Economic Incentives to Increase Security in the Internet: the Case for Insurance

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Bot Networks

- What are botnets used for?
- Access your online banking information
- Route illegal activities through your computer so that it looks like it is coming from you
- Store illegal files on your computer systems
- Send vast amounts of spam to other users
- See what you are doing on your computer
- Attack other computer systems in conjunction with other compromised systems...
Symantec Internet Security Threat Report

Symantec observed: an average of 61,940 active bot-infected computers per day (...) and 5,060,187 distinct bot-infected computers (over a period of one semester).
(1) Epidemic Model

- Bot herder directly infects agents $N$ with probability $p$.
- Each neighbor is contaminated with a probability of contagion depending on its state.
(1) Economic Model for the agents

• Each agent faces a potential loss $\ell$.
• Investment in security has a fixed cost $c$ and reduces the probability of loss.
• Binary choice:
  – in state N, the probability of loss is $p^N$.
  – in state S, the probability of loss is $p^S < p^N$.
• Optimal strategy is S if
  $$ p^S u[w - \ell - c] + (1 - p^S)u[w - c] > p^N u[w - \ell] + (1 - p^N)u[w] $$
(1) Solving a market failure?

- Epidemic risk model allows to compute price of anarchy: agents under-invest in all cases!
  Free rider problem and/or Critical mass problem.
  Varian (02), Kunreuther & Heal (03), L & B (08)
- Designing incentives for user behavior.
- Internalizing network externalities through cyber-insurance?
(2) A framework to study insurance

- **Principal-Agent Model**: the Principal (Insurer) proposes the contract and the Agent just has to accept or reject the contract.
- The Principal is **risk-neutral** (can diversify the risks) and the Agent exhibits **risk-aversion**.
- An **insurance contract** is a couple of a premium and a benefit: insurer offers a contract \((p[S], b[S])\) to agents in state S and \((p[S]+x, b[S]-y)\) to agents in state N.
(2) Example: Full coverage

Utility

\[ w - \ell \quad \text{to} \quad w \]

Wealth

\[ \pi \quad \text{to} \quad pl \]
(2) Optimal risk sharing under asymmetric information

- **Asymmetric information**: adverse selection and moral hazard.
- If the insurer observes the level of protection of the agent: optimal risk sharing requires that the insurer perfectly ensures the agent.
- If the insurer cannot observe the level of protection of the agent, trade-off between risk sharing and incentives.
(3) Analysis of two cases

(i) No moral hazard and full coverage.
   \[ b[s] = \ell - p[s]; \ x = y > 0. \]

(ii) Moral hazard and any contract.
   \[ x = y = 0. \]

Results:
- In cases (i) and (ii), insurance is not an incentive for protection (competitive insurance market or monopolistic insurer).
(3) Insurance as a good incentive

• If there is **no moral hazard**, there exists \( t \) such that in a competitive insurance market where the premium loading is forced to exceed \( t \), then insurance is an incentive to protection.

• Implementing a **tax** for individuals not investing in protection could enable an insurance market.

• If there is **no moral hazard**, a ‘social insurer’ is a good incentive.
To take away:

• Improving technical defenses is not enough! We need to find the proper economic incentives to deploy them.

• Moral hazard problem is a barrier for insurance and requires technical solutions: monitoring, estimating damages, security metrics.

• How to evolve the Internet to help insurers do a better job?