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# Lessons Learned from Implementing Privacy-Preserving Protocols for Smart Meters

**Benessa Defend**

**Real World Crypto, London**

**January 9, 2015**

# In Collaboration with

- Klaus Kursawe
- George Danezis
- Markulf Kohlweiss
- Elster
- Alliander

# Publication to Testing to Standardization

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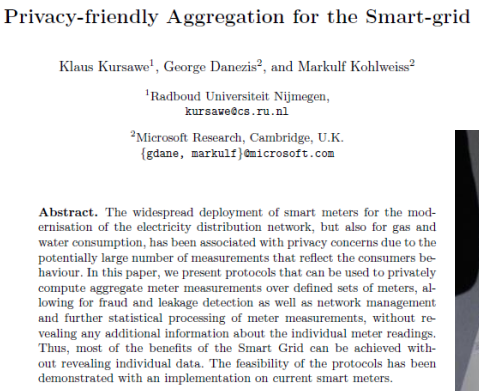

Privacy-friendly Aggregation for the Smart-grid

Klaus Kursawe[1], George Danezis[2], and Markulf Kohlweiss[2]

[1]Radboud Universiteit Nijmegen,
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{gdane, markulf}@microsoft.com

**Abstract.** The widespread deployment of smart meters for the modernisation of the electricity distribution network, but also for gas and water consumption, has been associated with privacy concerns due to the potentially large number of measurements that reflect the consumers behaviour. In this paper, we present protocols that can be used to privately compute aggregate meter measurements over defined sets of meters, allowing for fraud and leakage detection as well as network management and further statistical processing of meter measurements, without revealing any additional information about the individual meter readings. Thus, most of the benefits of the Smart Grid can be achieved without revealing individual data. The feasibility of the protocols has been demonstrated with an implementation on current smart meters.

Conference paper at *Privacy Enhancing Technologies Symposium*


Feasibility test for meter implementation

Proof of concept for robustness, integration and configuration

Implementation of Privacy-Friendly Aggregation for the Smart Grid

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In recent years a number of protocols have been suggested towards privacy-preserving aggregation of smart meter data, allowing electricity network operators to perform a large part of grid maintenance and administrative operations without having to touch any privacy-sensitive data. In light of upcoming European legislation, this approach has gained quite some attention. However, to allow such protocols to have a chance to make it into a real system, it is vital to add credibility by demonstrating that the approach scales, is reasonably robust, and can be integrated into the existing and planned smart metering chains. This paper presents results from integration and scalability tests performed on 100 DLMS/COSEM smart meters in collaboration with a meter manufacturer a
lessons learned,
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Using modern privacy preserving protocols, many of the privacy concerns can be mitigated, while providing the network operators with all of the data they need for grid operations, potentially with even higher data quality. The most prominent class of protocols in this respect are aggregation protocols, in which the sum of readings from multiple meters is computed without revealing the individual meter readings themselves. This is done by homomorphic encryption, i.e., encrypting the readings in a way that the encrypted ciphertexts can be added up, and the sum of ciphertexts – and only the sum– can then be deciphered to show the sum of the plaintexts. This approach, where applicable, is superior to collecting data and then restricting access to it (which

dlms

DLMS_GXX_PETS_V02_MJCG130605.doc

DLMS/COSEM Contributions 3:

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- ☒ Conformance testing (Yellow book)
- ☐ DLMS/COSEM client

