Mechanised Models and Proofs for Distance-Bounding

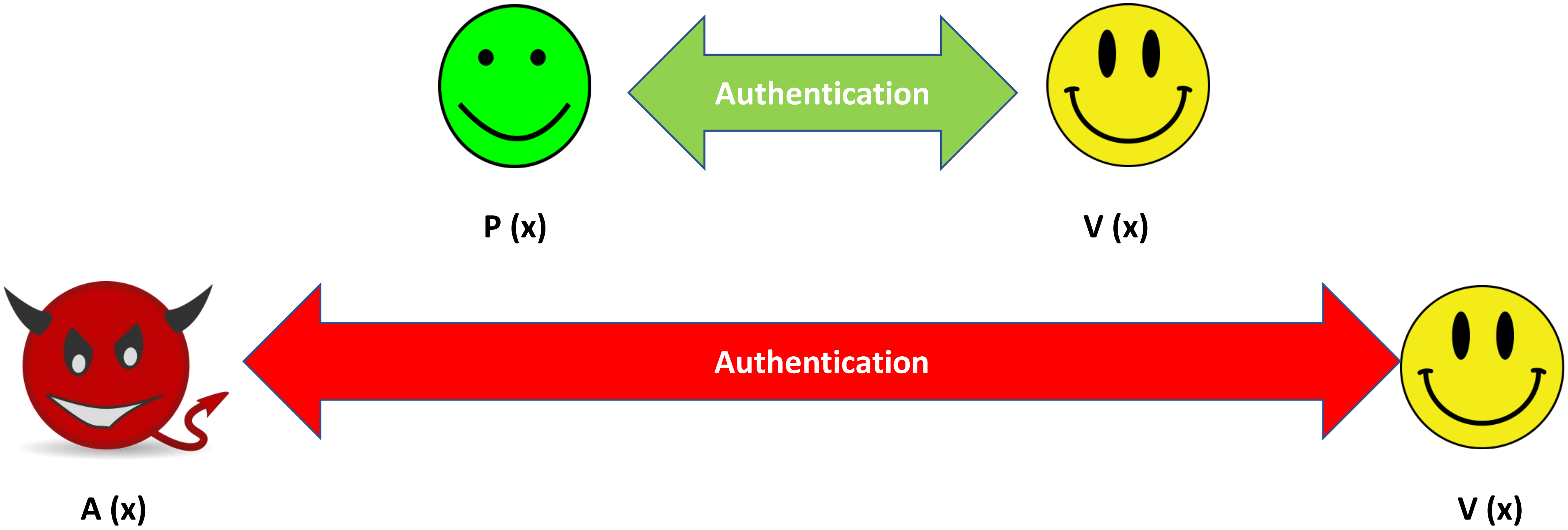
Ioana Boureanu, Catalin Dragan, François Dupressoir, **David Gerault**, Pascal Lafourcade

UNIVERSITY OF SURREY

University of BRISTOL

UCA UNIVERSITÉ Clermont Auvergne

Introduction



Authentication

P (x)

V (x)

