Towards Practical Attribute-Based Identity Management: the IRMA Trajectory

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irmacard.org

Outline

Identities versus attributes

- Identity management seems to revolve around identities
  - In practice this means uniquely identifying numbers, like social security number, or passport number
  - high-value targets for profiling & identity fraud
- But a more flexible identity ecosystem uses attributes
  - 'over 18', 'over 21', 'over 65', 'under 15', 'male', 'female'
  - 'student', 'doctor', 'president', 'top secret clearance'
  - 'NL-citizen', 'resident of Nijmegen'
  - 'home address', 'owner of bankaccount nr. ...'

Your **identity** is the collection of attributes that hold for you

Key idea in attribute-based IdM

- Each transaction only requires a **subset** of your attributes for authentication
  - the subset should be small & proportional: data minimisation
  - this also offers some protection against identity fraud
- Attributes support **contextual privacy**
  - an essential aspect of privacy is being able to reveal different aspects of yourself in different contexts
  - attributes support such "partial identities" or "personas"

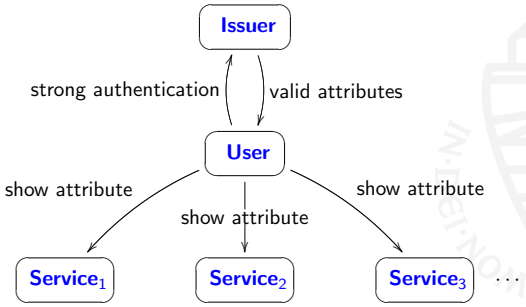
Identifying and non-identifying attributes

- In the attribute literature/tradition it is often (implicitly) assumed that attributes must be non-identifying
  - like: "female", "over 18", "UK citizen" etc.
  - strong emphasis on privacy-friendly usage
- In our "IRMA" approach we deliberately also allow identifying attributes
  - like: "bank account nr.", "social security nr.", "client nr.", or even "Facebook ID"
  - this greatly enlarges the usage & relevance & acceptance
- But this identifying usage is controversial
  - it enables tracking & tracing — which the technology is supposed to prevent
  - **proportionality** requirements need to be enforced — see later

Attribute-based authentication & authorisation

- Non-identifying attributes good enough for many transations:
  - a cheaper hair-cut for a student, or cheaper public transport for senior citizens
  - participation in local referendum for locals
  - buying games/books/videos online (over 16, or over 18)
  - participation in chatbox for minors (under 12, or 15)
- Attribute-based extends role-based access control
  - the captain of the ship can turn the ship's wheel
  - very relevant in the medical sector (access to files)
  - in the military (or elswhere): hierarchies/compartments/roles
- Typical transactions involve a combination of attributes
  - address, possibly with bank account, for pizza delivery
  - age + bank account for online gambling / XXX / ...
  - "doctor" status + medical registration number for write-access to medical record

User-centric attribute issuance-usage model



One may also have multiple issuers (government, banks, isp's, ...)

Requirements for attribute-bases systems

- Non-transferability: my little nephew should not be able to get my "over 18" attribute (and go to XXX sites)
  - realised via binding to my private key
- Issuer-unlinkability: the issuers should not be able to track where I use which attribute
  - typically realised via blind(able) signature
- Multi-show unlinkability: service providers should not be able to connect usage (at different providers)
  - realised via zero-knowledge proofs, or via "self-blinding"
- Revocation: rogue attributes (via stolen/lost cards) should be blockable.
  - most difficult, partly in conflict with previous requirements

Three main (cryptographic) systems

- U-Prove (based on blind signatures)
  - developed by Stefan Brands (Credentica), bought by Microsoft
  - specification available, under the Open Specification Promise
  - open source reference toolkits in C# and Java
  - multiple attributes in single (traceable) token, selective disclosure
- Idemix ("Identity Mixer", based on zero-knowledge proofs)
  - developed by Camenisch & Lysyanskaya, IBM Research Zürich
  - specs & sources also openly available
  - most properties, including revocation (by users, not by issuers)
  - most complicated (even "over-engineered")
- Self-blindable certificates
  - developed by Eric Verheul and others
  - uses bilinear pairings on elliptic curves
  - open implementation available

Nijmegen's contribution

- Fast(est) smart card implementation for all three approaches, by Pim Vullers — see his own IdMan paper/talk
- Practical realisation initiative "IRMA", based on Idemix
  - not all Idemix features, emphasis on *selective disclosure*
  - with several (semi-public) partners: Surfnet, TNO, SIDN
  - active role in discussion about next eID in NL
- Middleware development to create eco-system for attributes
  - attribute verification, issuing, management; registration
  - integration in websites, NFC phones & tables, POS terminal
  - experimental attribute issuing via government website
- Small pilot for own "Kerckhoffs" master students ($\pm$100), starting soon.

