Automating Security Analysis of Off-Chain Protocols

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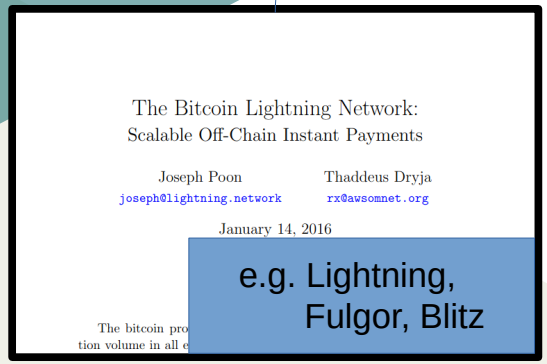
Modeling Blockchain Protocols

model


The Bitcoin Lightning Network:
Scalable Off-Chain Instant Payments

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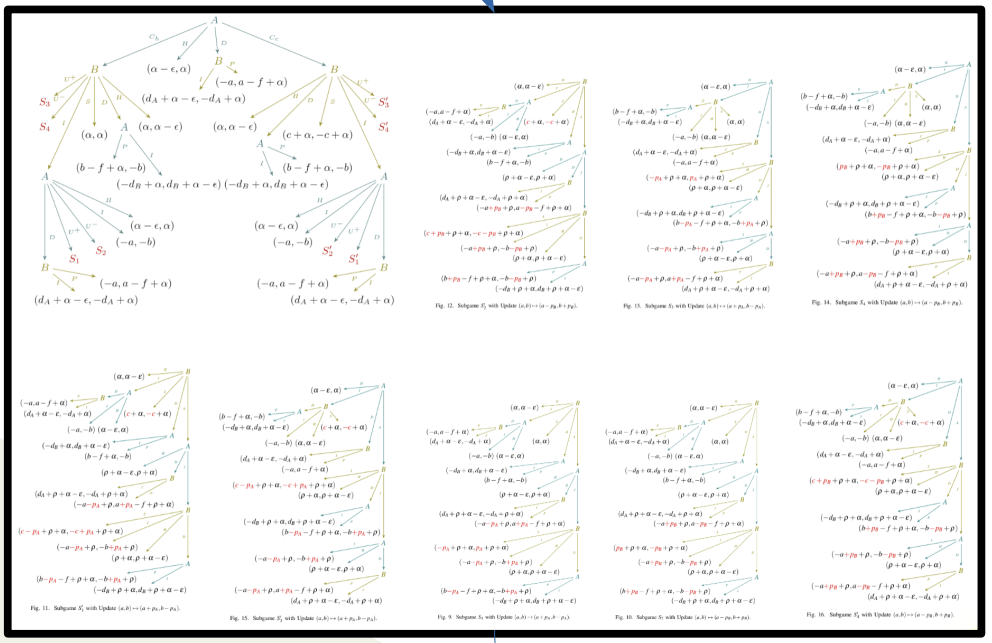
January 14, 2016