Authentication

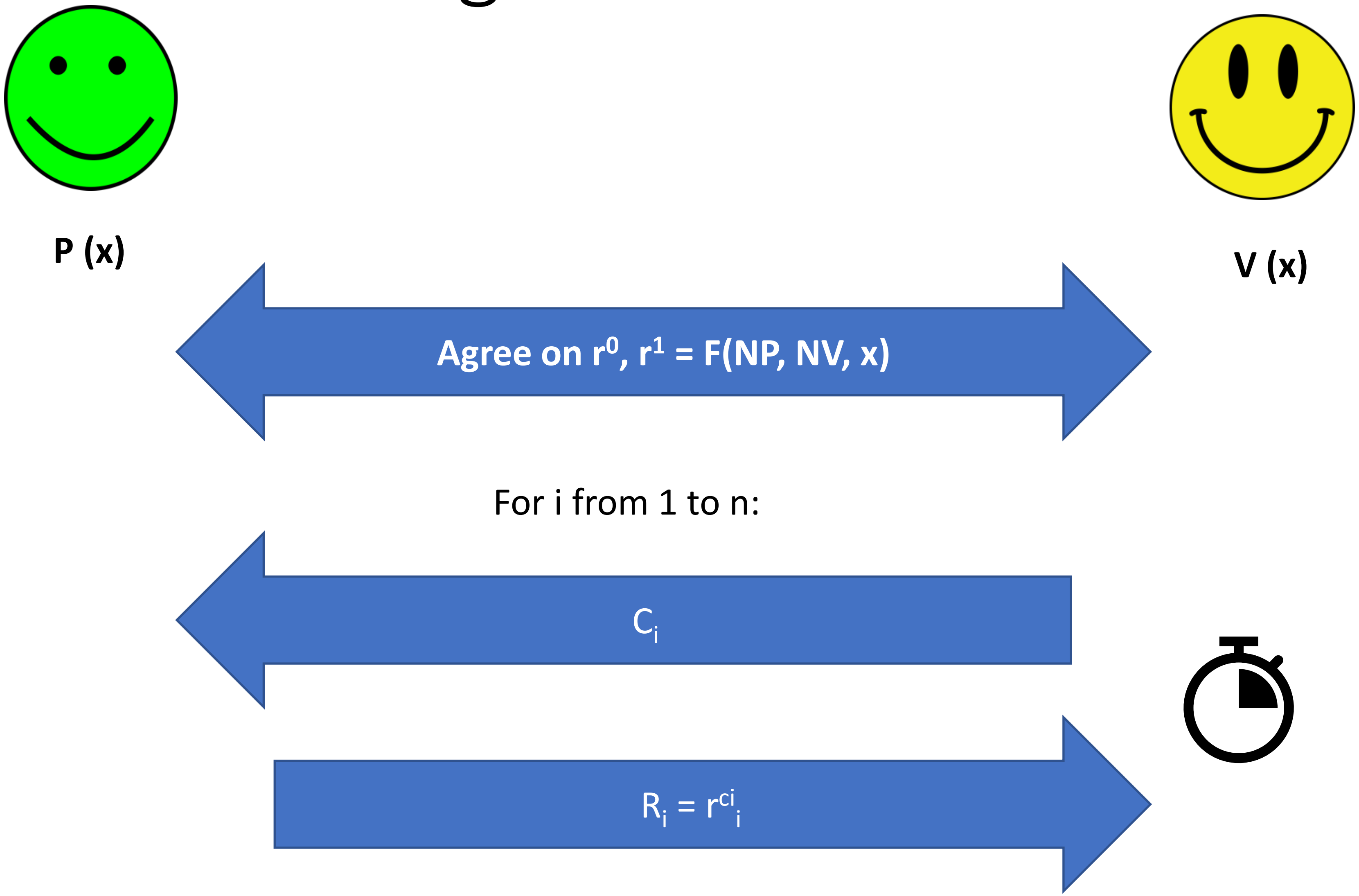
A (x)

V (x)

Questions:

- What if A knows more than one key?
- Can we model physicalities (time, distance) in a computational framework?

Distance Bounding Protocols



P (x)

V (x)

