A Privacy-Enhancing Protocol that Provides In-Network Data Aggregation and Verifiable Smart Meter Billing

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Outline

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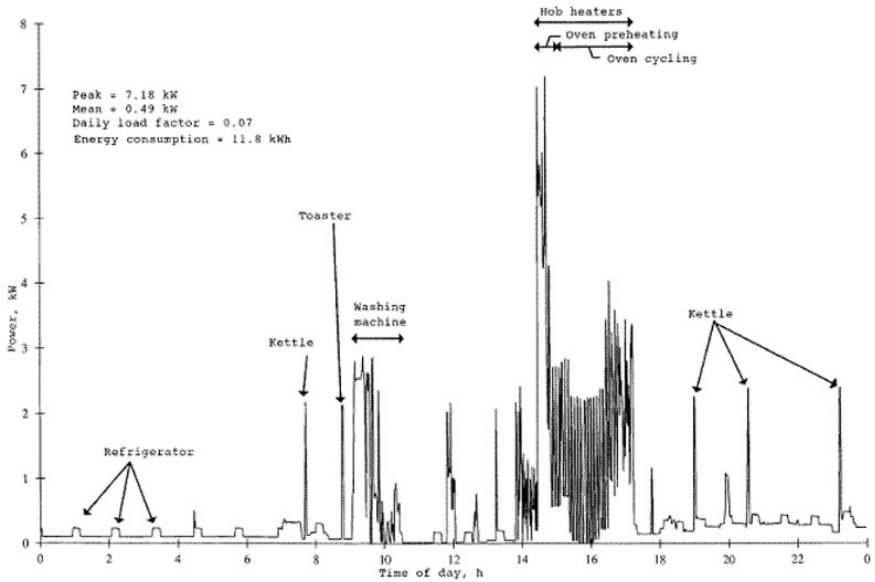
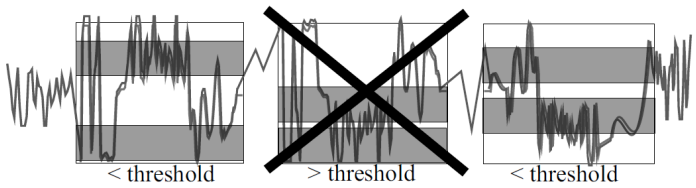
Privacy Problem



[NIST]



output matches to logfile

movie tng1
chunk 1 at 2103h

movie tng1
chunk 3 at 2113h

[Greveler et al., 2012]

Deployment

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80% of households equipped with smart meters by 2020 in EU [EUD, 2012]

Spatiotemporal consumption

Consolidated Measurements and Verifiable Billing

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Time Slot	$t = 1$	$t = 2$	$\cdots$	$t = T$	Bill
Customer 1 	m_{1_1}	m_{1_2}	$\cdots$	m_{1_T}	$\sum_{t=1}^{T} m_{1_j}$
Customer 2 	m_{2_1}	m_{2_2}	$\cdots$	m_{2_T}	$\sum_{t=1}^{T} m_{2_j}$
$\vdots$ 	$\vdots$	$\vdots$	$\ddots$	$\vdots$	$\vdots$
Customer N 	m_{N_1}	m_{N_2}	$\cdots$	m_{N_T}	$\sum_{t=1}^{T} m_{N_j}$
Consumption	$\sum_{i=1}^{N} m_{i_1}$	$\sum_{i=1}^{N} m_{i_2}$	$\cdots$	$\sum_{i=1}^{N} m_{i_T}$	✓

Time Series

One Round of Measurements

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- e-voting
- mobile sensing
- sensor networks
- e-cash

