# Which security for the Factories of the Future


**Pascal Lafourcade**

Chaire de Confiance Numérique



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# Chaire de Confiance Numérique

Research on Digital Trust of information and communication systems

- Supported by almerys and la Caisse d'Epargne d'Auvergne et du Limousin via la Fondation de l'Université d'Auvergne.
- Financially supported by la Région Auvergne

## Seminar

Free and open each month
1st Thuresday IUT Amphi B

`http://confiance-numerique.clermont-universite.fr/`

`http://webtv.u-clermont1.fr/`

# LIMOS Team "Réseaux et Protocoles"

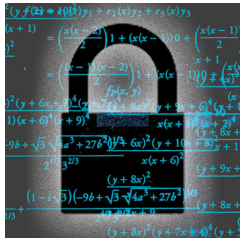
## Topics

Protocol design for Wireless LAN and Wireless Sensor Networks:

- Deterministic and low-power solutions for industrial application monitoring (EDF, AirBus ...)
- Low-power and scalable solutions for environmental applications (ClerVolc, overwater networks)
- Linear sensor networks

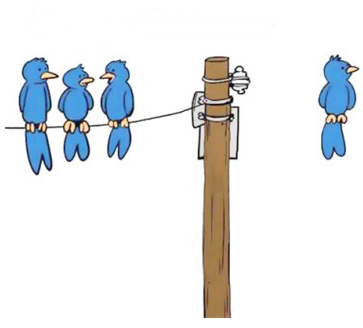
- Specification and evaluation of MAC and Routing protocols
- Simulation and prototyping, simulation toll design, Cross-layering

# My Research Topics



- Verification techniques for **cryptography**
  - Asymmetric Encryptions
  - Encryption Modes
  - Message Authentication Codes

- **Properties** for cryptographic protocols
  - e-vote, e-auction, e-exam, e-reputation ...



- **Intruder** models and algorithms for WSN
  - Neighbourhood Discovery Protocols
  - Secure Routing Algorithms
  - Key Establishments

# Factory Revolutions

## Yesterday

# Factory Revolutions

## Yesterday

Humans $\Rightarrow$ tasks
with machine

# Factory Revolutions

**Yesterday**

**Today**

Humans $\Rightarrow$ tasks
with machine

# Factory Revolutions

## Yesterday

Humans ⇒ tasks with machine

## Today

Humans control machines ⇒ tasks

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## Tomorrow

# Factory Revolutions

## Yesterday

Humans ⇒ tasks with machine

## Today

Humans control machines ⇒ tasks

## Tomorrow

Robots control machines ⇒ tasks

# Factories of the Future

- Robots control machines
- Changing the human's roles
- Designing robots is challenging

## Which kind of robots?

- Autonomous robots
- Smart robots
- Adaptative robots
- Collaborative robots

For sure the robots need to communicate!

# Security Challenges in the Factories of the Future

Data exchanged play a VITAL role !

## Properties

- Data Integrity
- Data Confidentiality
- Data Privacy
- Authentication
- Non-repudiation
- Avaibility
- Realtime constraints