The bitcoin pro
tion volume in all e

e.g. Lightning, Fulgor, Blitz



apply

check

Towards a Game-Theoretic Security Analysis of Off-Chain Protocols

Security Properties

no profit from deviation

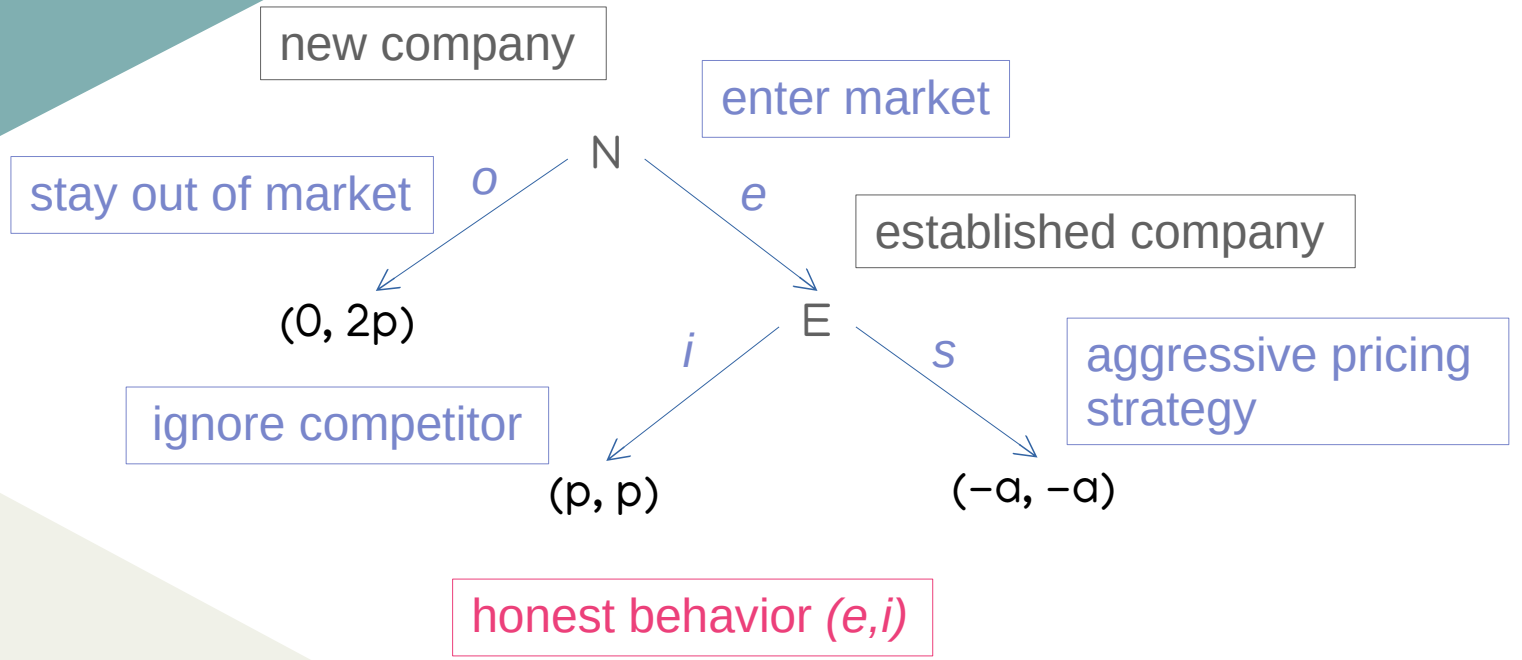
- **Collusion Resilience:** no subgroup of players profits from deviation
- **Practicality:** following protocol best choice in each step

honest users cannot be harmed (lose resources)

- **Weak Immunity:** A joint strategy σ is called *weak immune*, if every player that follows σ gets utility ≥ 0, regardless of how the other players behave.

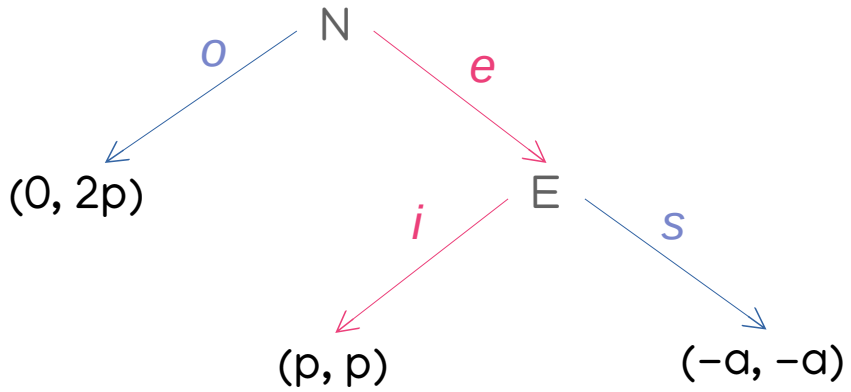
Example Game

Market Entry Game:



