Principles of Security — Part 5: Pervasive security Sections 3 and 4

Dusko Pavlovic

Oxford
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Security 5: Pervasive
Dusko Pavlovic
Introduction
Timed authentication
Social authentication
Conclusions

Outline

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Authentication with timed channels

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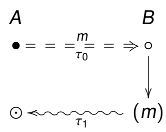
Preliminary example: a timed social protocol



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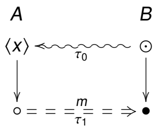

Social channel bandwidth

- $\sigma : \mathcal{T} \longrightarrow \mathcal{T}$: a short digest (hash) function

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such that

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- $\sigma : \mathcal{T} \longrightarrow \mathcal{T}$: a short digest (hash) function

such that

- $\sigma\sigma t = \sigma t$
  - "The digest does not change short terms."
- $\forall s\ \exists t.\ s \neq t\ \wedge \sigma s = \sigma t\ \wedge\ s \vdash t$
  - "For every term s, it is feasible to find a different term t with the same digest."

Social actions

- <B to A : β> — B shows an action β to A

Social actions

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axiomatized as follows:

- <B to A : β> $\Longrightarrow A : \beta_B$
  - "If A sees B perform β, then A knows that B has performed β."

Social actions

- $\langle B \text{ to } A : \beta \rangle$ — B shows an action β to A

axiomatized as follows:

- $\langle B \text{ to } A : \beta \rangle \implies A : \beta_B$
  - "If A sees B perform β, then A knows that B has performed β."
- $\langle B \text{ to } A : \beta \rangle \triangleright \langle C \text{ to } A : \gamma \rangle \implies A : \beta_B \triangleright \gamma_C$
  - "If A sees β_B before γ_C, then she knows that β_B occurred before γ_C."

Social actions

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- $\langle B \text{ to } A : t \rangle$ — B shows a term t to A

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- $\langle B \text{ to } A : t \rangle$ — B shows a term t to A

axiomatized as follows:

- $\langle B \text{ to } A : t \rangle \implies \sigma t \in \Gamma_A$
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Social actions

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axiomatized as follows:

- $\langle B \text{ to } A : t \rangle \implies \sigma t \in \Gamma_A$
  - "If B shows A a term t, then A sees the digest σt."
- $\langle B \text{ to } A : t \rangle \implies A : \exists u.\ \sigma u = \sigma t \wedge \langle B \text{ to } A : u \rangle_B$
  - "If B shows A a term t, then A knows that B has shown her some term with the digest σt."

Social actions

Graphic notation

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- $\beta_B \rightsquigarrow \odot_A$ represents $\langle B \text{ to } A : \beta \rangle$
- $\circ_B \overset{\sigma t}{\rightsquigarrow} \odot_A$ represents $\langle B \text{ to } A : t \rangle$

Socially authenticated key distribution

Bob announces his public key

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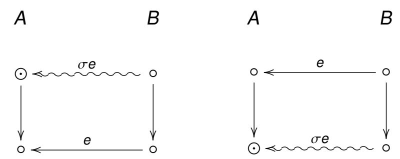
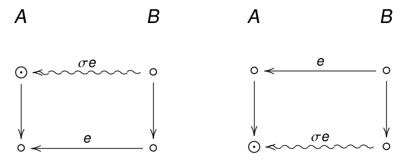


Socially authenticated key distribution

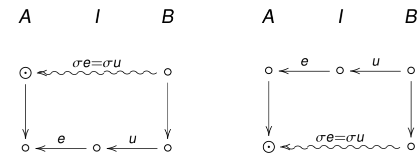
Bob announces his public key



- $e, \sigma e \in \Gamma_A$
- $A: \; B$ honest $\Longrightarrow \exists u.\ \sigma u = \sigma e \wedge \langle B \text{ to } A : u\rangle_B$

Socially authenticated key distribution

. . . but Ivan may have replaced it



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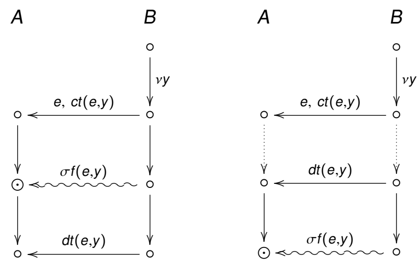
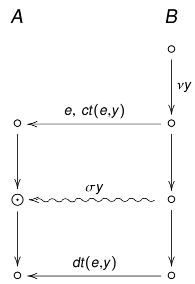
Social commitment