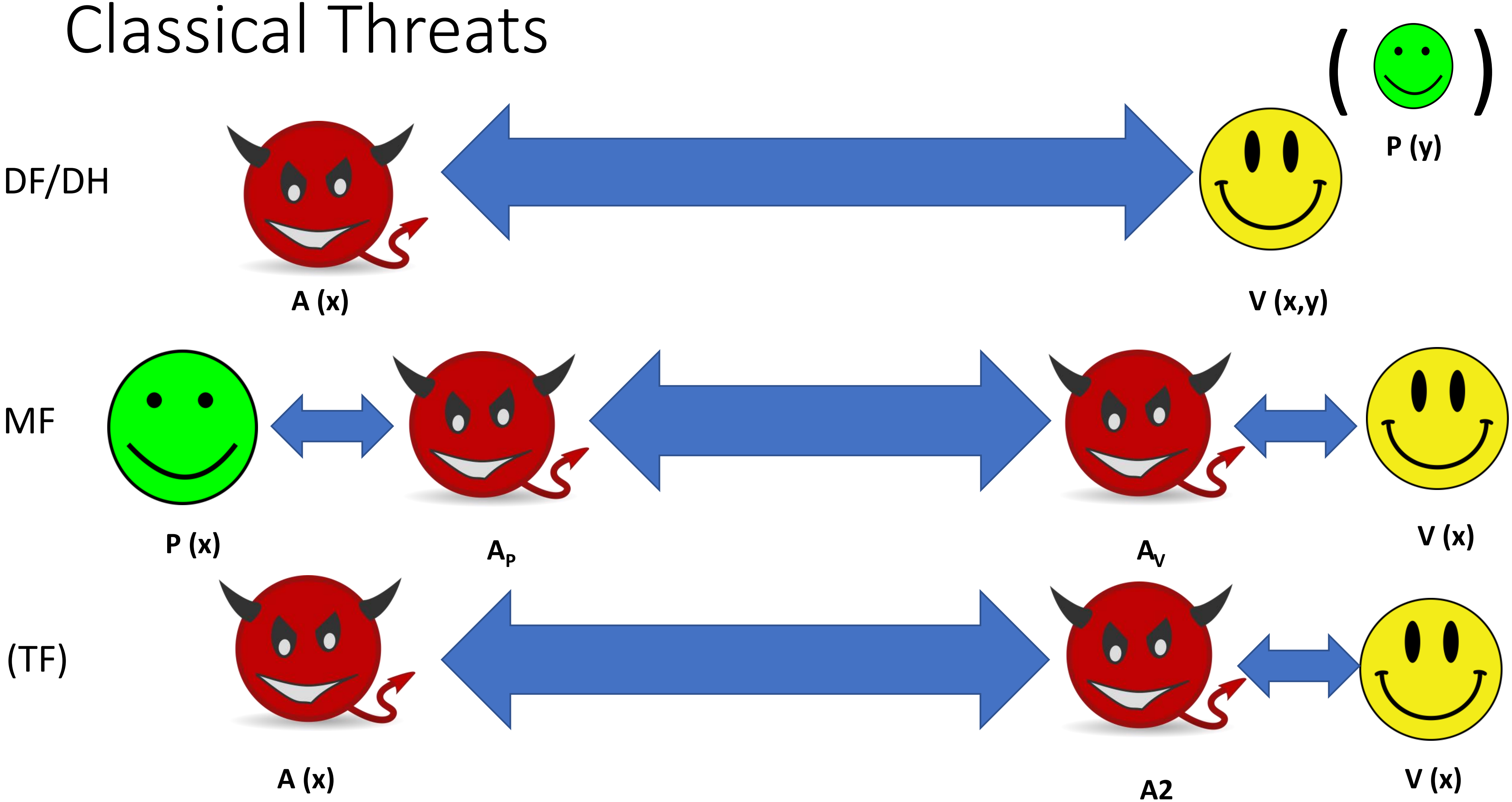
Agree on r^0, r^1 = F(NP, NV, x)

For i from 1 to n:

C_i

$R_i = r^{ci}_i$

Classical Threats



DF/DH

A (x)

V (x,y)

( )

P (y)

MF

P (x)

A_P

A_V

V (x)

