From Cryptographer's Cryptography to Engineer's Crypto

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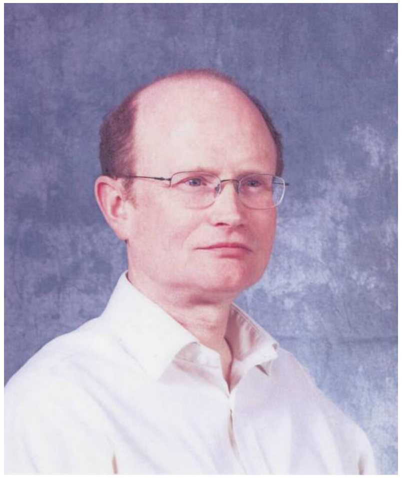


Graeme Proudler
TCG Technical Committee
Chairman

What the heck are you talking about!?

Cryptographer’s cryptography and engineer’s crypto

Are they the same thing?

They ought to be the same thing, but actually they are not.

- What do I mean by cryptographer’s cryptography?
  - Solutions designed by (academic) cryptographers
  - Published in cryptographic conferences and journals

  Technically cool!!!
- What do I mean by engineer’s crypto?
  - Solutions developed by (industrial) engineers
  - Used by banks, mobility, Internet ……

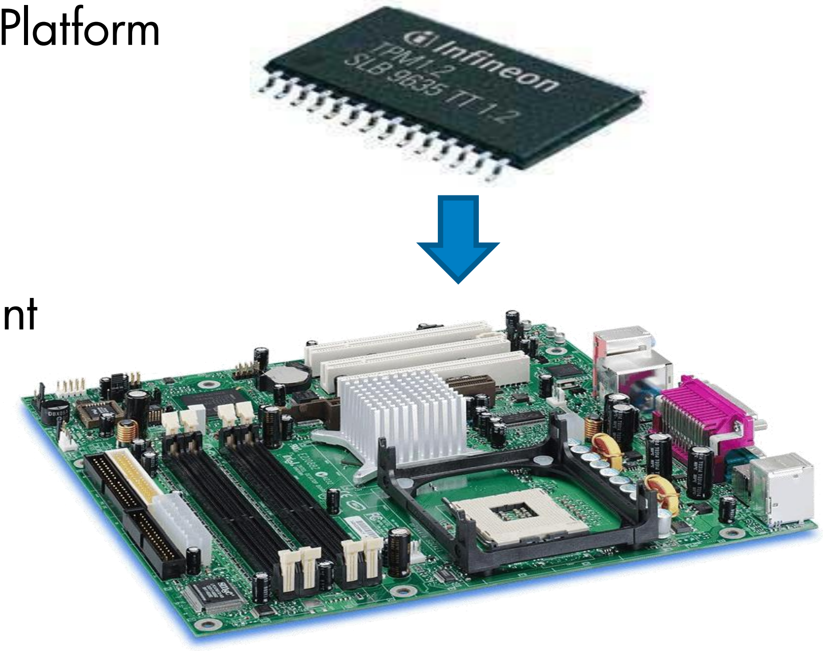
  Practically useful!!!

They’ve been getting further and further apart, but they still need to talk to each other

The content of this talk is based on

My experiences of working with TCG

- TCG (Trusted Computing Group) is an industrial standard body and aims to provide technical building blocks for trusted computing platforms
- The main technology of TCG is TPM (Trusted Platform Module)
- TPM is a small hardware chip
- TPM spec v1.2 = ISO/IEC 11889
- The next generation TPM is under development



TPM has become a crypto engine

Although it was designed for a different purpose

TPM supports:

- Hardware-based random number generation
- A set of cryptographic functions:
  - Hash functions
  - MAC functions
  - Key generation
  - Signing and signature verification
  - Asymmetric encryption and decryption
  - DAA (Direct Anonymous Attestation)
- Next generation TPM is intended to support algorithm agility, and might need additional cryptography such as:
  - KDF
  - Symmetric encryption and decryption
  - DH

How to select crypto algorithms for TPM?