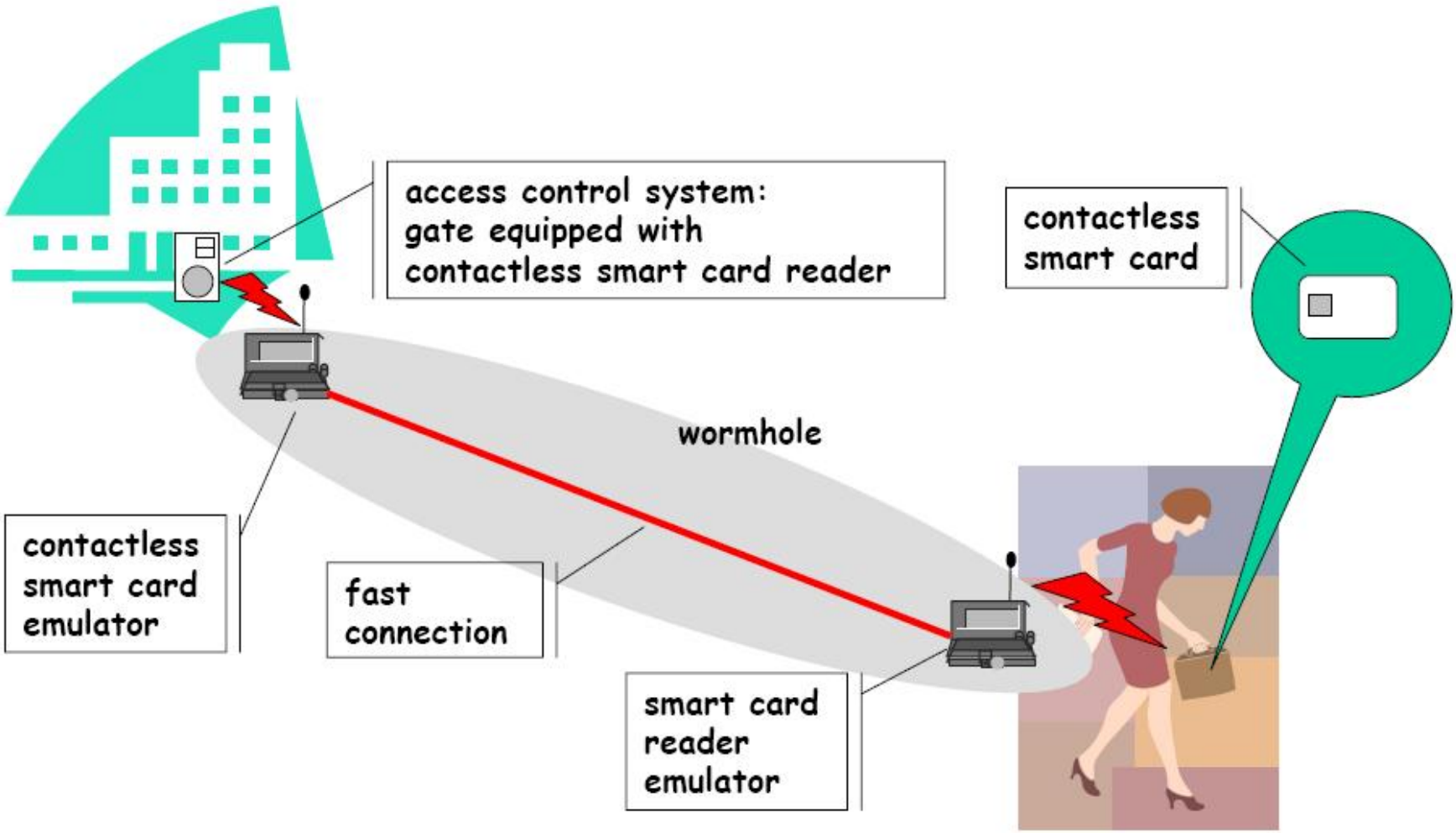

# Several Possible Attackers

- Insider vs Outsider
- Active vs Passive
- Local vs Extended
- Single vs Multiple
- Laptop vs Server



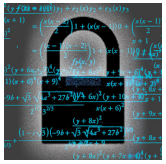



# Wormhole Attack



# What is cryptography based security?

**Cryptography:**



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- Protocols: Distributed Algorithms

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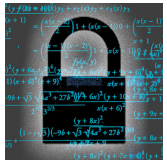

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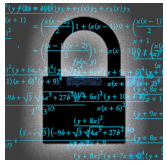

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- Passive, active
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Designing **secure** cryptographic protocols is **difficult**