Parallel initiative: ABC4Trust

- ABC4Trust is European FP7 research & development project (2010–2014, 12 partners)
- Development & implementation of unified common architecture that supports both U-prove & Idemix
- Two pilots (Söderhamn, Sweden & Patras, Greece) in fixed, educational setting
- Coordination with IRMA ongoing

Architecture and politics

- We see growing support for privacy-friendly *attributes* instead of one or more *unique identifiers*
  - Of course, the Google / Amazon / Facebook / Apple's of this world just wish to trace people and don't want such attributes
- Hosting of attributes is an issue in itself
  - usage of smart cards seems obvious, but there are alternatives
  - commercial interests play a substantial role
  - in the end, this matter is highly political ("information is power" and "architecture is politics")
- incentives & legal responsability/accountability for issuers is unclear and is a delicate separate issue

Architecture II: three models

1. **De-centralised / local**
   - attributes are stored under direct control of the user
   - smart card is obvious carrier; possibly also phone (see later)
   - direct interaction with verifier
2. **Centralised**
   - attributes are stored in some (central) database; verification proceeds via this central infrastructure
   - single-point of failure, privacy-unfriendly (content & traffic)
   - still requires strong authentication of users
   - but: this allows putting a €-charge on each verification!
3. **Pointer-based**
   - attributes remain with attribute-provider
   - slightly more privacy-friendly version: only traffic is visible

Architecture: reasonable perspective

- Simple, static attributes are stored locally, on smart cards
- Complex, dynamic attributes (data) stored centrally, accessible via strong authentication
  - using identifying attributes on smart cards

Allow some grey area between *local* and *central*

- Privacy freaks may want to store as much as possible locally
- Others may put more in the infrastructure — and reduce their cards to "authenticators", in the limit

Unexpected support for "local", from the military

- Military IT-people expressed interest in attributes on smart cards, such as "colonel", "NL army", "military ID nr." etc.
- They are not interested in privacy; but they do like the decentralised character and robustness of the approach
- Imagine a NL colonel visits a military base in UK; there is no way that NL is allowing UK access to its (LDAP) database for identity/rank/clearance verification.

Cards or phones, as carriers?

Why not put IRMA attributes on a (smart) phone?

Not such a good idea!

- There is a personal cryptographic secret involved; cards have protected hardware, phones not yet (like IPT)
- Software on phones is becoming as unreliable as on PCs
- Phones are often changed/lost, or owned by employer
- Extra effort required to take your card out of your pocket for a security/privacy sensitive action is good: it brings you in a higher state of alert.

Pseudonyms or attributes

- The German eID *Personalausweis* is a high-tech card, distributed since 2010
- Germans take privacy seriously; eg. there is no national social security (identity) number for citizens
- After mutual card-terminal authentication, basic (unsigned) attributes (like name, address) can be exchanged
- There is support for PKI-based signature, but no certificate is loaded by default — the user should do that him/herself
- Domain-specific pseudonyms can be generated.

In comparison:

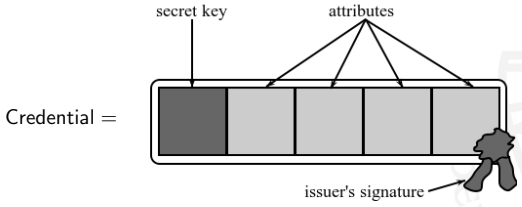
- attributes are more flexible & general (can contain pseudonyms)
- Idemix also allows domain-specific identifiers, eg. for one-time or long-term usage

Let's see some running code!

1. attribute verification
   - age bound and city, on NFC-enabled tablet
   - age bound for spicy website, using NFC phone as card reader
2. Attribute issuing: student status

Credentials and attributes

A card contains multiple credentials, each with multiple attributes:



- The secret key is securely stored in the smart card, making credentials non-transferable; required in "showing attributes"
- The issuer's signature guarantees authenticity and integrity
- Any subset of the attributes can be shown in transactions. This is called selective disclosure.

Example credential: address

Address
Country
City
Street + Number
Postal code

Separately usable attributes

Issued by: public authorities (eg. local, but not in UK)

- Name is not included, stored elsewhere (no credential overlap)
- Expiry info is omitted

Example credential: age boundaries

Junior bounds
≥ 12
≥ 16
≥ 18
≥ 21

Senior bounds
≥ 60
≥ 65
≥ 70
≥ 75

Issued by: public authorities

- Note: these attributes never expire, unlike for $\leq$.
- In Idemix bounds can be derived from the date-of-birth, in costly, slow manner; they can also be included directly, like above.

