Secure upgrade of hardware security modules in bank networks*

Riccardo Focardi[1] Flaminia Luccio[1]

[1]Università Ca' Foscari di Venezia, Italy
{focardi,luccio}@dsi.unive.it

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PIN processing infrastructure

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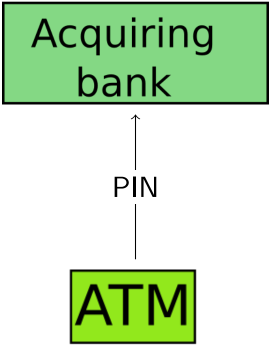

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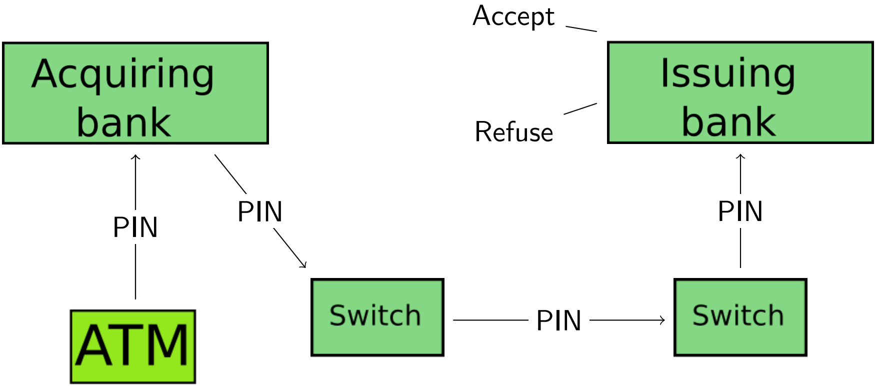

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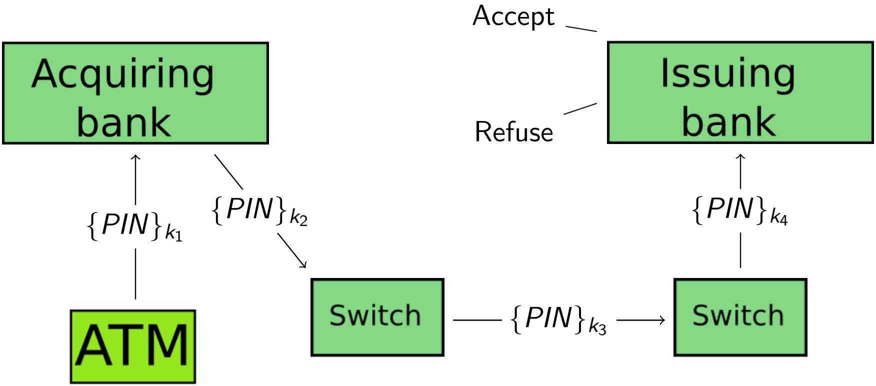

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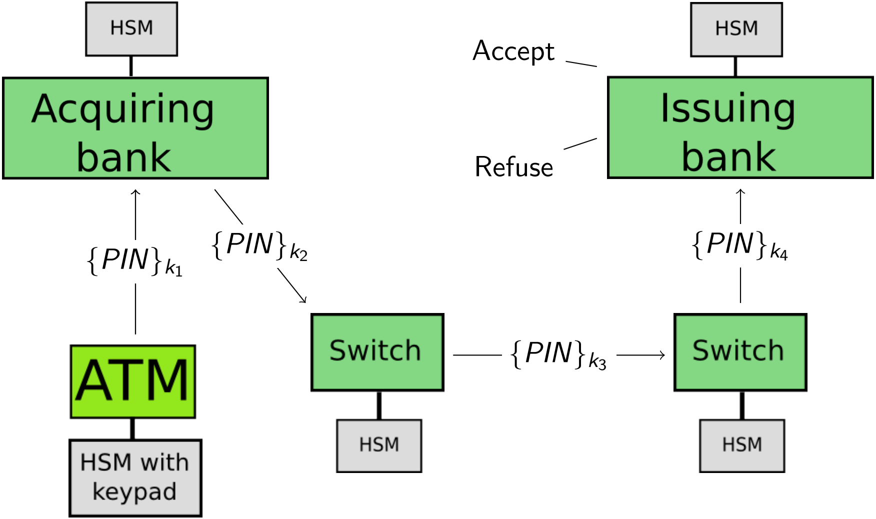