# 3-pass Shamir

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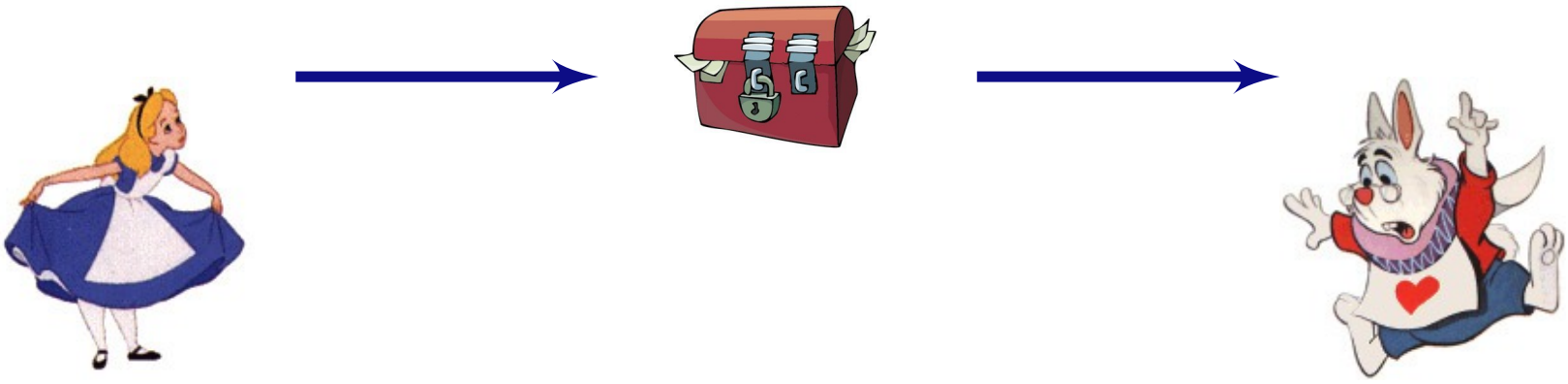

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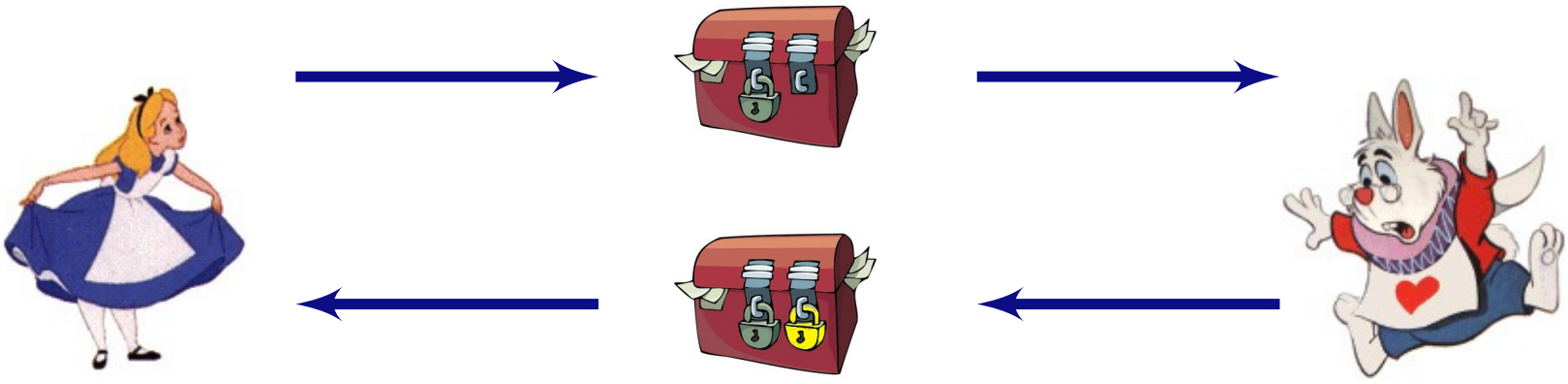