Example applications

- Junior age boundary: to order games/books/movies online, or to view/play certain content online (eg. catch-up-TV, games)
  - offline, for buying alcoholic drinks or cigarettes in a shop — or even from a vending machine
- Senior age boundary: to get reductions, eg. in public transport or in shops
- Both age ≥ 18 and country=NL: privacy-friendly *wietpas* for buying softdrugs (plans in NL abandoned)
  - the original *wietpas* was extremely privacy-unfriendly, and thus unpopular

Example credentials in medical sector

- For medical personel: (IRMA card as staff-pass): credential with medical role (eg. heart specialist, GP, nurse, pharmacist), registration number, etc. for access control to medical dossier

  Issued by: medical staff registry (BIG in NL)

- For patients: rudimentary medical dossier (known allergies, medicine usage) for ER usage.

  Issued by: eg. GPs or hospitals

Example credential: student card

Student card
University / College
Field of study
Student ID
Enrolment year

Issued by: universities

(Again: name is stored elsewhere: no overlap)

Example credential: citizen identity

Name
Family name
First name
Full first names
Initials

Identity
Social security number
Date of birth
Place of birth
Gender

Issued by: public authorities

Example credential: company access

Access
Main entrance
Parking
Vault
Intranet

Many different combinations and encodings are possible

Issued by: e.g. company itself, or third (commercial) party
(Convenient set-up for temporary personel/visitors/maintenance staff)

Example credential: festival/concert ticket

Festival
Festival name
Validity date
Pre-paid consumptions
Ticket number

Issued by: e.g. festival itself, or third (commercial) party

The role of Issuers

- Users can obtain new/updated credentials from Issuers, either online, or offline
- Issuers first authenticate Users, and then make valid attributes available for download
  - others ("Verifiers", "Relying Parties") trust these attributes
  - issuers are thus trusted parties
  - authentication can be based on existing attributes
  - "download" is in fact interactive credential creation, with card
- Issuers should publish how they authenticate and why they believe that the attributes they provide are valid
  (think of *Facebook* as issuer)

Example issuing: mobile phone number

- Imagine your MNO issues mobile phone number attributes
- A User goes to this MNO issue website (https!) and provides:
  - Name + date of birth, via IRMA card
  - phone number — simply by typing it in
- The MNO checks:
  - these data are consistent with an existing contract
  - phone presence, by sending a one-time code via texting
- Upon seeing the correct code within the same ssl-session, the MNO issues the phone number credential to the IRMA card

(Similarly for eg. email/IP addresses by ISP, or even *Facebook* identity)

Example issuing: bookstore membership

- Imagine a bookstore wishes to issue membership attributes
- Upon presenting an IRMA card in the shop, a credential is issued to the card, stating "member status" (gold / silver / bronze) and "member number" (pseudonym) and "issue date"
- At the checkout (different) reductions can be obtained via the combination of attributes:
  - "member status" or "member number"
  - "member number" + "student"
  - "member number" + "senior citizen"
- This issuing involves no authentication
- The bookstore can build up historical profiles, based on the membership number, which can be used for additional offers
  (compare to pseudonyms on German card)

Root credentials

Definition: A credential is called a root credential if in its issuing process no other credentials are used for user authentication.

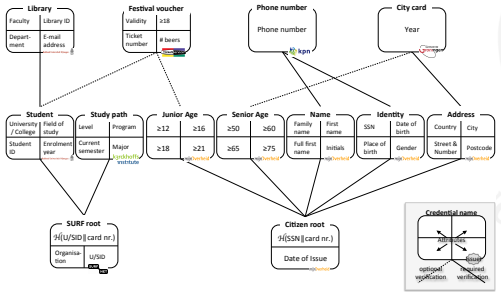
examples

- The MNO phone number credential is not 'root', since it relies on names + date of birth attributes existing on the card
- The bookstore credential is 'root'

- A root credential can be the root of a tree of other credentials that rely on it
- There may be multiple such trees
- Such tree structures should be public, for transparant trust

Example

IRMA – Credential Tree



Trees and spheres

Interesting question: should *Facebook* have its own root credential, or can it depend on others (like name, or date of birth)?

- If NO, then your *Facebook* credential will be part of an existing "identity tree"
  - a *Facebook* credential will then be linked to your real identity
- If YES, then *Facebook* credentials start a new tree, representing your "Facebook life"

Which spheres/personas should be (dis)connected?

