (Pseudo-Random Quality Assessment) makes use of Random Neural Networks
- A challenge: to use it in pricing models

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