Input for standardization

# Smart Grid 101

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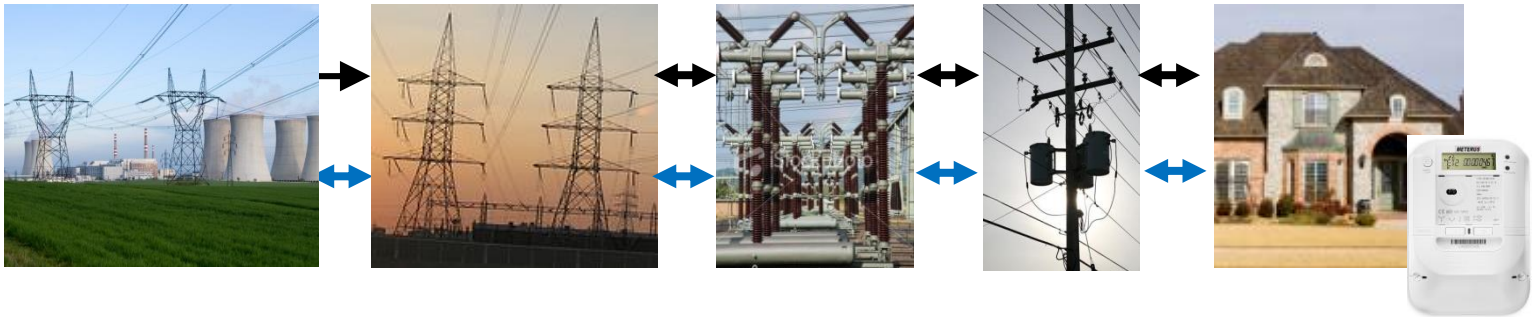
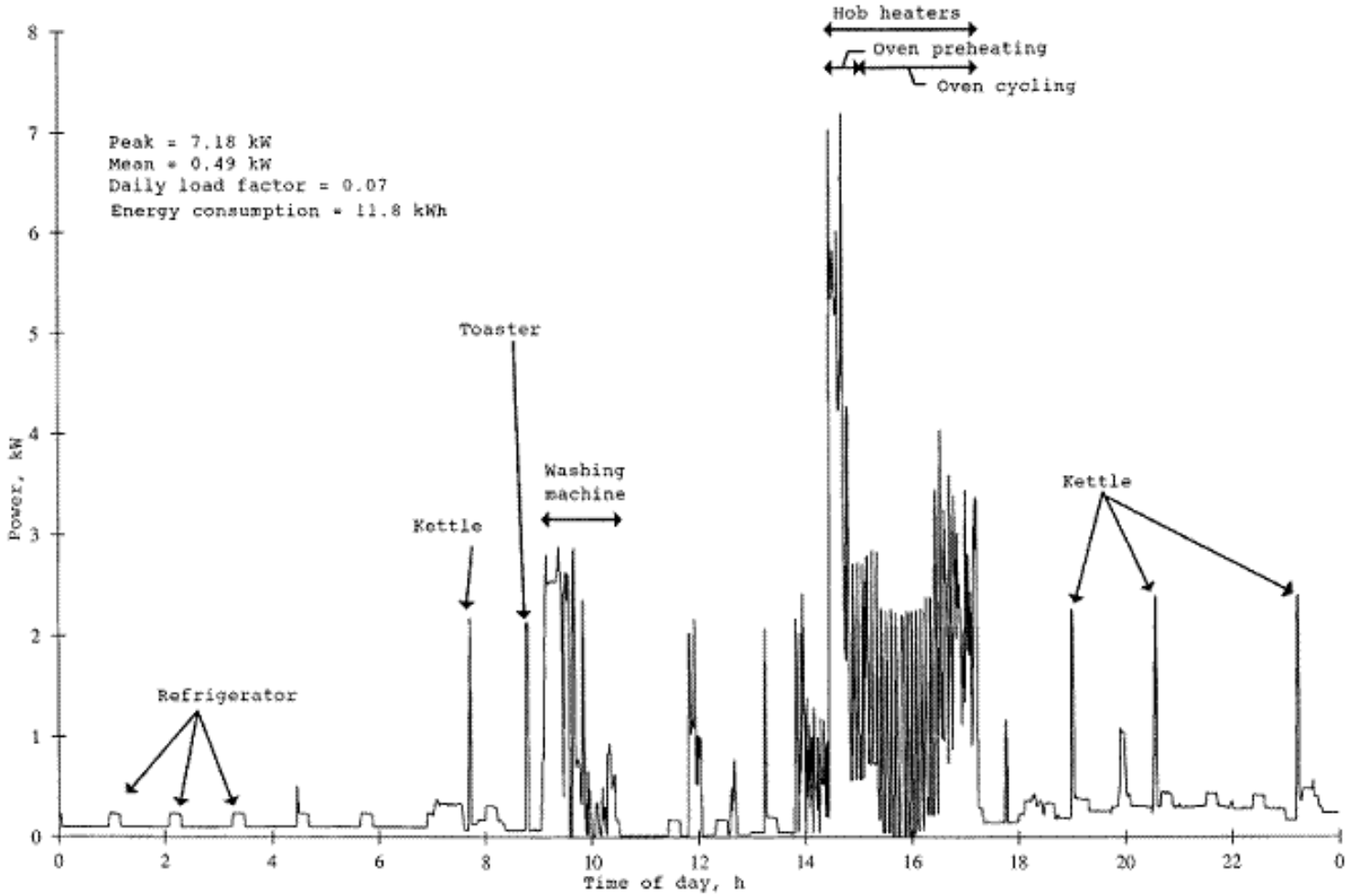
Energy **and information** flows in many directions, from generation to grid or building, from utility to customers, etc.