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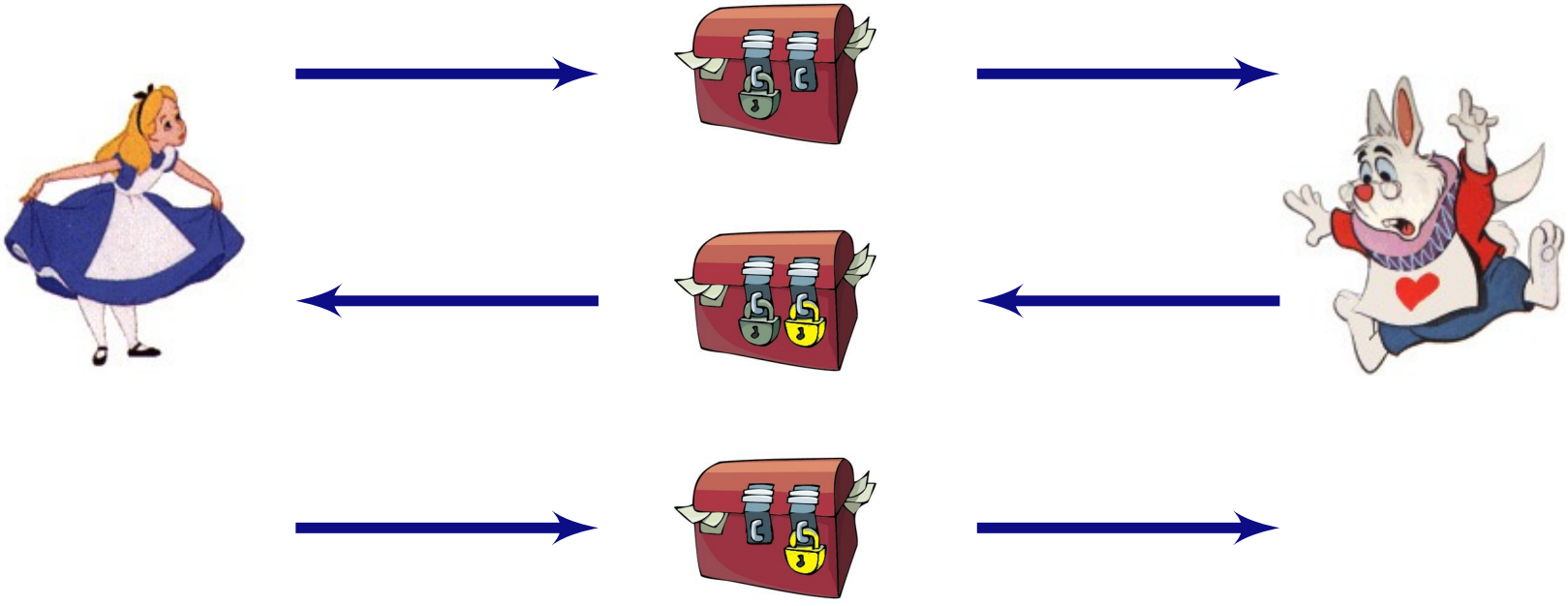