A lot of criteria but only a few of interest to the cryptographer

Even a crypto-agile TPM must have a restricted set of algorithms

What could affect crypto algorithm selection?:

- Regulation
  - Over the last ten years some (not all) cryptographic regulations have been relaxed
  - export/import licenses now permit some usage of symmetric algorithms
- Standardization
  - Authoritative recommendations
- Existing usage
  - Third party recommendations
- Potential market/business strategy
  - Mass-market
  - Niche-market
- Cryptographers’ advice

Cryptographers are living in a self-created world; engineers are living in a world often beyond their control

Life in these two worlds

Target and schema

Cryptographers

- Find a cryptographic problem
- Define a cryptographic primitive
- Define security of the primitive
  - A security model
- Design/attack a scheme
- Analyse security of the scheme
  - It is secure because it can be proved under the model, otherwise it is insecure
- Aim to create something elegant and delicate

Pressure/satisfaction: publications

Engineers

- Take a real world problem
- Choose a crypto solution to solve the problem
  - Regulation
  - Standards
  - Cryptographer's recommendations
- Evaluate usage cases of the solution
  - It is secure because it survives under real world attacks
- Worry about lifetime guarantee and maintainability

Pressure: customer satisfaction, success in the market

Life in these two worlds

Keywords and languages

Cryptographers

- Assumptions/hard problems
  - computationally infeasible
- Negligible
  - a mathematical function
- Provable security
  - proof under a model/hard problem
- Broken
  - don't achieve a claimed security level
- Practical
  - More efficient than previous works
- Oracles
  - ……

Engineers

- Assumptions
  - attackers are not interested
- Negligible
  - no a business case for criminal
- Security evaluation
  - pass a variety of case studies
- Broken
  - affecting real usage
- Practical
  - can be manufactured
- Oracles
  - no such things

Security proof is essential

But what cryptographers say is different from what engineers hear

Cryptographer: Here is our proposed scheme, blah, blah, blah

Engineer: Is your scheme safe?

Cryptographer: Yes, we have a security proof. Our scheme is secure as long as ……

Engineer: Good. Thank you very much

Engineer (to himself): She said the scheme is safe, why do I have to worry about what after "as long as" is?

Cryptographer (to herself): I didn't say it is completely safe!

There is a great disparity between cryptographer's and engineer's point of view regarding acceptable security levels