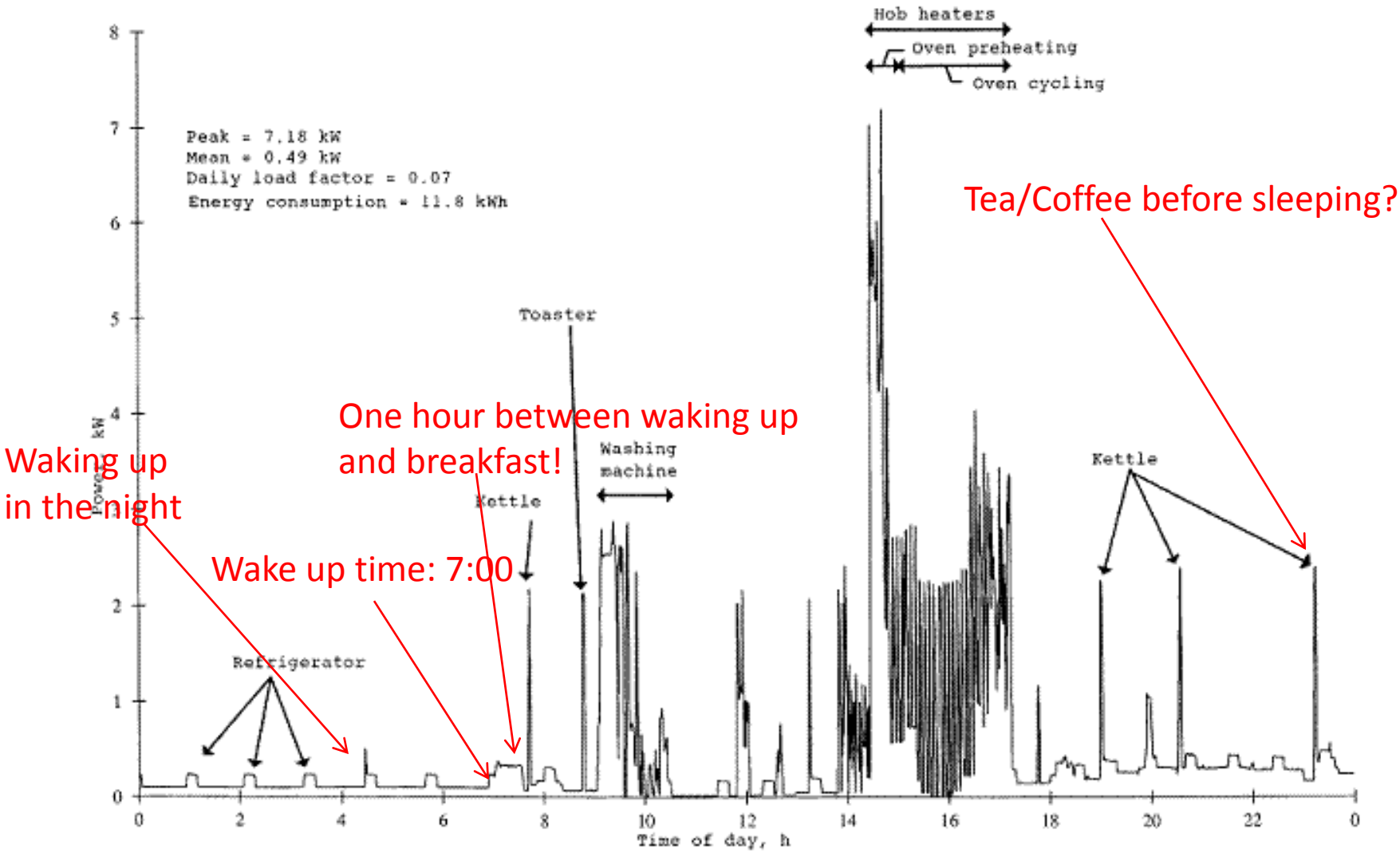

Smart meter data is useful for managing the grid, handling power outages, etc.

