Bootstrapping Trust in Networked Measurement Systems with Secure Sensors

Kristján Valur Jónsson and Ýmir Vigfússon

Reykjavik University, School of Computer Science
Menntabraut 1, 101 Reykjavik, Iceland
{kristjanvj,ymir}@ru.is

February 8, 2012

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Correct and reliable sensing in networked systems

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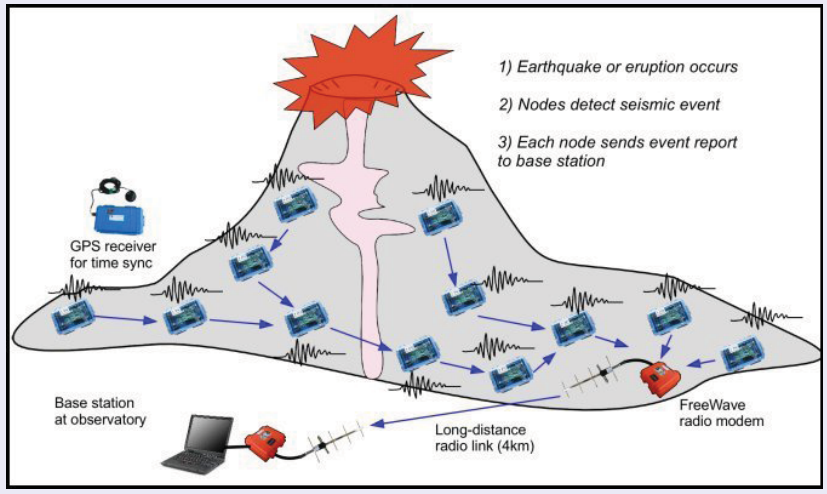
- **Dishonest world**: Some parties want to *influence* measurements.
- How do we approach this problem?

Sensing in networked systems



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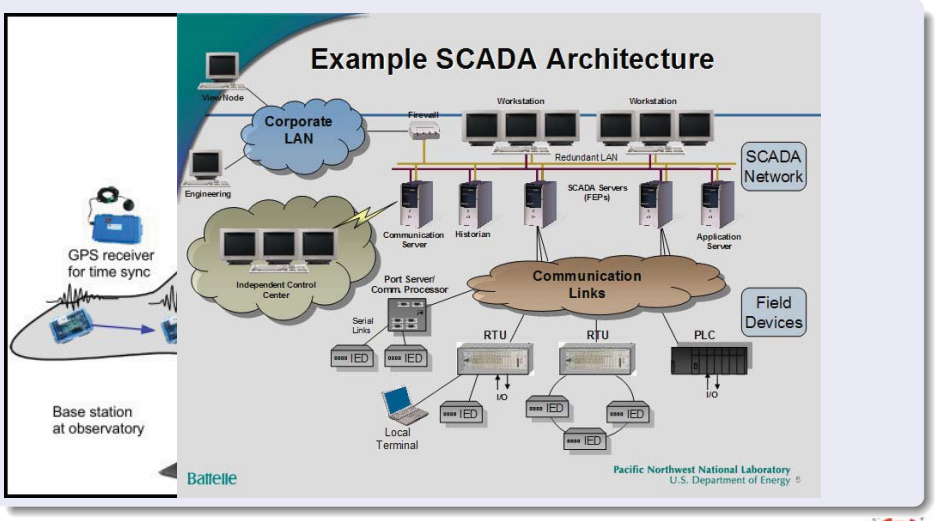