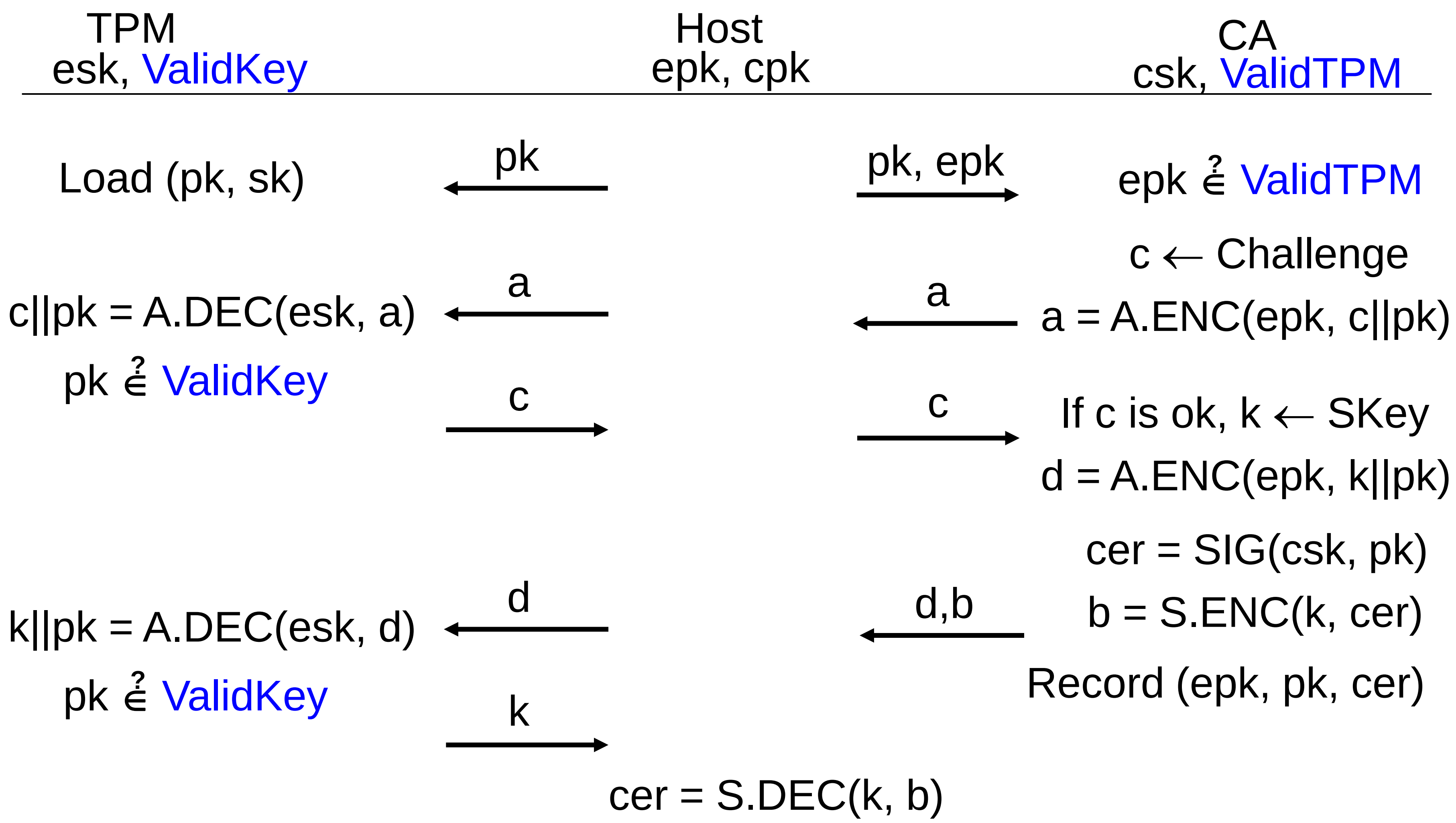
Privacy-CA solution

Secure under a weaker security model

Example 1: Privacy-CA solution

- This solution uses PKI to support anonymity
- It is specified in TCG TPM V1.2, ISO/IEC 11889

The TCG Privacy-CA Protocol



TPM esk, ValidKey		Host epk, cpk		CA csk, ValidTPM
Load (pk, sk)	← pk		pk, epk →	epk $\overset{?}{\in}$ ValidTPM
				c ← Challenge
c||pk = A.DEC(esk, a)	← a		← a	a = A.ENC(epk, c||pk)
pk $\overset{?}{\in}$ ValidKey	c →		c →	If c is ok, k ← SKey
				d = A.ENC(epk, k||pk)
				cer = SIG(csk, pk)
k||pk = A.DEC(esk, d)	← d		← d,b	b = S.ENC(k, cer)
pk $\overset{?}{\in}$ ValidKey	k →			Record (epk, pk, cer)
		cer = S.DEC(k, b)		

Privacy-CA solution

Secure under a weaker security model

Example 1: Privacy-CA solution

- This solution uses PKI to support anonymity
- It is specified in TCG TPM V1.2, ISO/IEC 11889
- A rigorous security analysis was done with Warinschi and Lee
- What does the proof tell us?
  - The protocol is secure only under a weak model: the adversary is not allowed to corrupt any TPM
  - From our point of view, the model is quite weak – breaking one TPM, an adversary can impersonate any other TPMs
  - We then proposed an enhanced protocol secure under a stronger model – the adversary is allowed to corrupt any TPM except one
- From TCG's point of view, its security level is acceptable
  - It works in many use cases (corporations, for example)
  - A broken TPM is a big problem only if the break is public knowledge, but if it is public knowledge it can be blacklisted

Authorisation Values

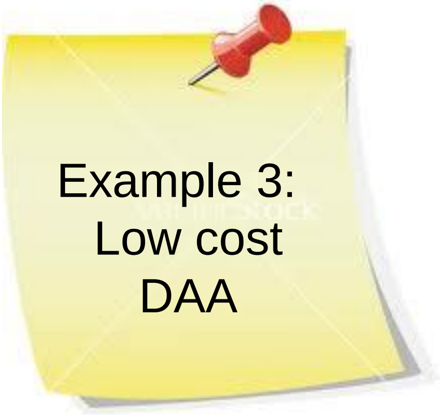
A piece of grey area

Example 2: Authorization values

- Authorization values are used as a key in communications between a TPM and user
- TCG allows users to use passwords as authorization values
- An off-line dictionary attack was discovered (joint work with Ryan)
- We also suggested a few remedies
- This contribution was well-received by TCG
- The next generation TPM is expected to include methods to handle
  - Low entropy authorisation values
  - Well known authorisation values
  - Reused authorisation values
- I agree that TCG has done its best, though it might not be satisfactory for cryptographers

Privacy is very important, but at what cost?