# However, smart meter data…




Elias Leake Quinn, Smart Metering & Privacy: Existing Law and Competing Policies, Spring 2009

# … is revealing.



# Legal Ramifications: EU Member States

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- General Data Protection Regulation: up to 2% of worldwide revenue fine for data protection violations
- In negotiation: may increase to 5% or 100 million euros

EUROPEAN COMMISSION

Brussels, 25.1.2012
COM(2012) 11 final

2012/0011 (COD)

Proposal for a

**REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL**

**on the protection of individuals with regard to the processing of personal data and on the free movement of such data (General Data Protection Regulation)**

(Text with EEA relevance)

{SEC(2012) 72 final}
{SEC(2012) 73 final}

European Commission, General Data Protection Regulation, COM(2012) 11 final

# Legal Ramifications: NL

- Dutch Senate blocked 2 smart meter bills in 2009 due violations of the Dutch Data Protection Act
- Grid operators had to halt smart meter rollout and lost millions in investments

**Smart metering and privacy in Europe: lessons from the Dutch case**

Colette Cuijpers and Bert-Jaap Koops

Tilburg Institute for Law, Technlogy, and Society (TILT), Tilburg University, The Netherlands

{cuijpers, e.j.koops}@tilburguniversity.edu

**Abstract.** The future of energy supply lies in smart grids, which enable energy supply to and from consumers. These two-way energy networks require smart energy metering systems. The vision of smart grids will require one or more decades yet to be fully realised, but since a roll-out of smart meters is a lengthy process, countries are already starting to implement smart metering legislation, following the European legal framework on energy efficiency. Rolling out smart meters, however, requires smart legislation. The Dutch example, where the Senate blocked two smart metering bills in 2009, demonstrates that introducing smart meters can be significantly delayed if the underlying legislation is flawed. In particular, the Dutch case shows that privacy is a crucial element in smart metering legislation. Energy consumption reveals details of personal life, in the most privacy-sensitive place – the home, and therefore smart metering has to strike a careful balance between detailed energy metering and privacy protection.

In this paper, we present the recent developments in smart metering and describe the Dutch case in detail. From this, we draw key lessons for countries that want to introduce smart metering. In terms of substance, the level of detail of smart meter readings and the mandatory or voluntary character of smart meters are crucial issues to take into account. Legislators must make a trade-off between the 'smartness' of the meter versus a comprehensive, mandatory roll-out. In terms of procedure, a privacy impact assessment is vital, and pitfalls of function creep should be avoided by resisting the temptation of making a meter 'too smart' all at once. From the outset, privacy and data protection law must be taken into account as an important requirement for the design of smart metering systems.