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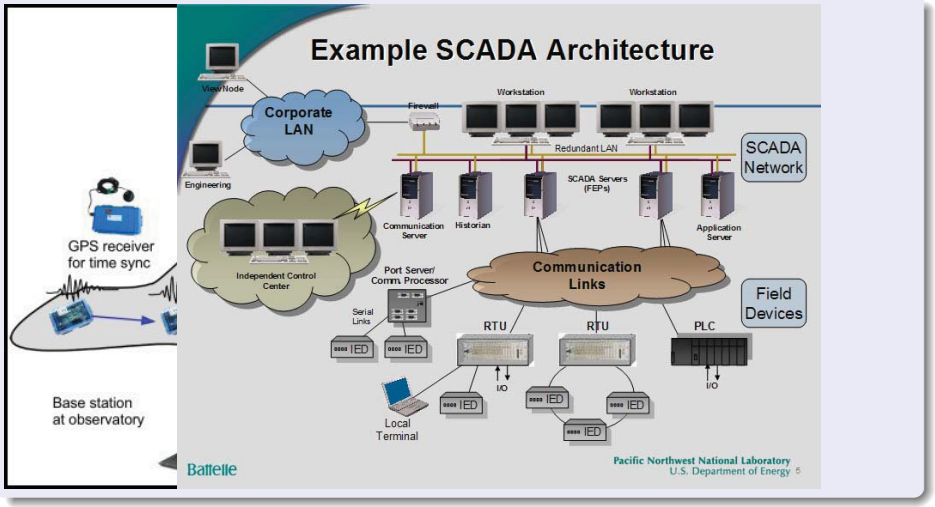

Observation node: Any networked node which carries a sensor

Security objectives and adversarial model

Objectives

- *Primary:* Sensor data **integrity**.
  - The *consumer* of the data can be confident in the *integrity* of delivered data, *even if some participants are corrupt*.

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- **Adversary**: Can corrupt *observation nodes*
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- Disregard: privacy, availability and process-of-measurement attacks

Establishing system trust

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Approaches

1. *Ostrich* – blind trust

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- *Primary product:* trustworthy data.
- *Essential functionality:* Integrity-preserving sensing

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Essential functionality

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Trusted sensor: Tool for secure sensing

Trusted sensor concept

Proposal

Model the trusted sensor on the *reference monitor* construct from classical trusted systems theory

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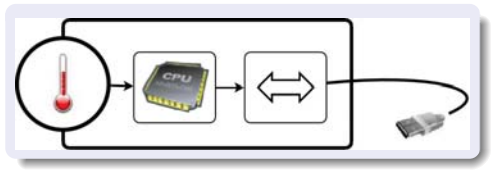
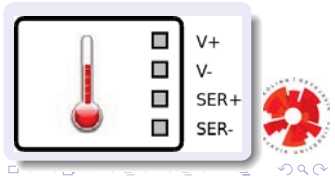
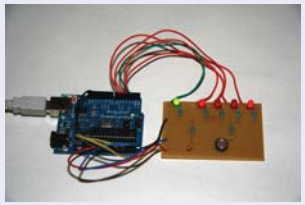




Sensor prototype implementation (2010)

Sensor



- Simple temperature and luminosity sensor
- Arduino Duemilanovae
- ATmega328 CPU

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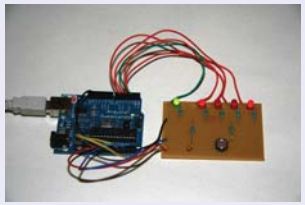

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Cryptographic primitives

1. *Encryption*: **AES-128** (Rijndael) in *CBC-mode*
2. *Message authentication*: **CMAC** (AES128-CMAC)

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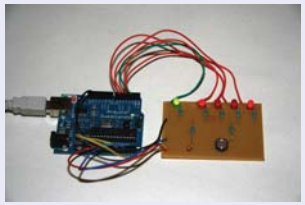

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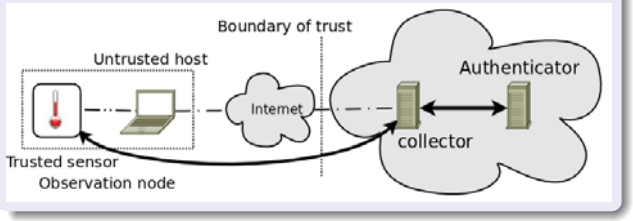
Prototype implementation – open source

- 1400 lines of C++ on ATmega328
- **TSense:** `http://code.google.com/p/tsense`
- **Crypto library:** `https://github.com/kristjanvj/ACrypto`

Prototype system

System diagram



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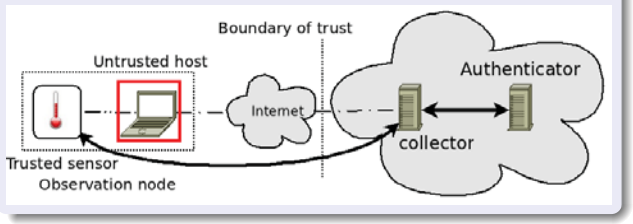