DAA – the work causing Graeme's headache …



Example 3: Low cost DAA

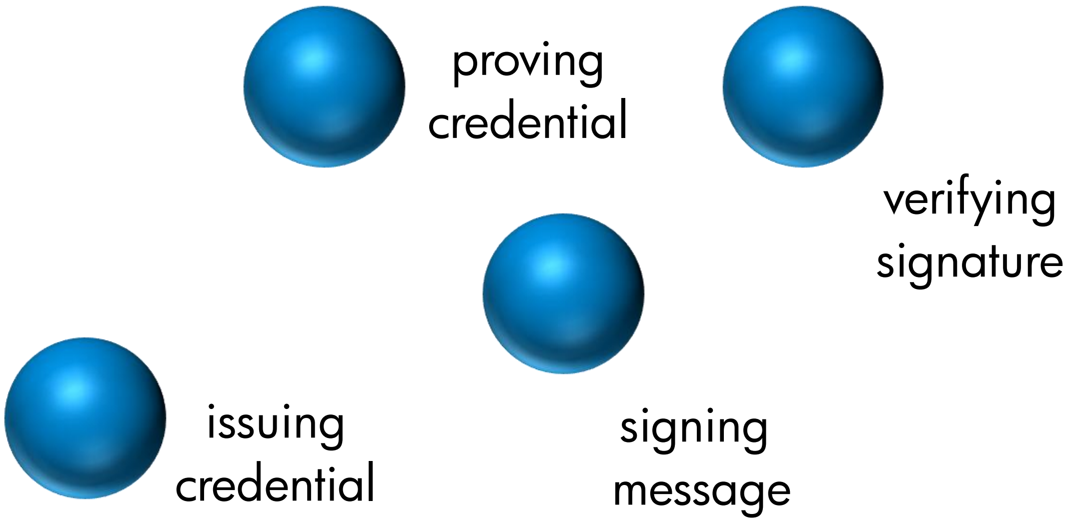
DAA is included in the TPM for consumer use cases

- TPM v1.2 has an RSA-DAA scheme (joint work with Brickell and Camenisch)
  - – which is inefficient
- TCG would like to significantly reduce the cost of DAA to the TPM
  - – There are a lot of academic interests in this area
- We have found several ECDAA solutions with very low cost
  (Joint work with many colleagues: Brickell, Li, Morrissey, Page, Proudler, Smart, …)
- Some solutions might be included in the next generation TPM
- Probably no one is going to be completely happy
  - – Cryptographer: it is not the best solution from our research
  - – Engineer: the DAA scheme still severely distorts the TPM's architecture
    - o Might be able to do better if we had more time