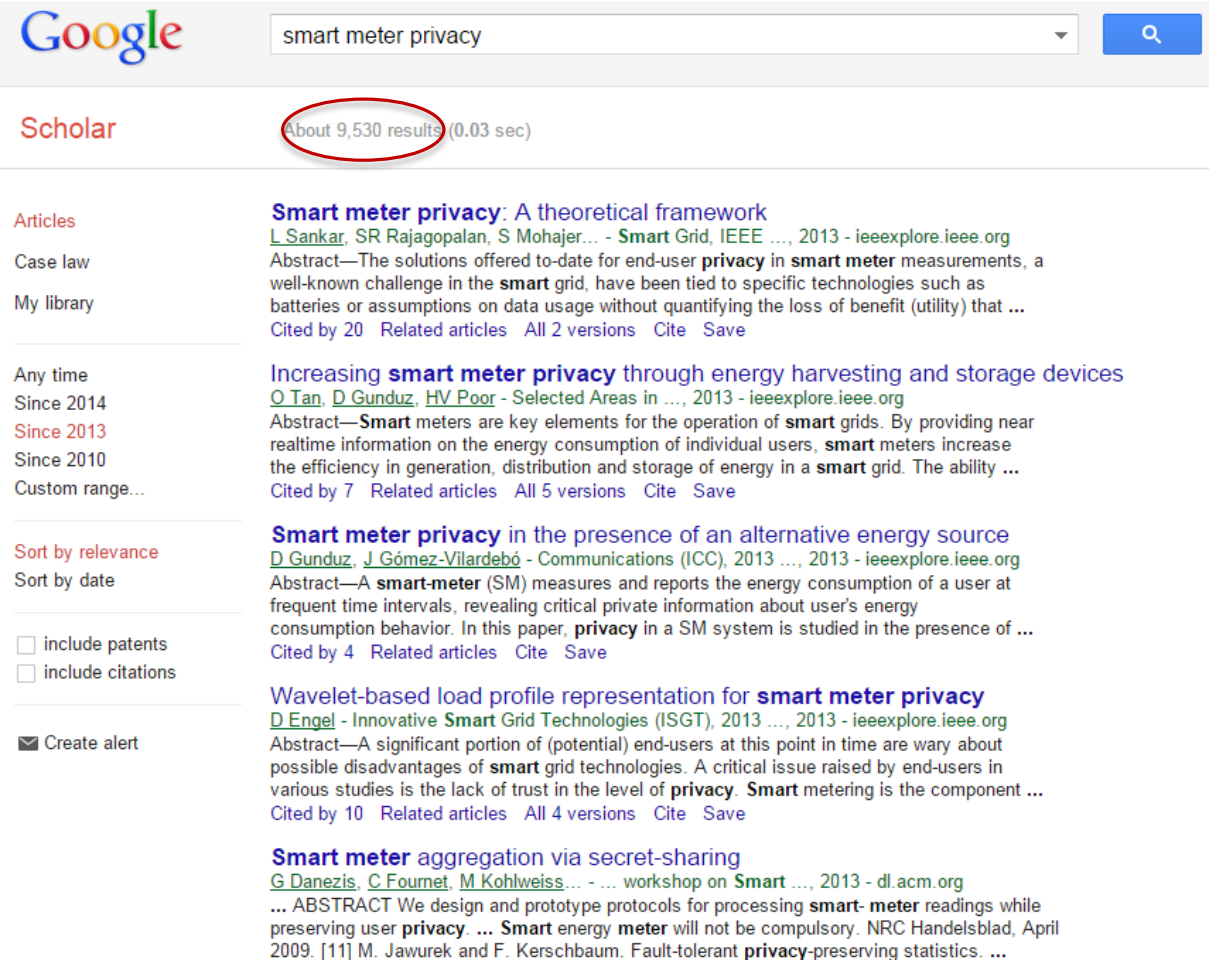
**Keywords:** Smart metering, energy, privacy, data protection, Europe, the Netherlands

adfa, p. 1, 2011.


https://pure.uvt.nl/portal/files/1477311/CPDP_final_Cuijper_Koops_springer_1_.pdf

# Privacy Approaches

- Aggregation
- Homomorphic Encryption
- Differential Privacy
- Rechargeable Batteries
- Anonymization Pseudonymization
- Trusted Platform Module



# Picking a Protocol to Implement & More

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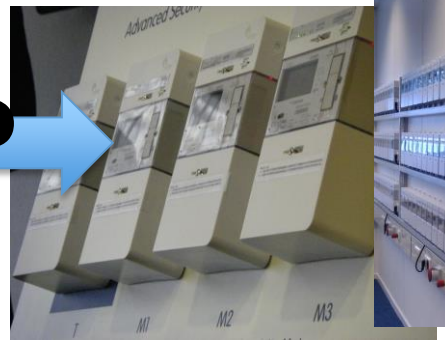


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dlms device language message specification

DLMS_GXX_PETS_V02_MJCG130605.doc

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# Implementation

- Implementation in Perl*
  1. Diffie-Hellman-based aggregation protocol
  2. Dining Cryptographers-based low-overhead aggregation protocol
  3. Billing protocol
- Implementation on 4 meters (and later 100)
  - Low-overhead aggregation protocol only


