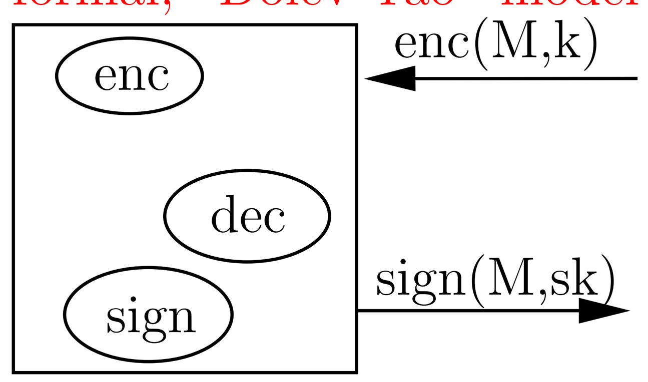
ARA SSIA FormaCrypt (2005)

Two models for the verification of cryptographic protocols:

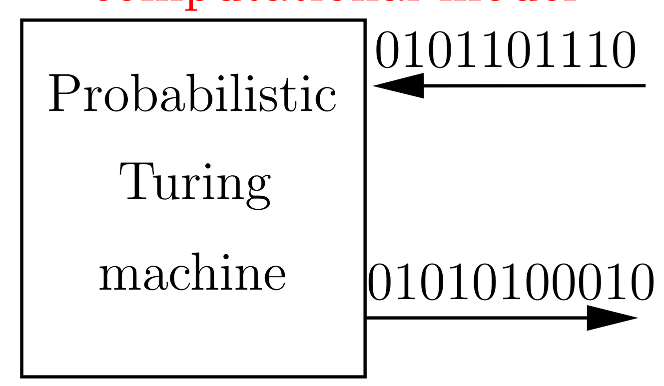
formal, "Dolev-Yao" model



abstract model; automatic proofs

Our goal:
bridge the gap between these two models

computational model



realistic model; manual proofs

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URL of the project: `http://www.di.ens.fr/~blanchet/formacrypt/`

A computationally sound prover

Goal:
Build a specialized, computationally sound, automatic prover.

Results already obtained:
An automatic, computationally sound prover that

- generates proofs by sequences of games, as in Shoup's or Bellare and Rogaway's method;
- proves secrecy and that events are executed with negligible probability;
- provides a generic treatment of cryptographic primitives, including shared- and public-key encryption, signatures, MACs, hash functions;
- is sound in the presence of an active adversary, for a parametric number of sessions;
- evaluates the probability of an attack (exact security).

The user is allowed (but does not have) to interact with the prover to make it follow a specific sequence of games.

Examples handled:

- many protocols: correct versions of Needham-Schroeder, Denning-Sacco, Otway-Rees, Yahalom, . . . protocols;
- Full Domain Hash signature scheme;
- encryption schemes of Bellare and Rogaway, CCS'93.

Publications:

B. Blanchet, IEEE S&P, Oakland, 2006
B. Blanchet and D. Pointcheval, CRYPTO, 2006.

Prover at `http://www.di.ens.fr/~blanchet/cryptoc-eng.html`

Planed extensions:

- Authentication properties.
- Other primitives, such as Diffie-Hellman key agreements.
- Improvements in the proof strategy, for more automation.

A computationally sound logic

Goal:
Design a computationally sound logic for reasoning symbolically on protocols.

Results already obtained:

- Adaptation of the Protocol Composition Logic (PCL) to the computational model.
  Soundness proof for a subset of PCL with positive tests.
- Extension to prove more complex properties, such as secrecy of keys.

This logic is compositional. For example, from the security of keys established using a key exchange protocol, one can prove the security of a secure channel application that uses these keys.

Publications:

M. Backes, A. Datta, A. Derek, J. C. Mitchell, and M. Turuani, TCS.
A. Datta, A. Derek, J. C. Mitchell, and B. Warinschi, CSFW'06.

Planed extensions:

- Soundness for any proof in PCL with computational tests.
- Make the semantics more direct and natural.

Case studies and comparison of the various approaches

Goal: Compare the results obtained by the three approaches above, on examples ranging from protocols of the literature to more complex, realistic protocols.

The modular approach

Goal:
Obtain computational soundness results, *i.e.*, show that security in the formal model implies security in the computational model.

Results already obtained:

- Computational soundness was shown for public-key encryption and signatures.
  Based on this result, we have implemented a tool that provides computational proofs of protocols, using the AVISPA formal protocol analyzer.
- We have extended computational soundness results to the case of hash functions, with a stronger notion of symbolic secrecy, decidable for a bounded number of sessions.
- For symmetric encryption, computational soundness typically requires the absence of key cycles. We have shown that this property is decidable for a bounded number of sessions.
- We have developed an equational theory for specifying cryptographic primitives, such that (symbolic) static equivalence is sound with respect to computational indistinguishability.
  This result includes the possibility for an adversary to guess low entropy values, such as passwords (guessing attacks).

Publications:

M. Abadi, M. Baudet, and B. Warinschi, FoSSaCS'06
V. Cortier and E. Zalinescu, LPAR'06
V. Cortier, H. Hördegen, and B. Warinschi, ICS'06
V. Cortier, S. Kremer, R. Küsters, and B. Warinschi, FSTTCS'06

Software at `http://www.loria.fr/~hordegen/avispa/`

Planed extensions:

- Branching properties (*e.g.*, fairness).
- Secrecy of keys.
- Primitives with more complex equational theories (Diffie-Hellman, XOR, CBC encryption).