- a, p > 0 integers

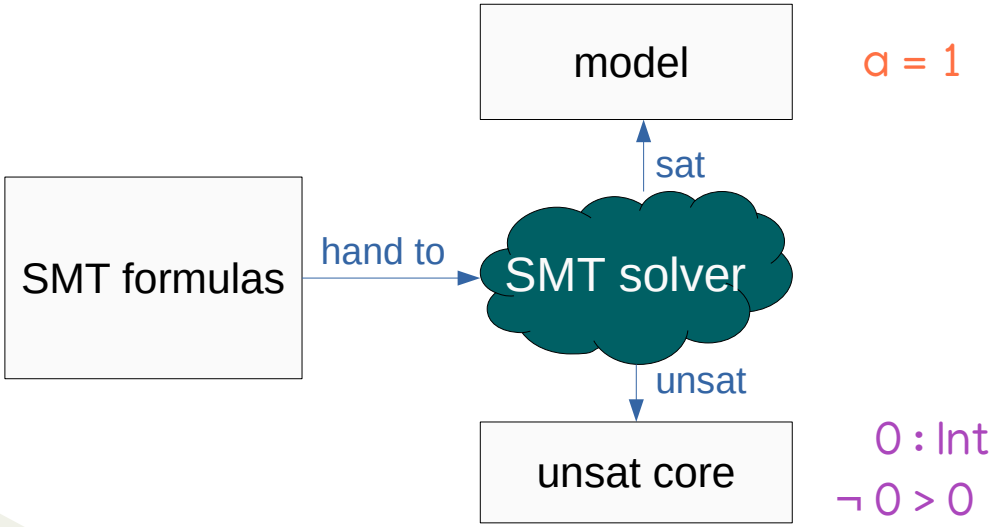
Weak Immunity of Market Entry



- Is *(e,i)* weak immune?
- Can E be harmed (lose resources)? → NO
- Can N be harmed (lose resources)? → YES

NOT weak immune, for any p, a > 0!

SMT Solving



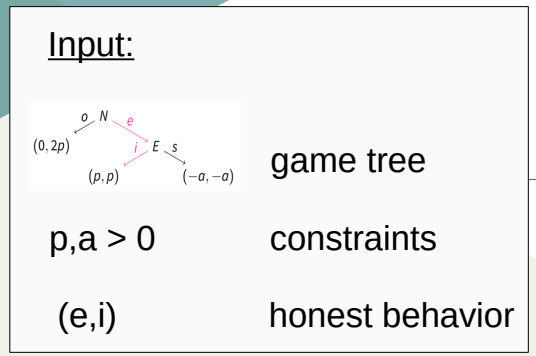
Example 1:

$$a : \mathrm{Int}$$
$$a > 0$$

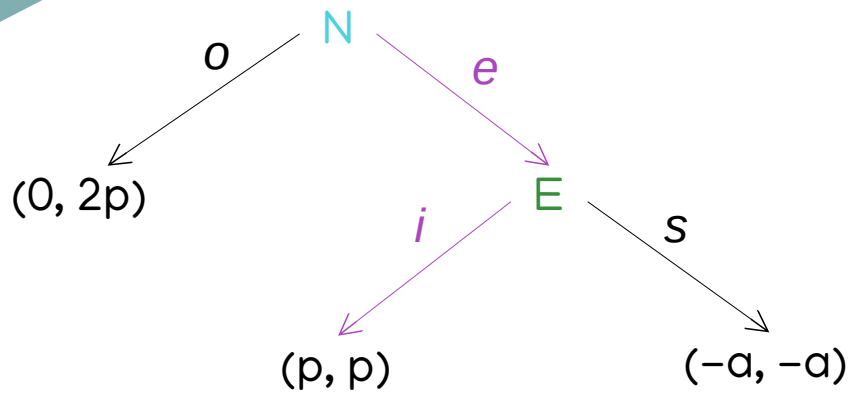
Example 2:

$$\forall\, a : \mathrm{Int} \,.\, a > 0$$

Automation Framework



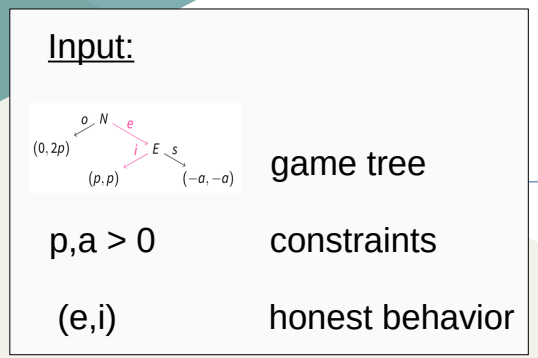
Encoding Weak Immunity



a, p > 0 integers

$$\forall\ p, a\ \texttt{Int} : (a > 0 \wedge p > 0) \rightarrow$$
$$(o \vee e) \wedge (i \vee s) \wedge$$
$$\neg(o \wedge e) \wedge \neg(i \wedge s) \wedge$$
$$e \wedge i \wedge$$
$$(o \rightarrow 0 \geq 0) \wedge (e \rightarrow p \geq 0 \wedge -a \geq 0) \wedge$$
$$(2p \geq 0) \wedge (i \rightarrow p \geq 0) \wedge (s \rightarrow -a \geq 0)$$

Take Away



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