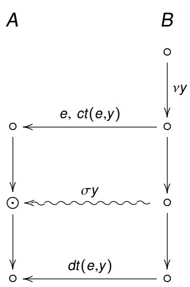


Authentication before decommitment



- $A: \; \exists y.\ \sigma y = s \wedge \text{<}B \text{ to } A : s\text{>}_B$

Authentication before decommitment



- $A: \; B$ honest $\Longrightarrow \exists y.\ \text{<} B \text{ to } A : \sigma y\text{>}_B$

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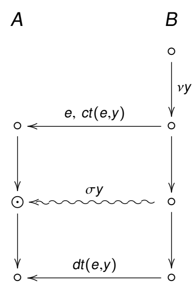

- $A: \; B$ honest $\Longrightarrow \exists u \exists y.\ \langle u, ct(u,y)\rangle_B \trianglerighteq \text{<}\sigma y\text{>}_B$

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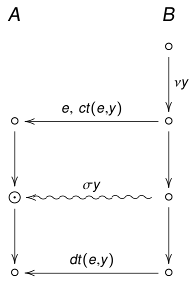
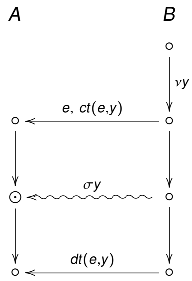


- $A: B$ honest $\Longrightarrow \exists u.\ (\nu y)_B \trianglerighteq \langle u, ct(u,y)\rangle_B \trianglerighteq \lessdot \sigma y \gtrdot_B$

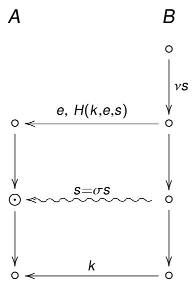
Authentication before decommitment



- $A: B$ honest $\Longrightarrow (\nu y)_B \trianglerighteq \langle e, ct(e,y)\rangle_B \trianglerighteq \lessdot \sigma y \gtrdot_B \trianglerighteq \langle dt(e,y)\rangle_B$

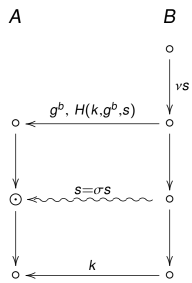
Authentication before decommitment

Wong-Stajano template



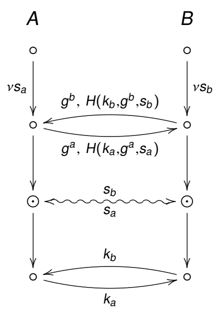
Authentication before decommitment

Wong-Stajano-$\frac{1}{2}$



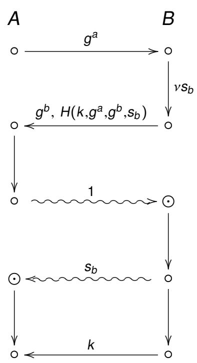
Authentication before decommitment

Wong-Stajano

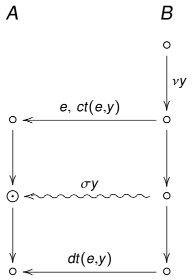


Authentication before decommitment

Wong-Stajano 3



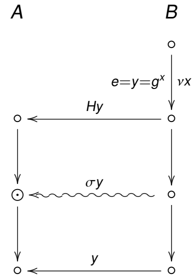
Authentication before decommitment



- $A : B$ honest $\Longrightarrow (\nu y)_B \trianglerighteq \langle e, ct(e,y)\rangle_B \trianglerighteq \lessdot \sigma y \gtrdot_B \trianglerighteq \langle dt(e,y)\rangle_B$

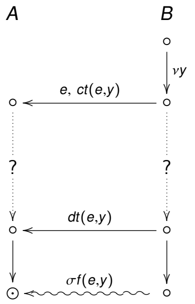
Authentication before decommitment

Hoepman-$\frac{1}{2}$



- $A : B$ honest $\Longrightarrow (\nu x)_B \trianglerighteq \langle H(g^x)\rangle_B \trianglerighteq \lessdot \sigma(g^x) \gtrdot_B \trianglerighteq \langle g^x\rangle_B$

Authentication after decommitment



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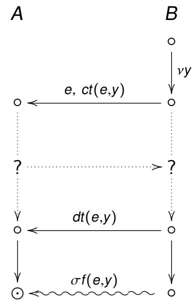