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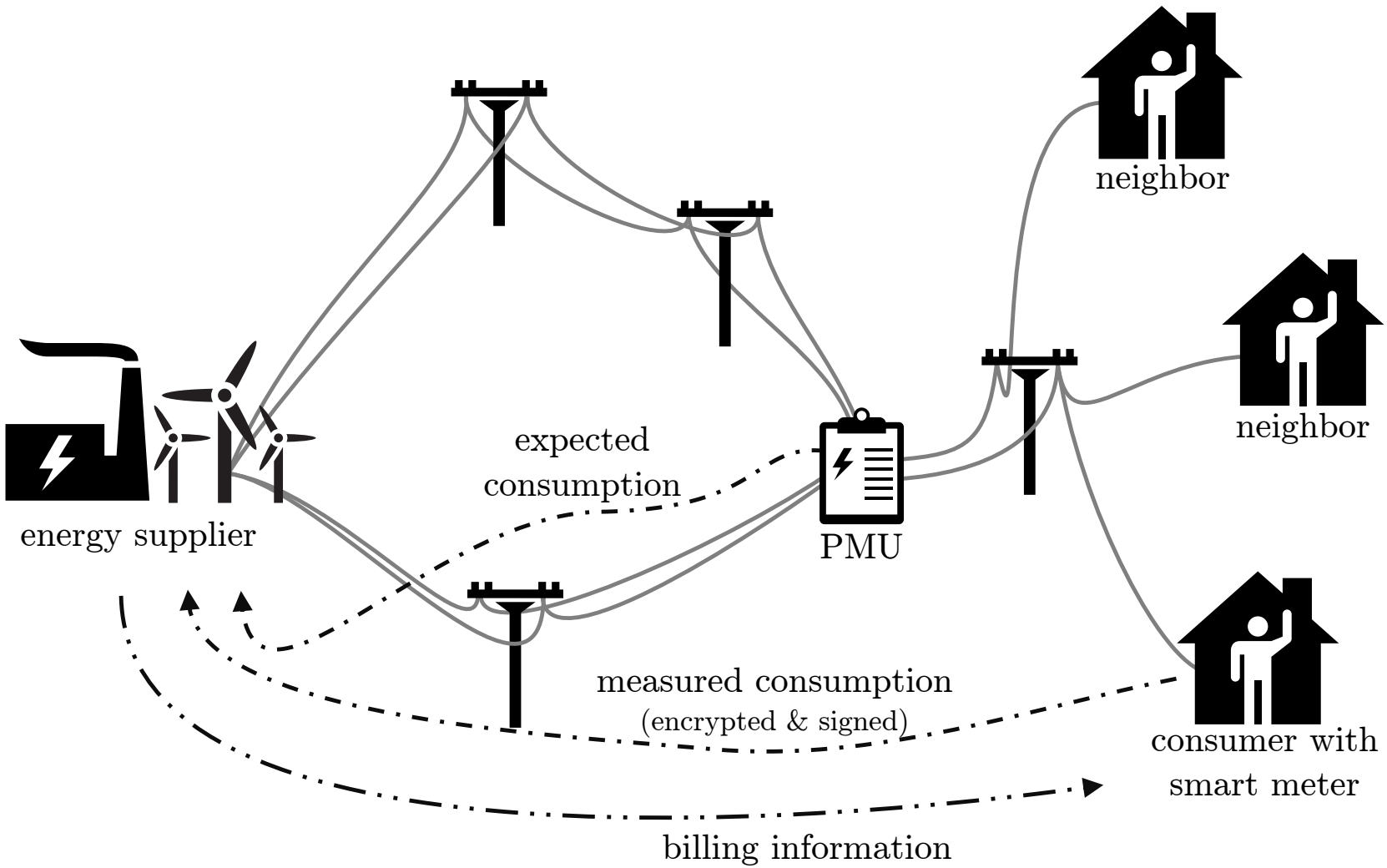
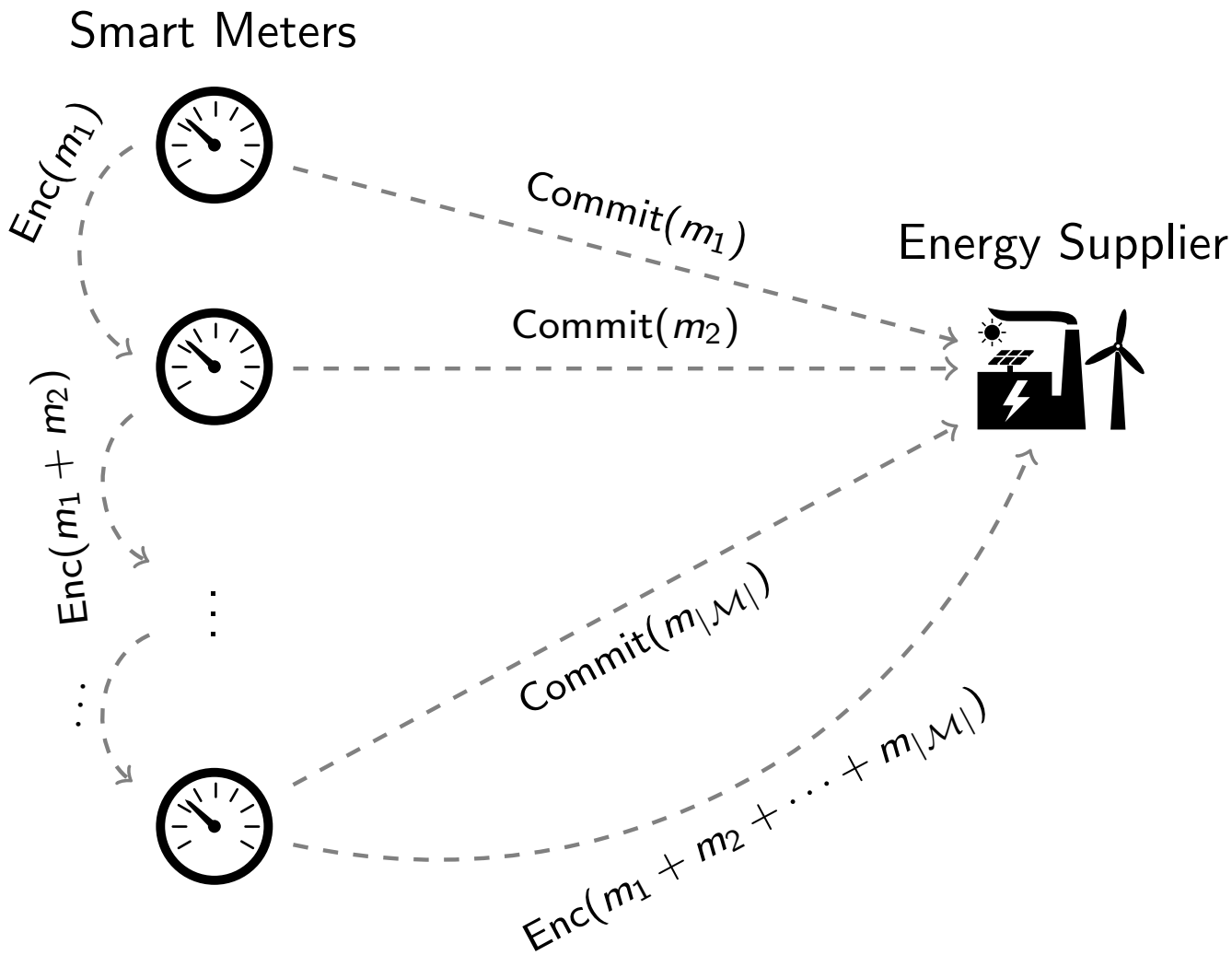
Smart Grid Scenario

with a phasor measurement unit (PMU)



Communication Model



Cryptographic Primitive

Commitment with a matching homomorphic encryption

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Paillier Cryptosystem:

$$\mathrm{Enc}(m) = \mathrm{Enc}(m, s) = \gamma^m \cdot s^N \mod N^2$$

Pedersen Commitments:

$$\mathrm{Commit}(m, r) = g^m \cdot h^r \mod p$$

Matching: commitments take place in the order N subgroup of $\mathbb{Z}^*_{4N+1}$, where $4N + 1$ is a prime number.

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Further Work

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Further Reading:

- IEEE CNS 2014
- iKUP Keeps Users' Privacy in the Smart Grid
- [Borges and Martucci, 2014]

Further Work:

- efficient cryptographic primitives
- communication complexity
- privacy in e-vehicle to grid

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Conclusion

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- Privacy-preserving protocols should have:
  - Consolidated Consumption
  - Billing
  - Verification
- Commitment with a matching homomorphic encryption

Thank You!

Any comments and suggestions are welcomed.
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