Players

- Vulnerable observation node

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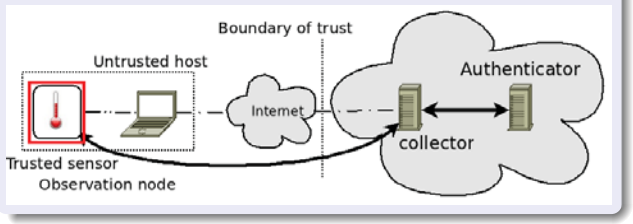

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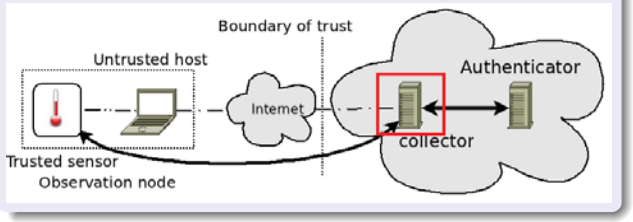

Players

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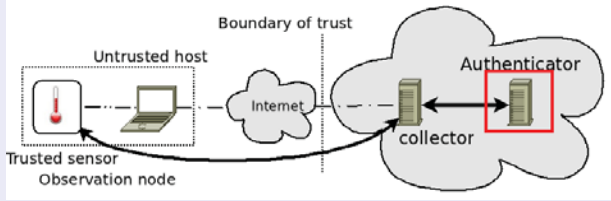

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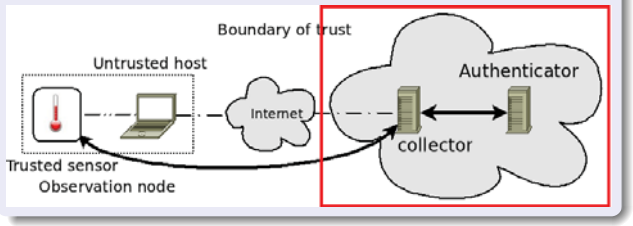

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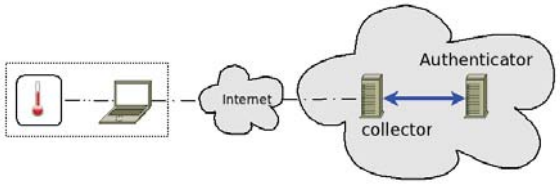

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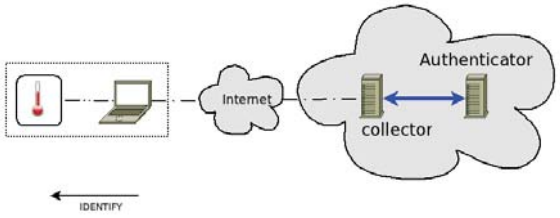

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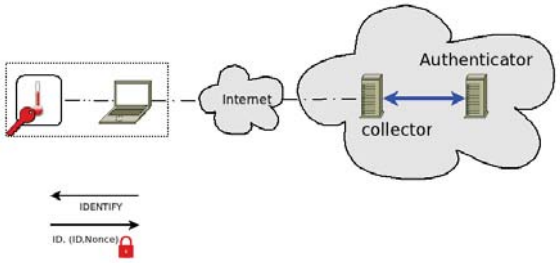

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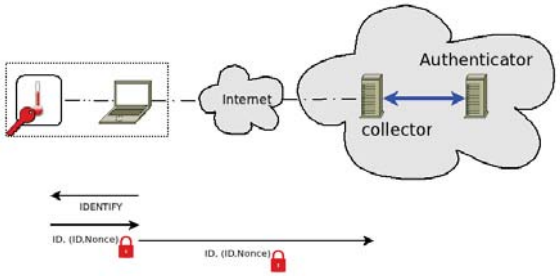

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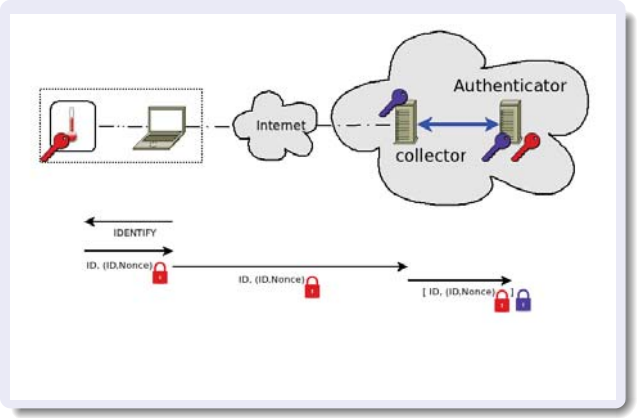