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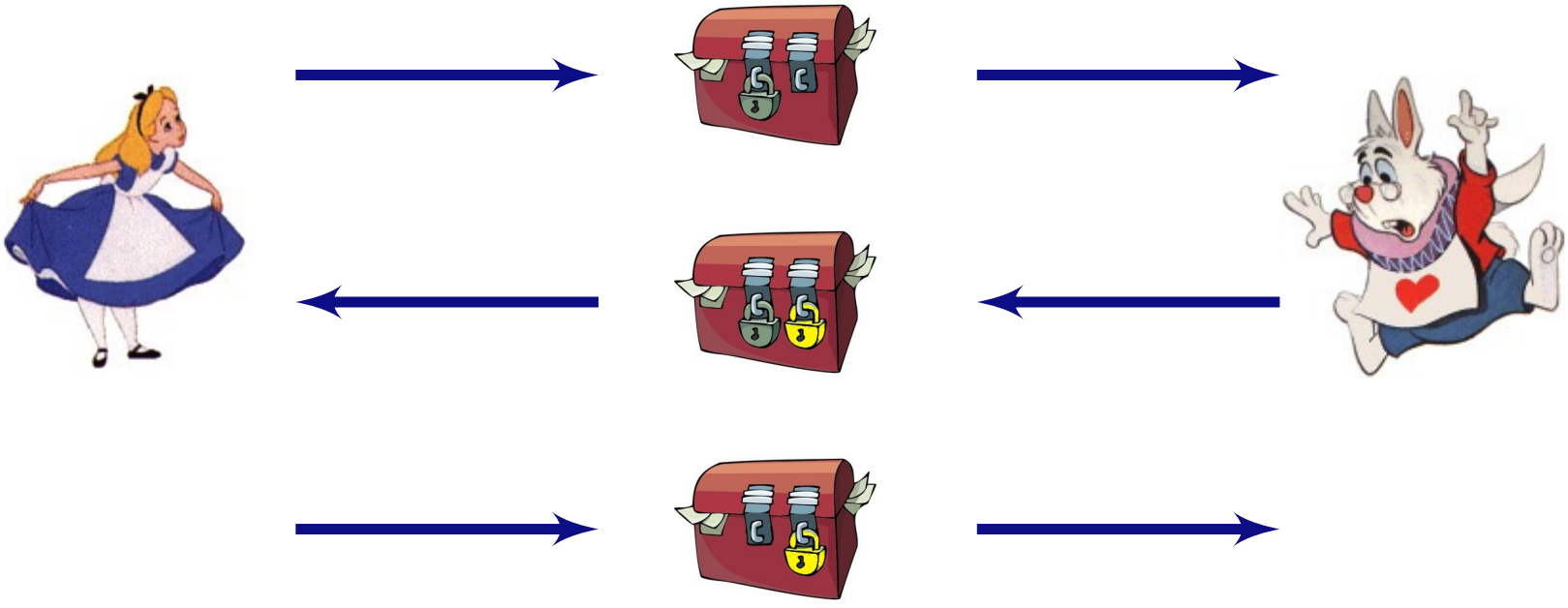

## Abstract Representation

$$1 \quad A \quad \rightarrow \quad B \quad : \quad \{m\}_{K_A}$$

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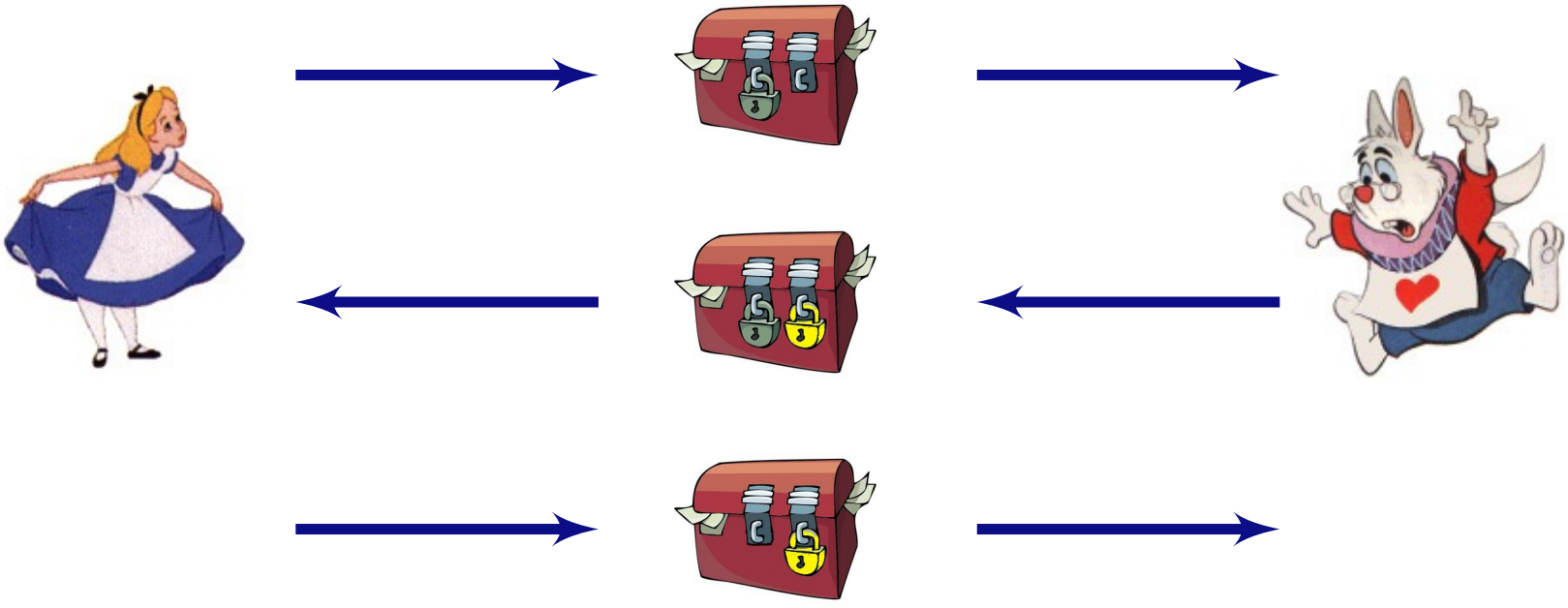