Hardware Security Module (HSM)

- Tamper resistant
- Security API for
  - Managing cryptographic keys
  - Decrypting/re-encrypting the PIN
  - Checking the validity of the PIN

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Our goal:

propose 'cheap' HSM upgrading strategies

1. securing subnetworks while keeping service up
2. trade-off between hardware and manpower cost

The PIN verification API

- *Encrypted PIN Block* : contains the PIN at the ATM

PIN_V(EPB , vdata,len,dectab,offset)

- Data for computing the user PIN
- Returns the equality of the two PINs

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3. The two values coincide: PIN_V returns 'true'

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This kind of attack is practical

- an average of 13.463 PIN_V calls for a four-digit PIN [Focardi, Luccio, FUN'10]
- ... an insider might disclose thousands of PINs in a lunch-break!

Verizon Breach Report 2008

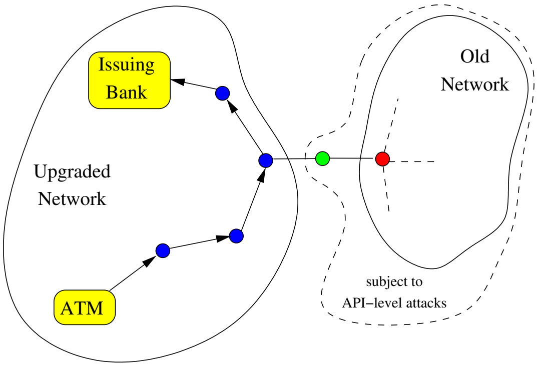
"Were seeing entirely new attacks that a year ago were thought to be only academically possible"
"What we see now is people going right to the source [..] and stealing the encrypted PIN blocks and using complex ways to un-encrypt the PIN blocks."
(Quotes from Wired Magazine interview with report author, Bryan Sartin)

How to prevent the attack?

- low-impact CVV-based fix [Focardi, Luccio, Steel, NORDSEC'09]
  - **mitigates** the attack (50000 times slower)
- point-to-point MAC-based fix and type-based proof of security [Centenaro, Focardi, Luccio, Steel, ESORICS'09]
  - **prevents** the attack but requires modifying each HSM

HSM upgrade

- replace old, flawed, functionalities with new, patched, APIs
- keep the service up: new and old HSMs should 'talk'
- IDEA: special *borderline* HSMs placed temporarily
  - supporting both old and new APIs (still flawed!)
  - translating from/to upgraded and non-upgraded subnetworks



The HSM upgrading problem

- initially *non-upgraded* tree network
- *U technicians* moving on the network and upgrading nodes
- technicians place borderline HSMs, when needed
- borderline HSMs can be moved when all the neighbouring nodes are upgraded

HSM upgrading strategy

A sequence of moves that upgrades an initially non-upgraded network

HSM upgrading number $uhn(T, U)$

The number of borderline HSMs needed to solve the HSM problem on a given tree T and with a given number U of technicians

The Connected Monotone Decontamination problem [Barrière et al., SPAA'02]

- initially *contaminated* tree network
- a set of *agents* moving on the network
- agents decontaminate nodes they traverse
- decontaminated nodes left unguarded are recontaminated

Decontamination strategy

A sequence of moves that clears an initially contaminated network

Connected search number $csn(T)$

The number of agents needed to solve the CMD problem on a given tree T

The two problems are strictly related

Theorem

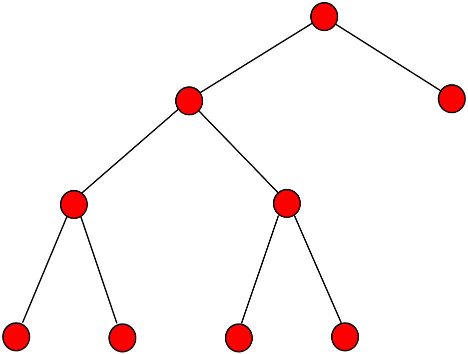
Given a tree T, we have $uhn(T, 1) \leq csn(T) \leq uhn(T, 1) + 1$