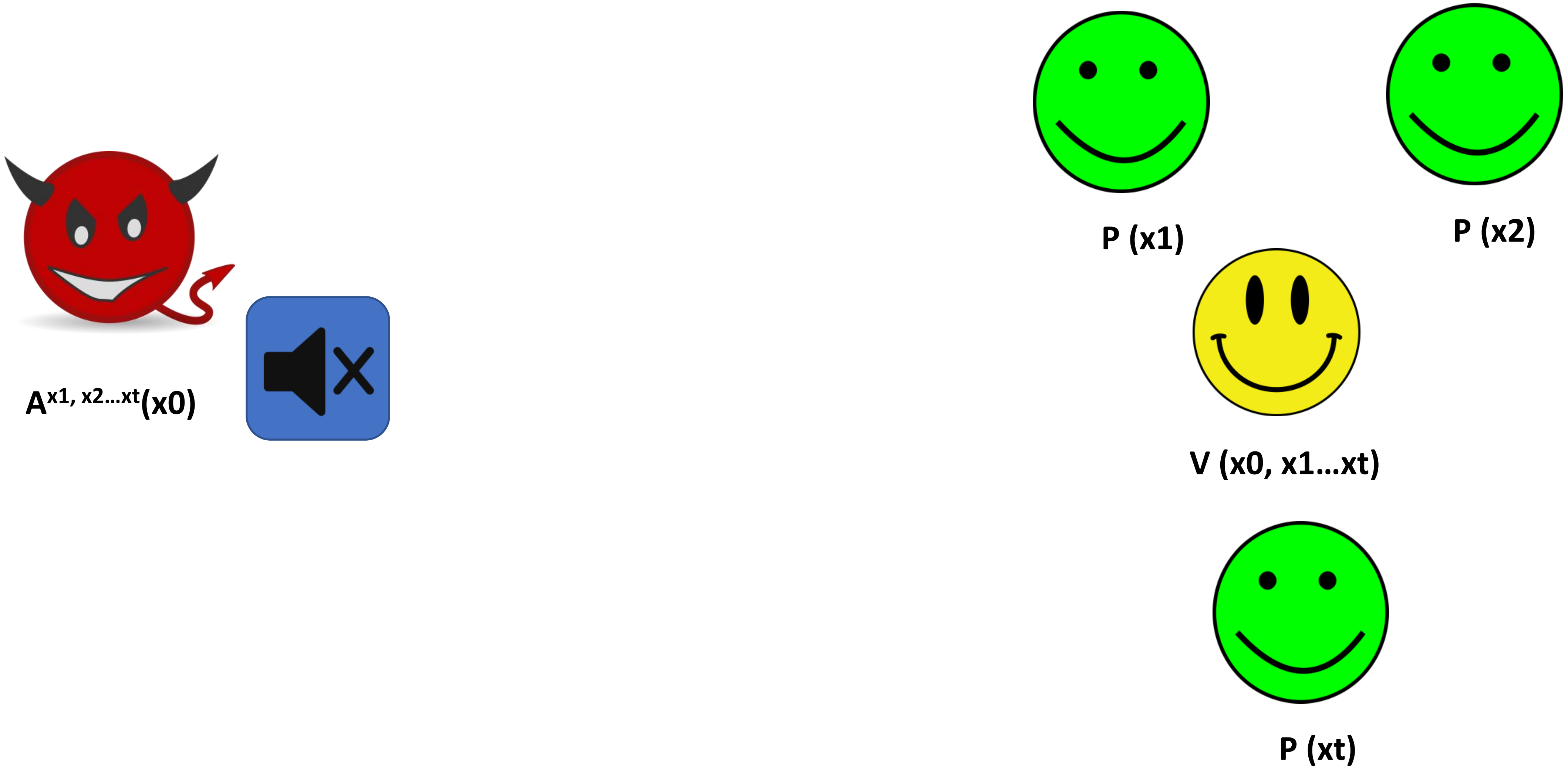
(TF)

A (x)

A2

V (x)

