From Enabling to Enforcing Privacy

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Why privacy for eHealth?

- Healthcare data: inherently private.
- Subversion of data processing: dangerous!

Current approaches to privacy in eHealth

patient privacy (1/3): access control

- Anderson [And98]: restrict #users that access a record, restrict #records accessed by a user.
- Louwerse [Lou98]: consent-based access control necessary to implement “need-to-know”.
- Evered et al. [EB04]: minimal disclosure rules: use middle layer.
- Reid et al. [RCHS03]: RBAC + explicit consent + explicit denial for privacy.
- Kalam et al. [KBM$^+$03]: RBAC, TBAC insufficient for context-aware policies. Organisational BAC (OrBAC).
- Cuppens et al. [CCG07]: inconsistent access rules: rule prioritisation.

patient privacy (2/3): architectural design

- Ko et al. [KLS+10]: privacy issues in wireless sensor networks for eHealth.
- Maglogiannis et al. [MKD09]: patient location privacy via proxies.
- Chiu et al. [CHCK07]: privacy-aware cross-institution image sharing: RBAC and watermarks.

patient privacy (3/3): cryptographic approaches

- vd Haak et al. [HWB+03]: digital signatures, PK authentication.
- Ateniese et al. [ACM+03]: patient pseudonyms, method to transform statements on pseudonym a to pseudonym b.
- Layouni et al. [LVS+09]: wallet-based credentials for patient control of sensor info.
- De Decker et al. [DLV08]: Belgian healthcare system compliant system using ZKP, signed proofs of knowledge, bit-commitments.

Doctor privacy

- Matyáš [Mat98]: prescription analysis while preserving doctor privacy.
- Ateniese et al. [ACM+03]: doctor privacy to protect against administrative meddling.
- De Decker et al. [DLV08]: doctor privacy to prevent bribery.

Survey summary

- Access control to ensure patient privacy:
  [And98, Lou98, RCHS03, KBM+03, EB04, CCG07].
- Architectural design for patient privacy:
  [CHCK07, MKD09, KLS+10].
- Using crypto for patient privacy:
  [HWB+03, ACM+03, LVS+09, DLV08]

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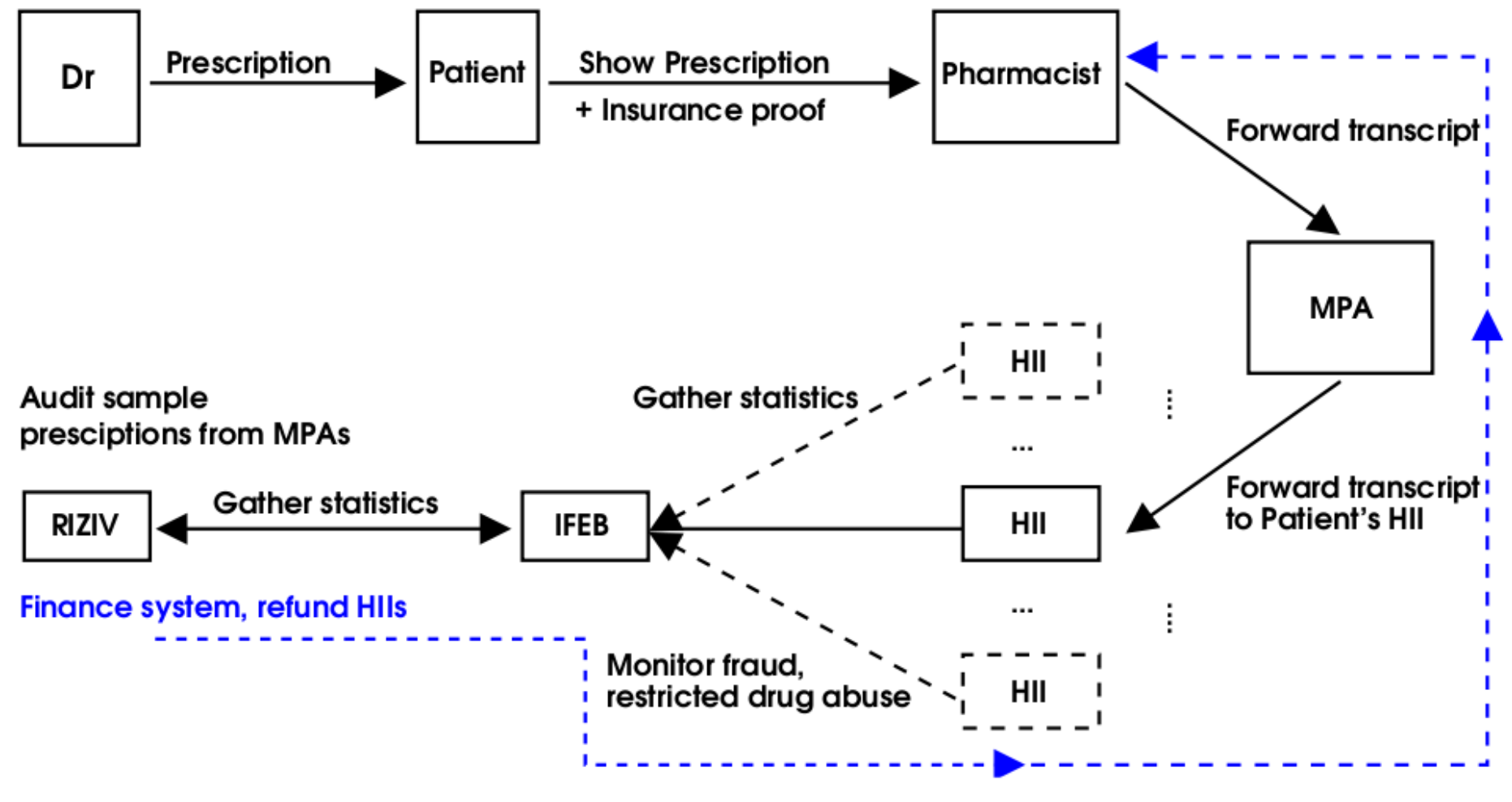
- Doctor privacy:
  [Mat98, ACM+03, DLV08]
- Much focus on patient privacy, not on doctor privacy.