## Abstract Representation

$$\begin{array}{llcll} 1 & A & \rightarrow & B & : \{m\}_{K_A} \\ 2 & B & \rightarrow & A & : \{\{m\}_{K_A}\}_{K_B} \end{array}$$

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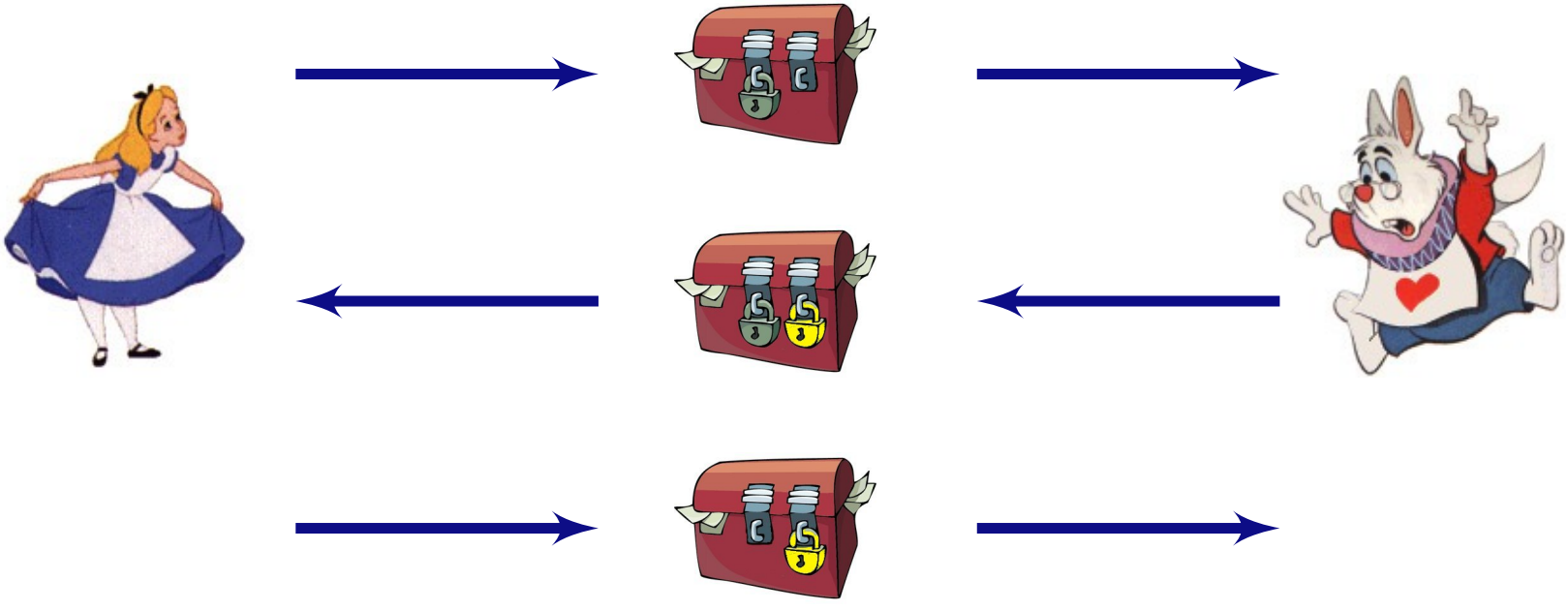