FlexiDB: A Motivating Example

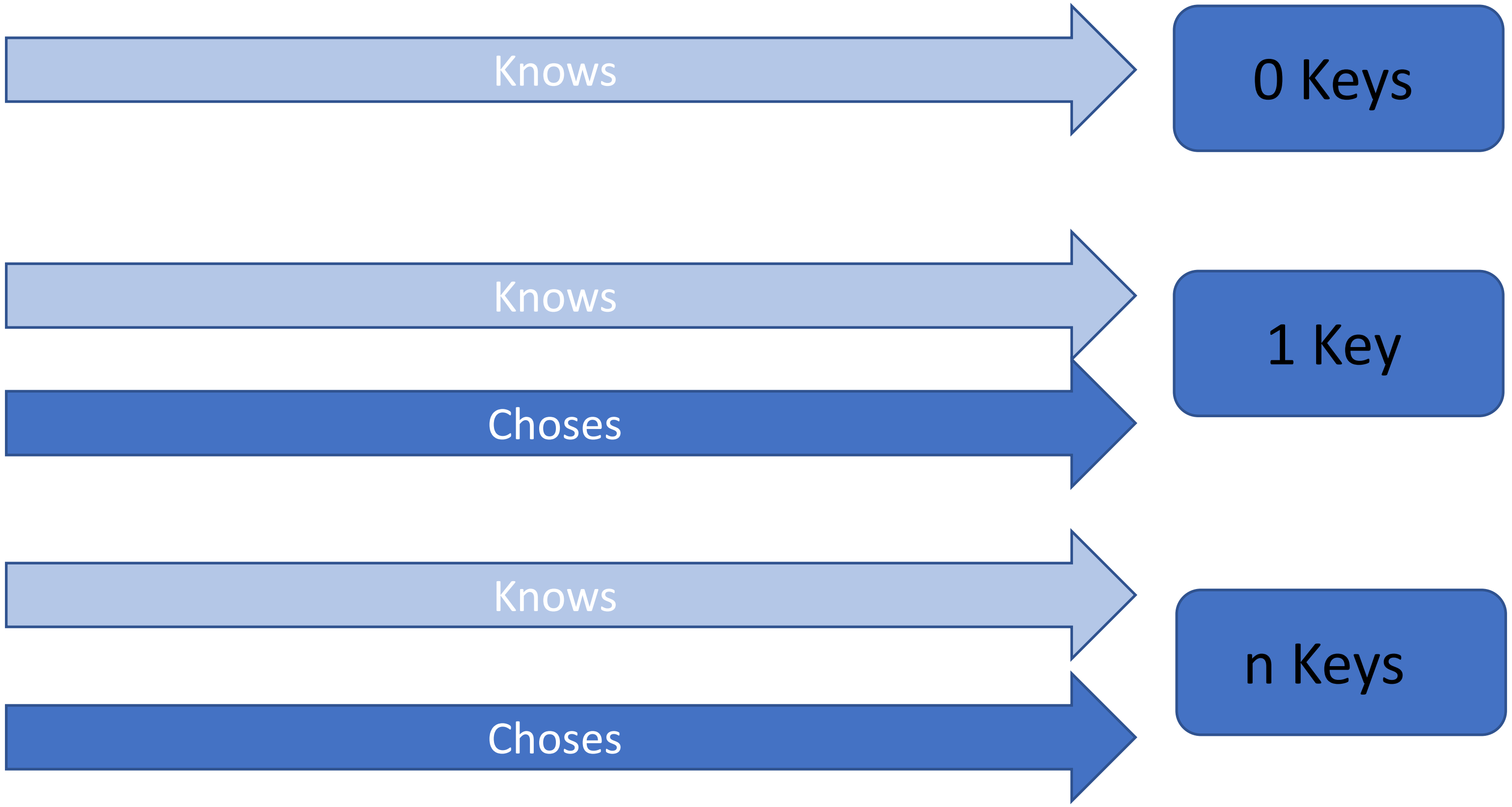


FlexiDB: Party Corruption

- Outsider

- 1-weak-Insider
- 1-strong-Insider

- n-weak-Insider
- n-strong-Insider



Knows

0 Keys

Knows

Choses

1 Key

Knows

Choses

n Keys

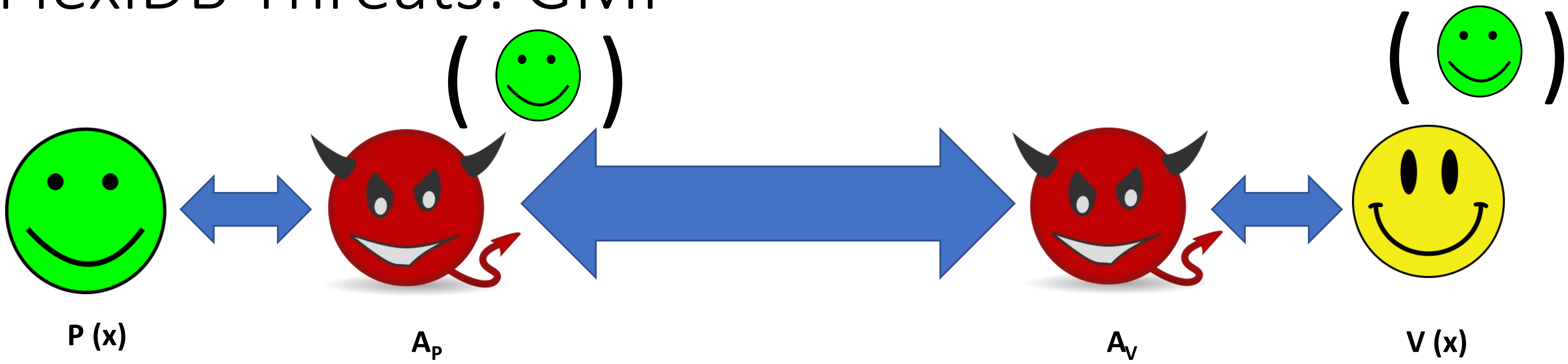
FlexiDB: Network Corruption

- Dummy
  - Send/receive within range
- Amplifier
  - Send/receive from afar
- Injector
  - Send/receive/block/overwrite within range
- Full
  - All of the above