*by George Danezis

# Understanding Requirements

1. Meter Restrictions - cost, computing power, memory
2. Bandwidth - limited bandwidth, geography
3. Security Architecture - network topologies
4. Protocol Integration - integration into existing standards
5. Use cases – understand what data is needed

**Result**: implemented low-overhead aggregation instead of more feature-rich & robust protocols

# Lessons Learned

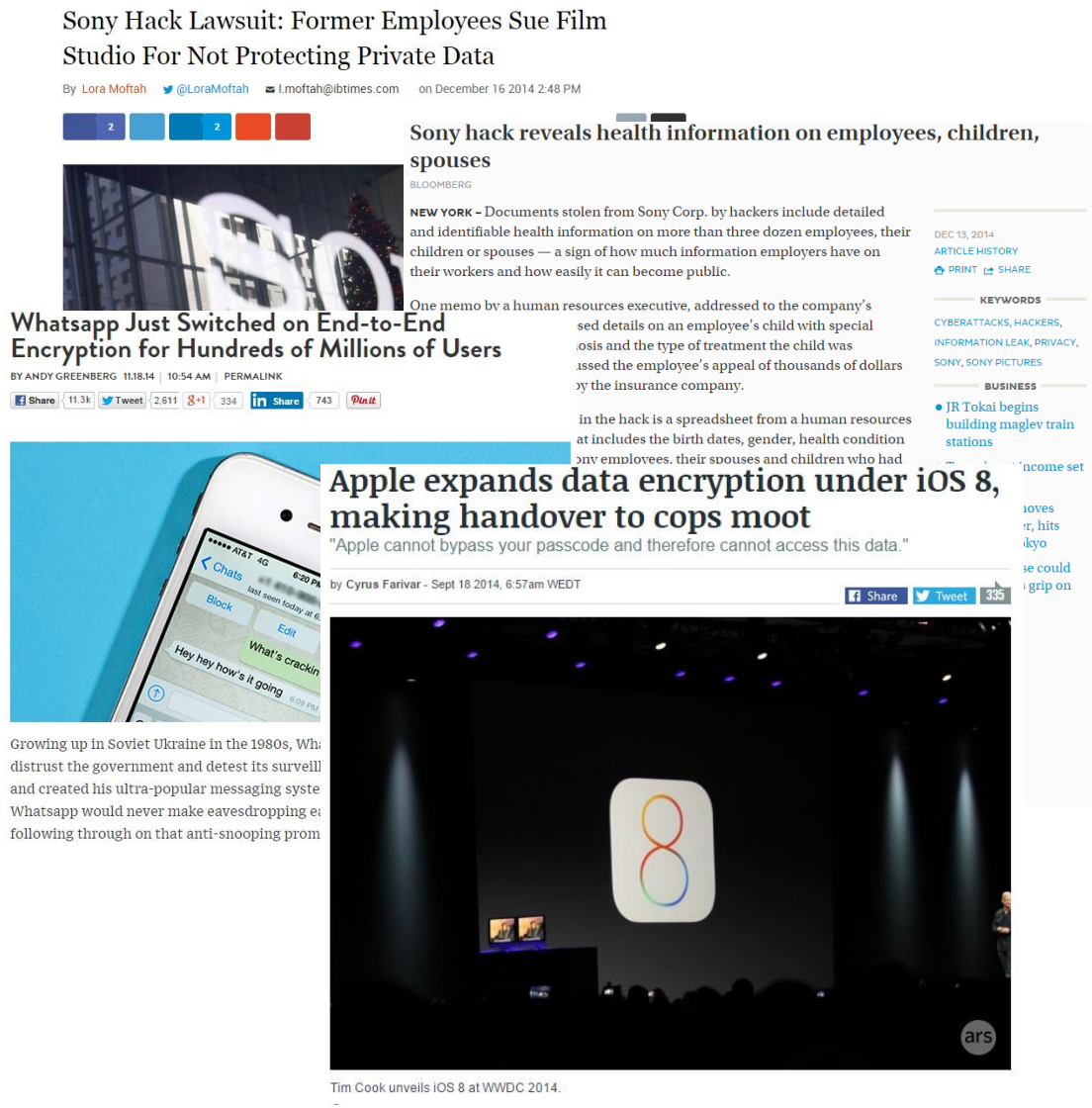
1. Define the use cases
2. Selling privacy
3. Provide clear explanations
4. Ease of integration vs. Feature richness
5. Importance of standardization
6. Working prototypes
7. Patience