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Commutative Encryption

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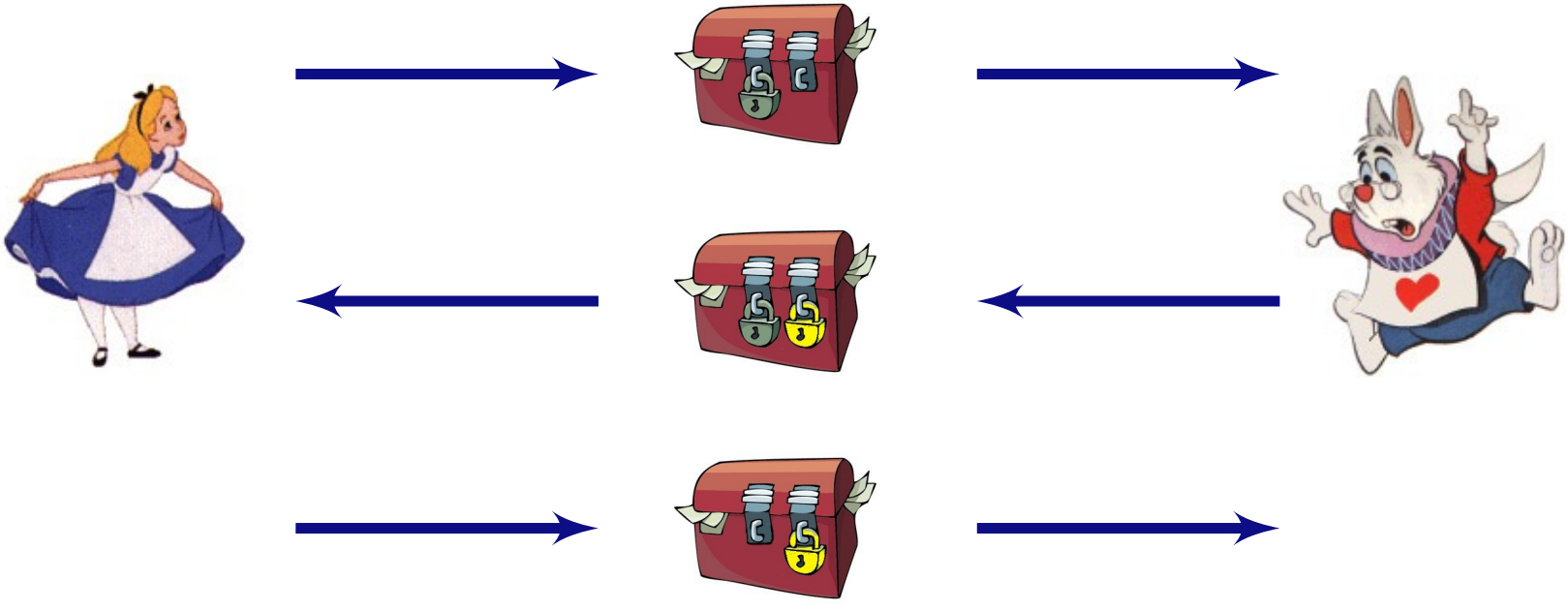

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Commutative Encryption

# Logical Attack on Shamir 3-Pass Protocol (I)

## Perfect encryption one-time pad (Vernam Encryption)

$\{m\}_k = m \oplus k$

## XOR Properties (ACUN)

- $(x \oplus y) \oplus z = x \oplus (y \oplus z)$ **A**ssociativity
- $x \oplus y = y \oplus x$ **C**ommutativity
- $x \oplus 0 = x$ **U**nity
- $x \oplus x = 0$ **N**ilpotency