Sufficient concern for privacy?

- roles:



- enforced privacy

Motivation for doctor privacy

- [ACM+03]: safeguard against administrative meddling.
- [DLV08]: prevent bribery by pharmaceutical industry.

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Privacy **invasion** needs motivation.

Neither relation with doctors is on equal footing.

Enforced privacy

- Emerged in voting: vote buying (receipt-freeness) [BT94].
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  RF+resistance against:
  - Forced randomised voting.
  - Forced abstention.
  - Forced to give up voting credentials.

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- Considered in online auctions: [AS02, CLK03].

What is enforced privacy?

Privacy

- what can the intruder find out?
- observer
- optional: enabling

Enforced privacy

- what can you prove?
- prover + verifier
- mandatory: enforcing

EPRIV project

"understanding and verifiying enforced privacy"

- application domain: voting, auctions, healthcare, anonymous routing, ...

- approach:
  1. domain-specific case study $\Longrightarrow$ domain-specific verification framework.
  2. specific frameworks $\Longrightarrow$ domain-independent verification framework.
  3. tool support.

Case study: DLV08

- formalise protocol in applied π.
- extract and formalise requirements upon the model.
- use ProVerif to prove[a] security.

DLV08 requirements:

- . . . , doctors cannot prove what they prescribed, . . .

[a] limited models where necessary

DLV08 protocols

- patient-doctor
- patient-pharmacist
- pharmacist-MPA
- MPA-HII
- IFEB-MPA

Doctor not often involved: easy to ensure prescription privacy?

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Doctor not often involved: easy to ensure prescription privacy?

but a pharmacist also knows things about prescriptions!

Privacy challenges for eHealth

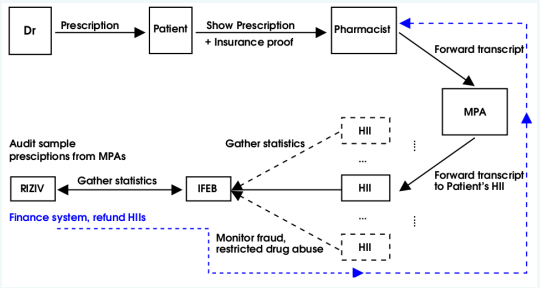
Challenge I: Enforced privacy.

- doctor privacy. . . who else?
- needs privacy-enforcing protocols and techniques.
- also needs independent verification framework.

Privacy challenges for eHealth

Challenge II:
Coalition-enforced privacy.

- one party may help another wrt unveiling privacy.



- helper can help either prover or verifier.

- helping verifier: threshold crypto.
  helping prover: ??.

Enforced privacy in DLV08

Notation:

- $P_{dr}(a, a)$: doctor prescribes a, claims to prescribe a.
- ${P_{dr}}'(a, b)$: doctor prescribes a, claims to prescribe b.

Privacy enforced iff:

$$P_{dr}(a, a)|P_{pt}|P_{ph}|P_{mpa}|P_{hii} \approx {P_{dr}}'(b, a)|P_{pt}|P_{ph}|P_{mpa}|P_{hii}$$

Possible directions

- privacy-strengthening coalitions
- game-theoretic approaches
- improving tool support

Conclusions

- 2 key privacy challenges:
  - Challenge I: enforced privacy
  - Challenge II: coalition-enforced privacy
- formal methods necessary for security
- initial steps made
- still some work left.

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