# Define the Use Cases

- Interview potential users
  - What kind of data do you need?
  - If I was the privacy fairy and could eliminate all privacy restrictions, what kind of information would you want?
- Usually only a derivative of private data is needed

# Selling Privacy

- Frame as business enabler
- With privacy:
  - Legal access to data you couldn't get otherwise
  - Easier DPIA
  - No private data to protect
  - No bad press from accidental loss or theft of private data



Sony Hack Lawsuit: Former Employees Sue Film Studio For Not Protecting Private Data

By Lora Moftah @LoraMoftah l.moftah@ibtimes.com on December 16 2014 2:48 PM

Sony hack reveals health information on employees, children, spouses

BLOOMBERG

NEW YORK – Documents stolen from Sony Corp. by hackers include detailed and identifiable health information on more than three dozen employees, their children or spouses — a sign of how much information employers have on their workers and how easily it can become public.

One memo by a human resources executive, addressed to the company's

DEC 13, 2014
ARTICLE HISTORY
PRINT SHARE

KEYWORDS

CYBERATTACKS, HACKERS, INFORMATION LEAK, PRIVACY, SONY, SONY PICTURES

BUSINESS

- JR Tokai begins building maglev train stations

Whatsapp Just Switched on End-to-End Encryption for Hundreds of Millions of Users

BY ANDY GREENBERG 11.18.14 | 10:54 AM | PERMALINK

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Growing up in Soviet Ukraine in the 1980s, Wha
distrust the government and detest its surveill
and created his ultra-popular messaging syste
Whatsapp would never make eavesdropping ea
following through on that anti-snooping prom

Apple expands data encryption under iOS 8, making handover to cops moot

"Apple cannot bypass your passcode and therefore cannot access this data."

by Cyrus Farivar - Sept 18 2014, 6:57am WEDT

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Tim Cook unveils iOS 8 at WWDC 2014.

# Importance of Clear Explanations

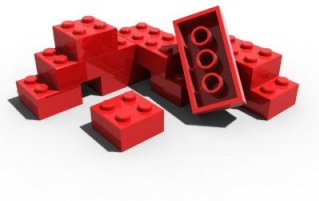
- Good metaphors
- Intuitive examples
- Explaining one-way functions using Lego:

# Lego Example: Homomorphic One-Way Functions

$x \rightarrow g^x$

+

+



$y \rightarrow g^y$

=

=

$x*y \rightarrow g^{x+y}$

# Ease of Integration vs. Feature Richness

- Optimize protocol and parameters for easy integration
  - Deep changes require more effort and money
- Fewer changes means it is more likely to be adopted
  - Add-on to standard
  - No changes to central system
  - Only small changes to meter firmware
- Simple protocol might be better than a fancy protocol
  - Very low overhead vs. more features

# Importance of Standardization

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- Ensure widespread adoption - individual companies don't have to seek out their own solution
- Create an add-on vs. major change

# Working Prototypes

- Need to prove it works
- Small implementation for feasibility
- Large scalability, integration, robustness tests


4 Meters

100 Meters

# Patience: 2011 - Now

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PETS
Publication

Implementation:
4 Meters

Scalability & Integration
Tests: 100 Meters

**2011** **2012** **2013**

Working Groups
Talking to Industry

TASK FORCE SMART GRIDS

EXPERT GROUP 2: REGULATORY RECOMMENDATIONS FOR DATA SAFETY, DATA HANDLING AND DATA PROTECTION

REPORT

ISSUED: FEBRUARY 16, 2011

Interviews

Input for
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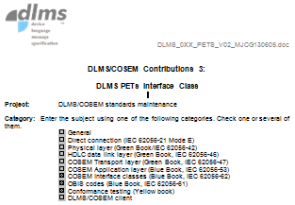

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# Conclusions

- Use good examples
- Privacy as business enabler
- Ease of integration can trump fancy features
  - But don’t exclude use cases!
- Make sure all required properties are included – hard to make changes later
- Standardization can lead to widespread adoption

# Questions

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