Intuitively:

- Borderline HSMs as ‘still’ agents transported by the *unique* technician
- Agent moves simulated by the technician reaching a borderline HSM and moving it

reuse known algorithms and generalize them to U technicians

The algorithm with 1 technician



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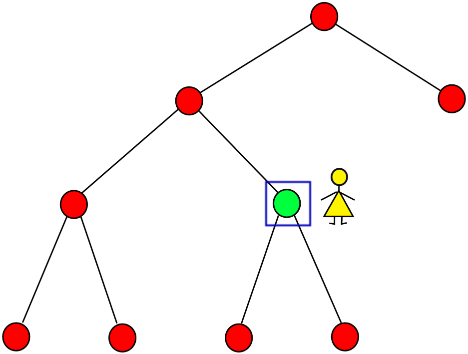

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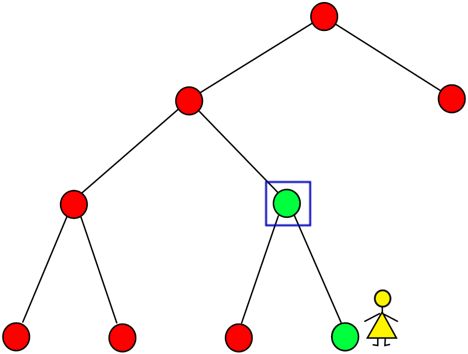

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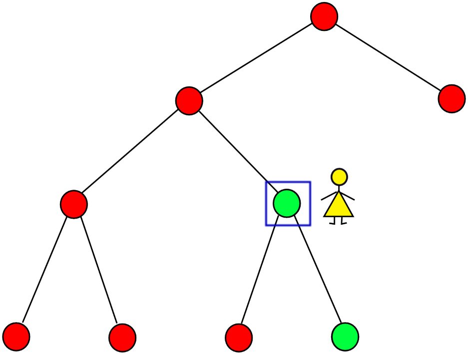

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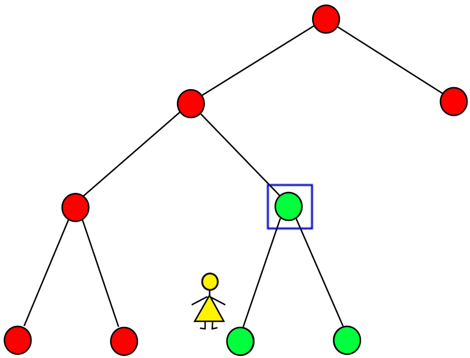

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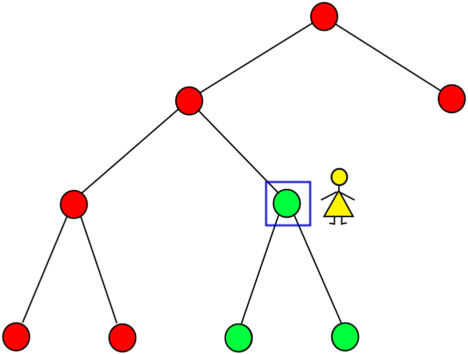

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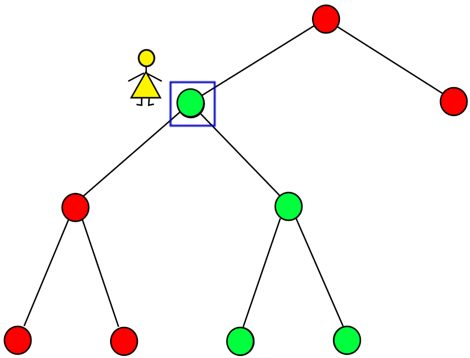

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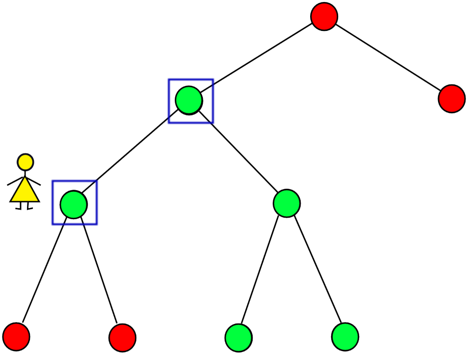