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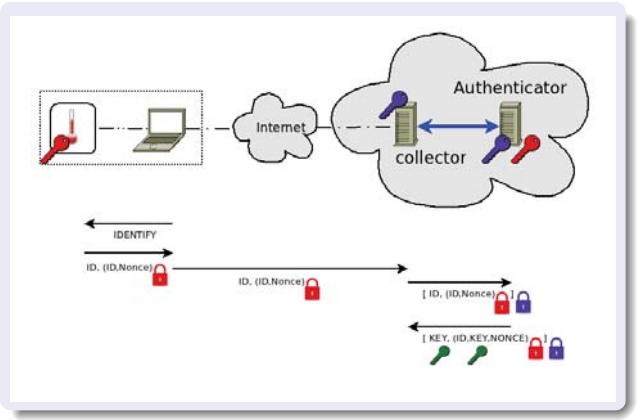

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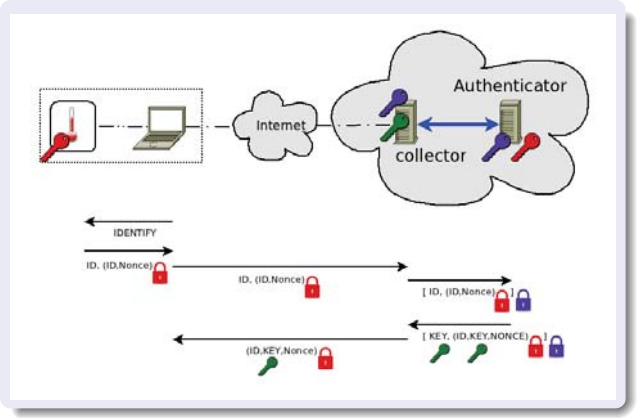

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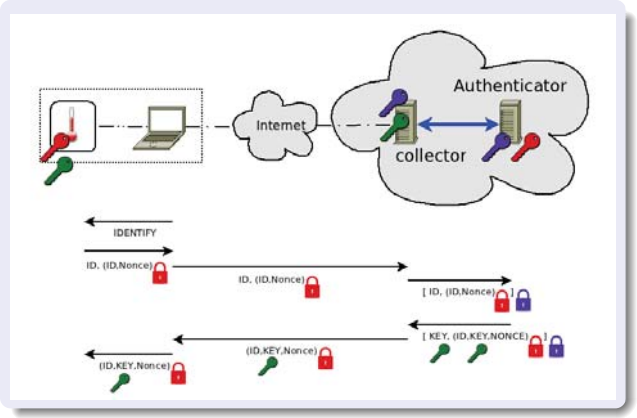

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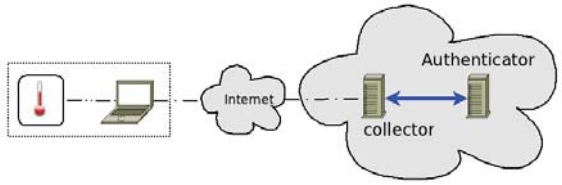

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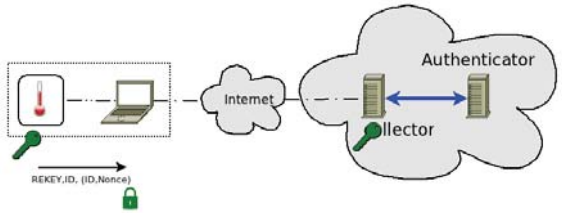

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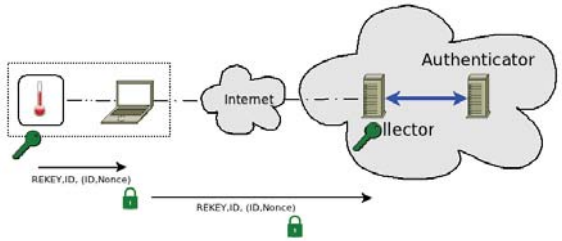