FlexiDB: An Overview

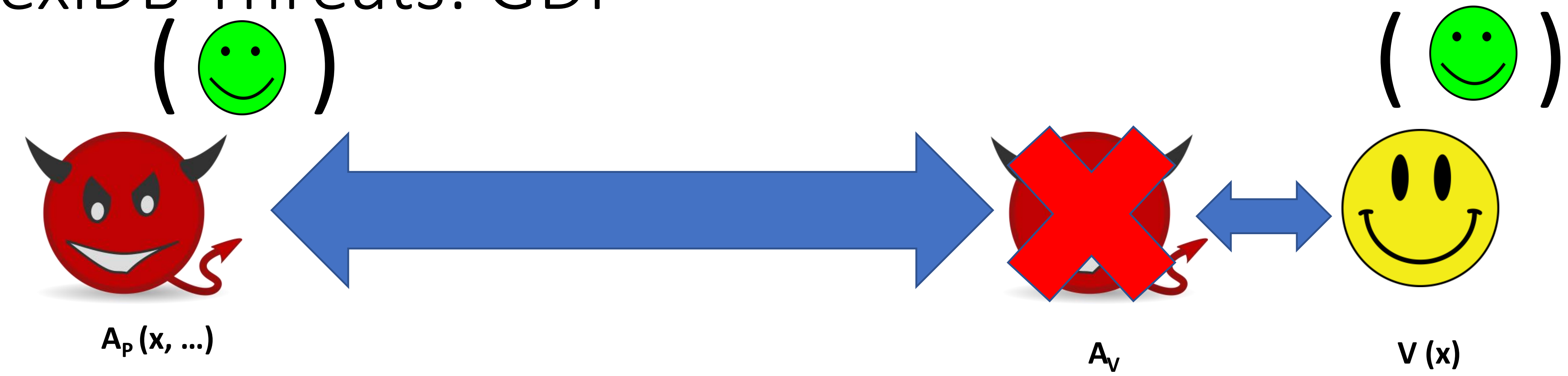
- All parties have a position in the metric space
  - Parties = provers, verifiers, 2 adversarial entities
- Adversary = $\{A_P, A_V\}$
  - Depending on the threat
  - Parametrised by channel/party corruption abilities
- A Challenger provides Oracles to A:
  - Join
  - Move
  - Replace
  - Start session

FlexiDB Threats: GMF



- Learning phase: (Loc(A_P, A_V), dP, dV) <- A
- A wins if V accepts an authentication on x
- No new attacks
    - (Except for toy protocols)

FlexiDB Threats: GDF



- Learning phase: (Loc(A_P), dP, dV) <- A
- A wins if V accepts an authentication on x
- New attacks
  - Motivating example (n-weak Insider, full)
  - PRF programming attacks (1-weak Insider, full)
  - TF-resistant protocols (1-strong Insider, amplifier)
  - EMV-RRP-V2 (1-weak Insider, full)

Easycrypt Mechanisation

- Easycrypt modules: Environment, P/V, $O^{P,V}$
- Environment with physicalities
  - Time
    - Global clock, real
    - Get_time, Add_time
  - Locations
    - Real (1d)
    - Get_locations, Set_locations
    - Distance |x-x'|
- Models a form of Outsider, full type GMF
  - Adv can only interact w/ the prover once during attack phase
  - Single prover/verifier
- Tested on EMV-RRP

Conclusion

- New model with more granularity
  - On party corruption
  - On network corruption
- New attacks
  - Maybe too strong, but interesting for future applications
- Mechanisation in EC
  - As an proof-of-concept on modeling physicalities in EC
  - Working model for EMV-RRP

Thank you!