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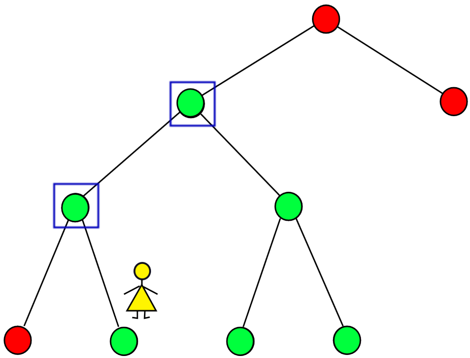

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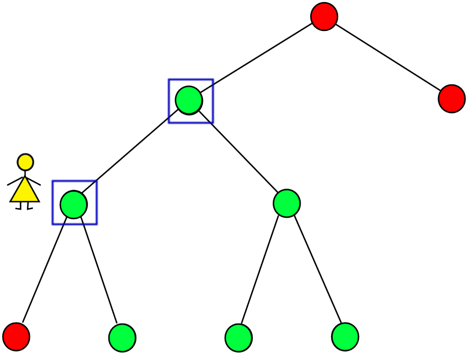

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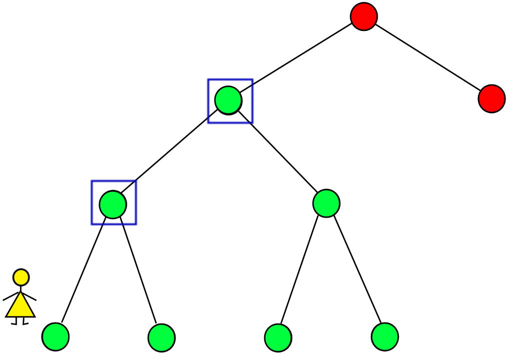

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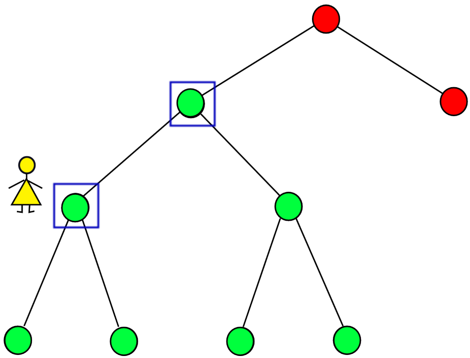

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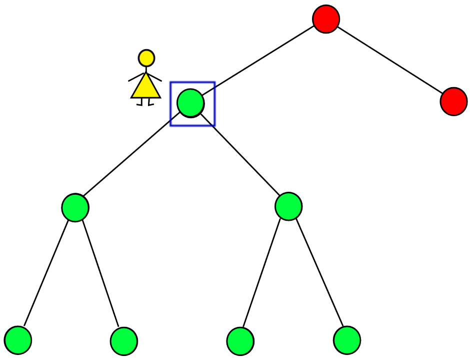

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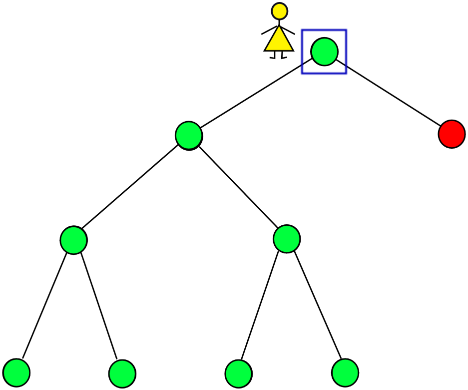

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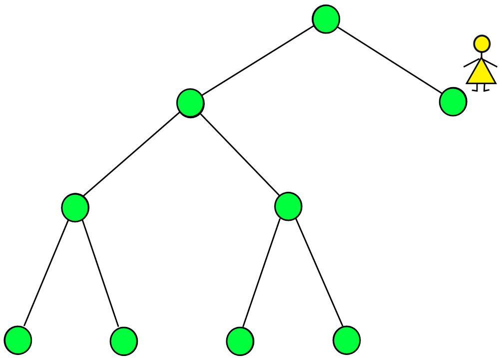