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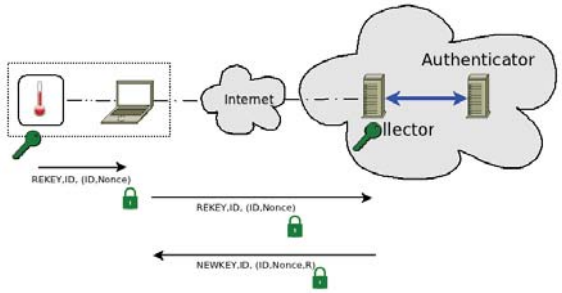

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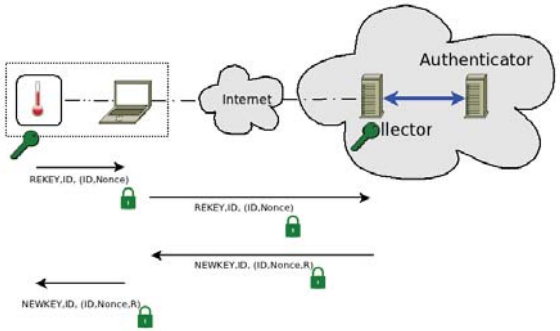

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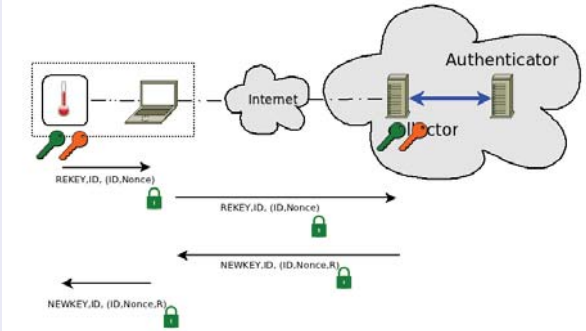

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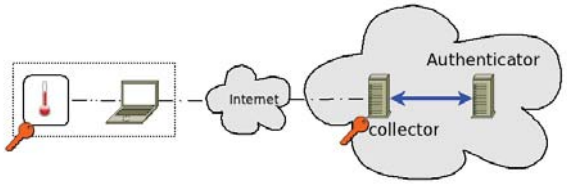
$$K_T = \text{KDF}(R)$$

Protocols III: Secure data transfer



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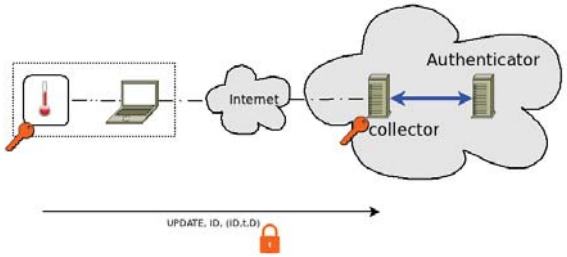

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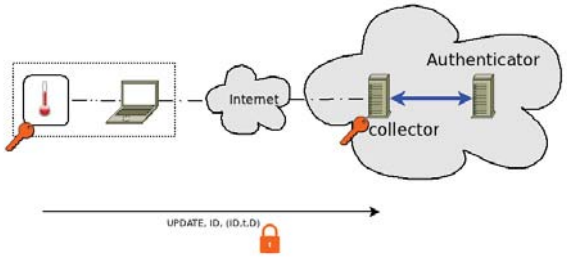

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Composition – Encrypt-then-MAC

$$C = \mathcal{E}_T(P) \quad T = \mathcal{T}_T(C) \quad \textit{keypair } K_T = (K_{Te}, K_{Tm})$$
$$m = \langle C, T \rangle$$

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gives

1. Accepted sensor is *a member of the group of trusted devices*
2. *Graceful degradation* of security in case of sensor compromise

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Definition

Two sub goals of the integrity objective

1. **Correctness:** *All data received consists of unaltered sensor observations*
2. **Completeness:** *All data produced by trusted sensors is contributed to the final aggregate*

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Overall aggregate correctness guaranteed *modulo completeness*

Conclusions

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Future work

- Miniaturization and design of a sensor device
- Tamper-resistance.
- Formal verification procedures
- Public key authentication
- Distributed aggregation