A non cryptographer’s crypto solution

Using engineer’s logic to see crypto

Example 4:
Graeme’s
DAA join



proving credential

verifying signature

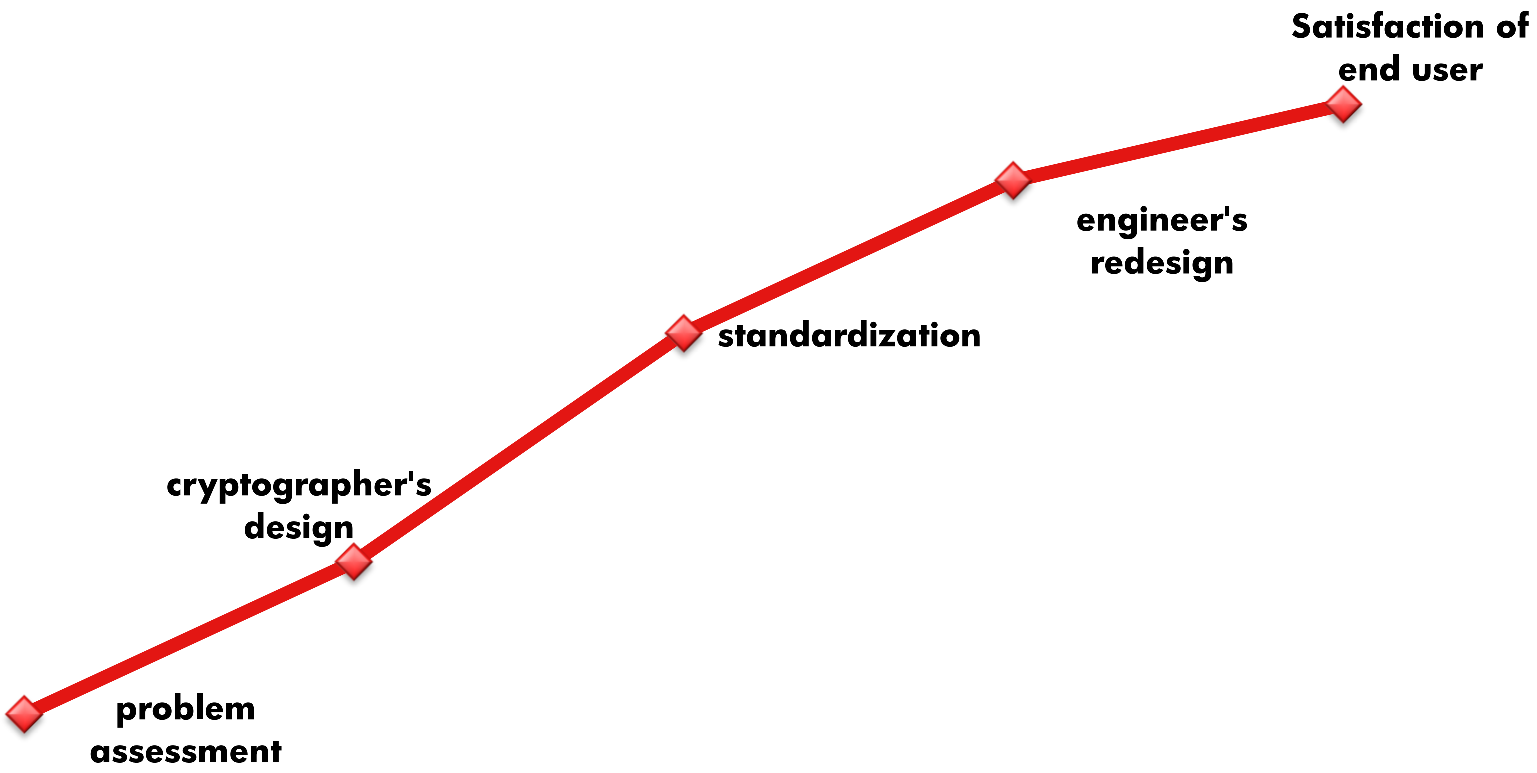
signing message

issuing credential

Graeme’s observation: why prove the credential? Signing a message and verifying the signature is sufficient to carry out the “proving” function.

Cryptography is not solely the domain of cryptographers but also the domain of computer engineers

Stages of cryptographic development



This talk covers the cryptographer's design to the engineer's redesign.

Standards – a bridge

Between cryptographers' cryptographer and engineers' crypto

- Cryptographers and engineers have different ways of thinking and use different languages
- Standards are a bridge between them
- It is much much easier to convince engineers to use a cryptographic mechanism if it appears in some standard(s) than if published in a well-known conference or journal
- Standards help the engineer make a quick and safe decision

Cryptographers and engineers are in the same boat

Please be nice to each other

Cryptography (crypto)

- Gives a lot of pleasure to the cryptographer
- Is just a recipe as far as the engineer is concerned
- Creates a minefield for problems if the engineer needs to tweak the cryptography

On the one hand (cryptographers talking about engineers)

- What they have done is all wrong
- Neither of them can be proved in an acceptable model
- They don't know what they are doing

On the other hand (engineers talking about cryptographers)

- Cryptographers create all the problems
- "Cryptographers are a real pain" -- Graeme Proudler
- "The first thing we do, let's kill all the cryptographers." ---------------- an anonymous engineer

Can we be nicer to each other?

Is cryptographic theory practically relevant?

One way to answer it

Assumptions:

1. Suppose n out of N cryptographers will say YES, $n > \varepsilon$
2. Suppose m out of M engineers will say YES, $m > \varepsilon$

Goals:

A. I want to get my theory published
B. I want to get my theory used

XYZ. The answer to the above question is YES under these two assumptions

Proof (sketch):

- Based on Assumption 1, I have to say YES with Goal A, otherwise my submission will be rejected with a non-negligible probability
- Based on Assumption 2, I have to say YES with Goal B, otherwise my scheme will never be built
- Therefore XYZ follows since A and B are the only two goals we are concerned

□

Thank You!
&
Questions?