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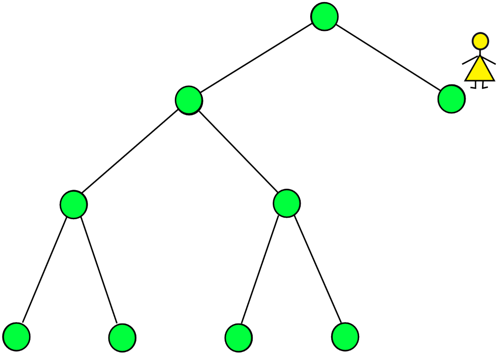
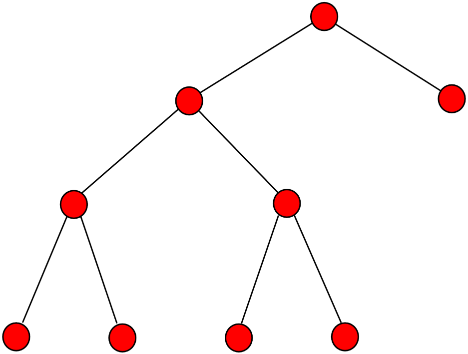


- Two borderline HSMs needed

The algorithm with 2 technicians



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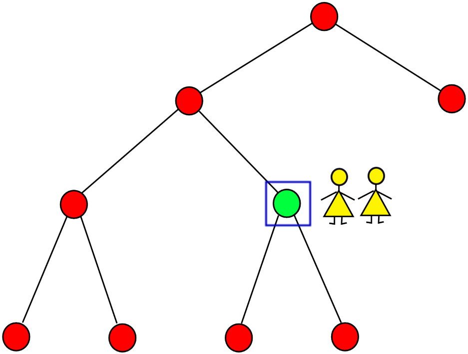

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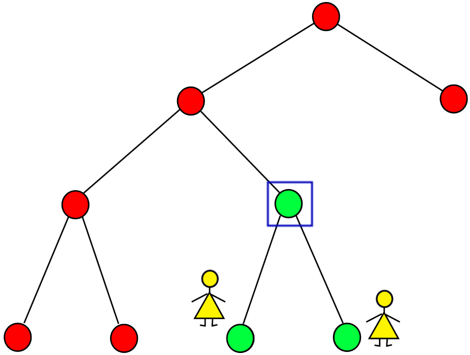

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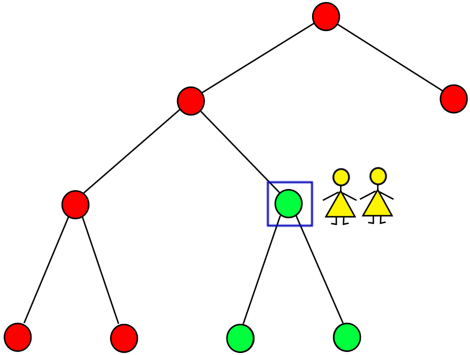

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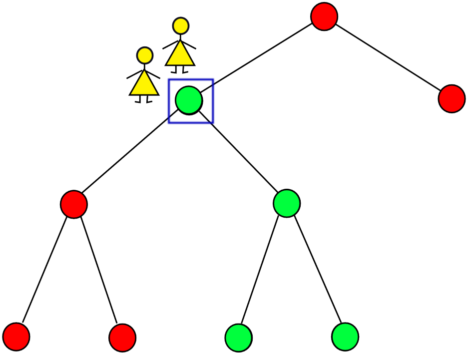

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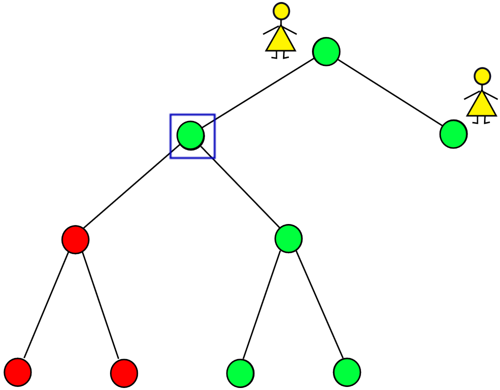