- who should decide this, and on which grounds . . . ??
- the identity ecosystem is of great social/political importance

Why governance needed?

1. To set a legal framework, with
   - responsabilities & accountability, for attribute issuers
   - proportional attribute access, for verifiers (& issuers)
2. To design credential trees and decide on dependencies
   - implicit goal: to protect users
3. To manage software & cryptographic keys (certificates)

Control over what?

- All IRMA software is open source, so anyone can put it on smart cards, and start distributing cards
- A closed scheme is possible via cryptographic keys, eg:
  - cards contain public keys of some authority
  - card readers (terminals) need certificates signed by this authority — before cards communicate with them
- Such keys give control, both over issuers and over verifiers
  - if they don't follow the rules, they can't participate

Of course, alternative schemes, with different keys, may exist

IRMA governance

- At this early stage there is no real separation of roles
- Ideally, in the future, an independent foundation runs the scheme
  - commercial interests and public trust don't mix well
- Indepent foundations are probably least controversial for running large, open IT-infrastructures
  - eg. DNS in NL

In the remainder of the discussion I assume there is such an independent IRMA foundation

Attribute access for verifiers

- **Recall:** the risk is that verifiers read too many attributes

Governance model

- prospective verifiers register with IRMA foundation, stating their goals & requesting access to certain attributes
- if the request is proportional, access is approved
- verifier obtains certificate capturing acces to these attributes
- IRMA cards check such certificates first, before they reveal any attributes

Attribute access for issuers

- **Main risks:** weak attribute validation, or excessive subject verification requirements (unnecessarily linking spheres)

Governance model

- prospective issuers register with IRMA foundation, stating which attributes they wish to issue and how they do the necessary validation & subject verification
- if the attributes are "useful" & reliable, and verification is proportional, read & write access is approved
- issuer obtains necessary certificates

Card-to-cardholder binding

Two mechanisms:

1. Photo of cardholder
2. PIN

Card view

Front

Back

- There is only a picture on the frontside, nothing else
- There is a (random) card number on the back, which is:
  - not present inside the (chip in the) card
  - useful for "lost-and-found" scenarios
    (The card has a randomised UID)

PIN issues

Each card comes with two PINs

- **One for attribute reading**
  - Which attributes should be protected by PIN?
  - Balance between: ease-of-use, ease-of-abuse, confidentiality
  - over 18: *yes*, medical data: *no* (restrict read-certificates)
- **One for personal card management**
  - card owner can manage own attributes on card (like apps on phone)
  - also access to card logs

User convenience

User convenience is not an explicit goal

- message: security and privacy require careful behaviour
- users will have to be conscious about what they are doing
- using your IRMA card should give the same alertness as in using your ordinary keys.

Own pilot project plans (this year)

- ±100 security master students can get IRMA card
  - request via national student authentication (Surfnet)
  - requires photo upload and email (for communication only)
  - face-to-face handover, with additional authentication
- Additional attributes: ba/ma/phd, univerisity, study, name, address, town, country, age bounds, ...
- Application scenarios: free printing, cheaper coffee, goodies on website, ...
- Students are encouraged to test security and develop additional application scenarios
- Goals: fine-tuning & learning about practical challenges

eID developments in NL

- NL is late — through legal fight over earlier tender
  - delay may actually be an advantage
  - existing PKI cards are hardly used in practice (except Estonia)
- NL has social security number
  - but its usage is restricted to the public sector
  - it forms the basis for much-used national authentication system (DigiD), based on password and/or OTP via text message
- Two (main) eID requirements in NL:
  - strong authentication, based on smart cards
  - usable both in the public and private sector
- Two important options:
  1. copy German card, using pseudonyms
  2. introduce IRMA cards, using attributes

Option 1 is safest bet, but option 2 is most flexible

Main points I

- Important step towards practical use is: also allow identifying attributes — even though they go against the spirit
- IRMA work is based on smart & fast Idemix implementation
  - approach offers privacy & security, much user control
  - also development of open middleware
- Not just *pushing the technology*, but also *pushing the management part*
  - requires looking at the broader social/political picture

Main points II

- Scaling-up attribute use requires carefully designed & controlled identity eco-system
  - attributes form delicate dependency trees
  - governance preferably via independent foundation
  - incentives & accountability for issuing unresolved
- Open character can be innovation motor, leading to many, now unforeseen, applications.
- Recommended next step: organisation of large scale pilot, with ten thousands of users, like in university pass, or city pass.
- This technology gives policy makers & regulators the tools to enforce privacy & security by design!

Thanks for your attention. Questions/remarks?