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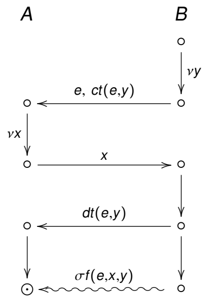

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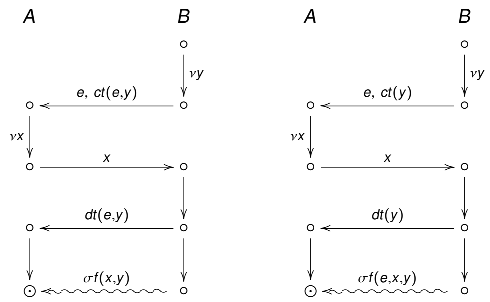
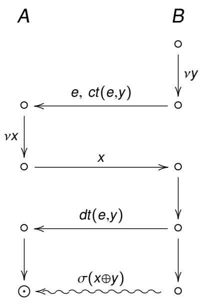


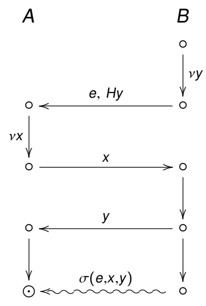
Authentication after decommitment

Vaudenay: SAS-$\frac{1}{2}$



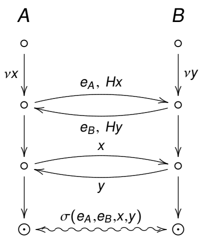
Authentication after decommitment

Nguyen-Roscoe: HCBK-$\frac{1}{2}$



Mutual authentication after decommitment

Nguyen-Roscoe: HCBK (2-party)



Mutual authentication after decommitment

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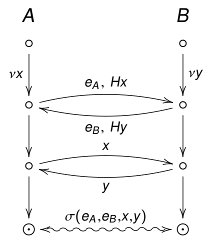

Assumption: Initiator establishes the order

Mutual authentication after decommitment

Nguyen-Roscoe: HCBK (2-party)

$$\Big((\nu x)_A\ \langle e_A, Hx\rangle_A\ (u_1,u_2)_A\ \otimes\ (\nu y)_B\ \langle e_B, Hy\rangle_B\ (v_1,v_2)_B\Big)\ ;$$

$$\Big(\langle x\rangle_A\ (u_3)_A\ (u_1,u_2/e_B,Hu_3)_A\ <\sigma(e_A,e_B,x,u_3)>_A\ \otimes\ \langle y\rangle_B\ (v_3)_B\ (v_1,v_2)/e_A,Hv_3)_B\ <\sigma(e_A,e_B,v_3,y)>_B\Big)$$

Multi-party authentication after decommitment

Nguyen-Roscoe: HCBK

Assumptions (to be discharged)

- agreed ordering of the principals

Multi-party authentication after decommitment

Nguyen-Roscoe: HCBK

Assumptions (to be discharged)

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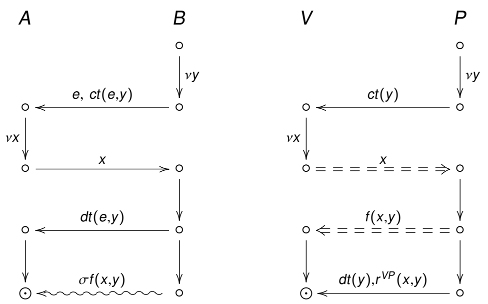
Multi-party authentication after decommitment

Nguyen-Roscoe: HCBK

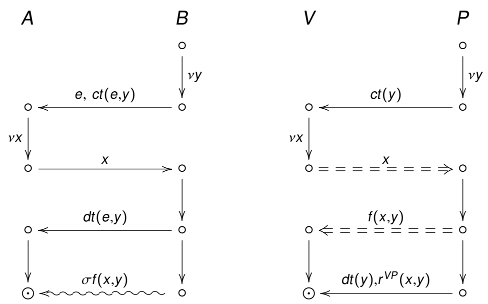
Assumptions (to be discharged)

- agreed ordering of the principals
  - all principals must digest at the same payload
- social protocol to compare the digests

Structural similarity — conceptual difference



Structural similarity — conceptual difference



Social authentication is not challenge-response:
x on the left is not a challenge, but a binder, analogous to y.

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Summary

- computation is becoming pervasive: in physical space
- new security landscape
  - need stronger authentication: proximity...
  - weaker cryptography: low power devices
  - bootstrap distance, proximity, routing...