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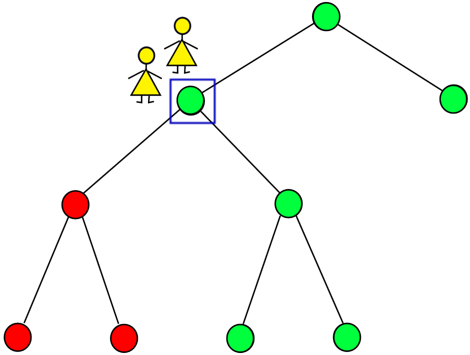

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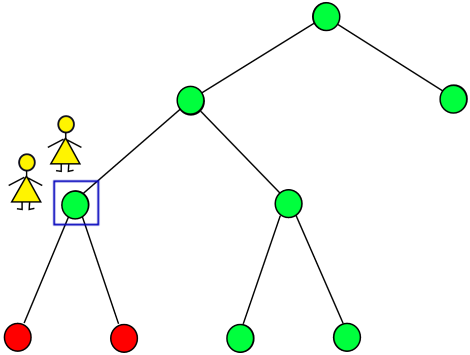

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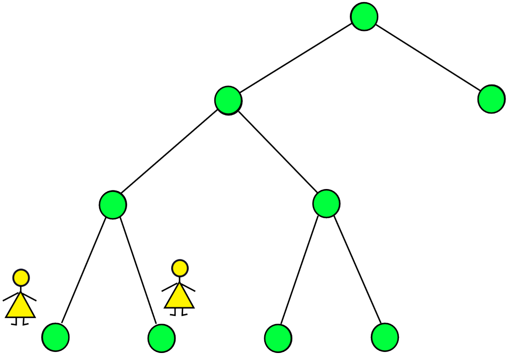

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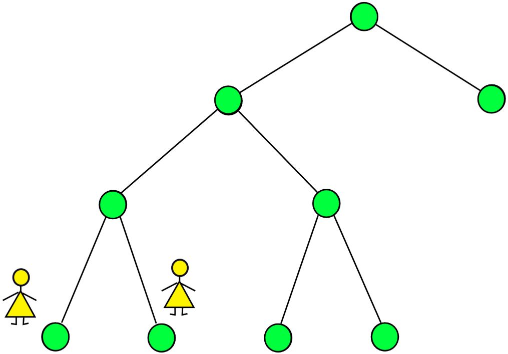

- Only one borderline HSM needed!

Cost trade-off: an example

- Let C_H be the cost for one HSM and C_U the cost for one technician
- $2C_H + C_U$ versus $C_H + 2C_U$
- Suppose $C_H = 10000€$ and $C_U = 5000€$ we obtain
  - 25000€ versus 20000€

- In general, $BC_H + UC_U$ where B is derived by applying the strategy

Conclusion

- strategy for HSM upgrading on tree networks
- trade-off between hardware and manpower cost

Open problems

- placing HSMs on edges instead of nodes
- trade-off between cost and security
    - counting the number of secured paths
- measuring the travelling cost
    - weighted graph
    - independent distance matrix
- extensions to more topologies

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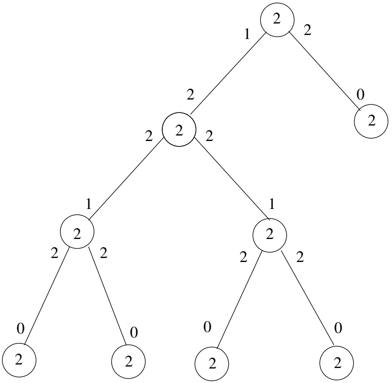
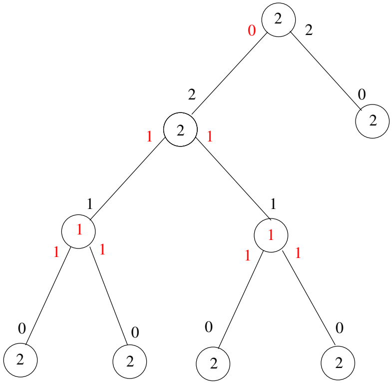

2
1 2
2 0
2 2 2 2
1 1
2 2
2 2 2 2
0 0 0 0
2 2 2 2

U=1


2
0 2
2 0
1 2 1 2
1 1
1 1
1 1 1 1
0 0 0 0
2 2 2 2

U=2