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Vernam encryption is a commutative encryption :

$$\{\{m\}_{K_A}\}_{K_I} = (m \oplus K_A) \oplus K_I = (m \oplus K_I) \oplus K_A = \{\{m\}_{K_I}\}_{K_A}$$

# Logical Attack on Shamir 3-Pass Protocol (II)

## Perfect encryption one-time pad (Vernam Encryption)

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## Shamir 3-Pass Protocol

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\begin{array}{llcll}
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Passive attacker :

$m \oplus K_A \qquad m \oplus K_B \oplus K_A \qquad m \oplus K_B$

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Passive attacker :

$$m \oplus K_A \oplus m \oplus K_B \oplus K_A \oplus m \oplus K_B = m$$

# Second Example

## Needham Schroeder Key Echange 1976

$$A \rightarrow B : \{A, N_A\}_{Pub(B)}$$

$$B \rightarrow A : \{N_A, N_B\}_{Pub(A)}$$

$$A \rightarrow B : \{N_B\}_{Pub(B)}$$

- Use cryptography
- Small programs
- Distributed

# Cryptography is not sufficient !

## Example : Needham Schroeder Key Echange

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Broken 17 years after, by G. Lowe

$$A \to I : \{A, N_A\}_{Pub(I)} \qquad I \to B : \{A, N_A\}_{Pub(B)}$$
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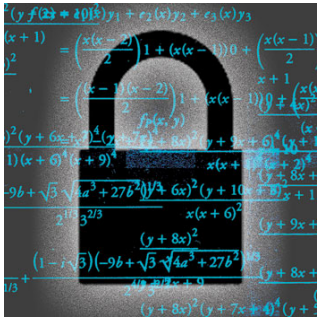
Computer-Aided Security

# Formal Verification Approaches

Designer



Attacker

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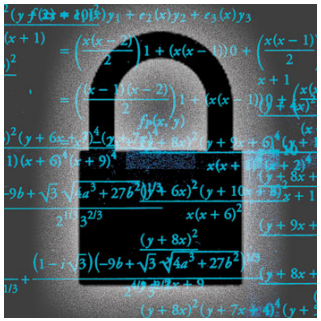

Attacker

Security Team

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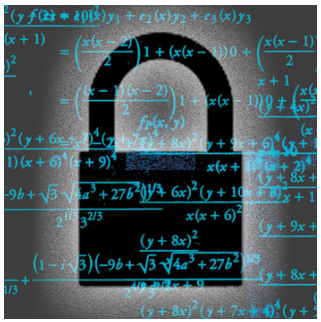

Attacker

Give a proof

Security Team

# Formal Verification Approaches

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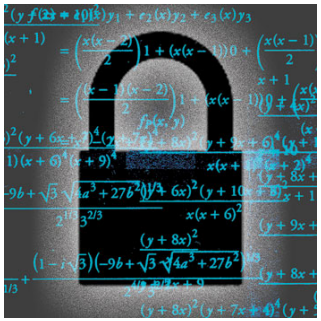

Attacker

Give a proof


Find a flaw

Security Team

# Necessity of Tools to Analyze Cryptographic Protocols

- Protocols are small recipes.
- Non trivial to design and understand.
- The number and size of new protocols.
- Out-pacing human ability to rigourously analyze them.

GOAL : A tool is finding flaws or establishing their correctness.

- completely automated,
- robust,
- expressive,
- and easily usable.

Existing Tools: AVISPA, Scyther, Proverif, Hermes, Casper/FDR, Murphi, NRL ...

# Things to bring home

Several **challenges** for the Security
of factories of the future.

- Security should be at the **conception** of the factory
- Designing secure protocols is difficult
- Formal methods are useful for designing secure protocols




*Protocol* + *Properties* + *Intruder* ⇒ *Security*

Thanks for your attention

Questions ?

Do not avoid security issues !