# Sender-Binding Key Encapsulation

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# Preliminaries

- Universal Composability (UC) Framework [3]
- Notions of
  - weak CCA for Tag-based encryption (TBE) or (tag-based) Key encapsulation mechanism (KEM)
  - IND-OT and (R)CCA Data encapsulation mechanism (DEM)
- Hybrid PKE – the KEM/DEM Paradigm, e.g. [7]

# Motivation

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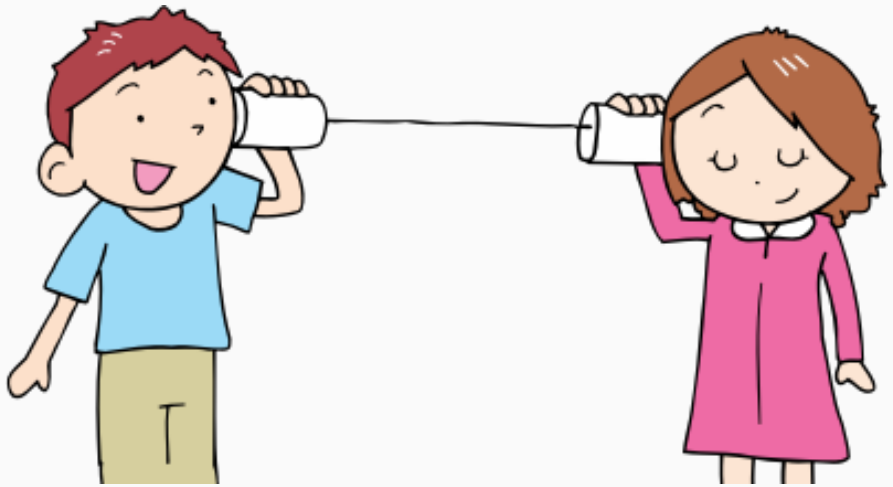
- Only CCA2 secure PKE is not enough
  - A Relay-Attack is still possible
  - Authenticated channels are a requirement
- What is an authenticated channel? $\rightarrow$ e.g. a secure signature scheme combined with a secure certification authority



# Motivation

CCA2 security is unncessarily strong ([4, 2, 11])

→ The non-malleability of information passing through an authenticated channel **overlaps** with the non-malleability of the employed IND-CCA2$_{\text{PKE}}$ secure PKE.

# Motivation

This motivation was adressed recently in [2] by showing that a PKE does not to need to be stronger than **sender-binding CPA**.

# Motivation

What about hybrid encryption?

# Related Work

# Related Work on the KEM/DEM Paradigm

Relaxations considering only the DEM

- Shoup [13] showed: IND-CCA2$_{\text{KEM}}$ + IND-CCA2$_{\text{DEM}}$ yields an IND-CCA2$_{\text{PKE}}$ secure PKE as a result.
- First relaxation in [6] to a one-time-IND-CCA2$_{\text{DEM}}$ (sometimes called IND-OTCCA [7]).
- One main finding of Herranz, Hofheinz and Kiltz in [7] was that CCA2 security could so far **only** be reached via a CCA2 secure KEM in conjunction with IND-OTCCA DEM.
- Abe et al. [1] showed IND-CCA2$_{\text{tag-KEM}}$ KEM + IND-OT$_{\text{DEM}}$ DEM yields an IND-CCA2$_{\text{PKE}}$ secure PKE as a result. (This work subsumes the Kurosawa-Desmedt-KEM + DEM from [10])

# Related Work on the KEM/DEM Paradigm

Relaxations considering only the KEM

- Constrained CCA from Hofheinz and Kiltz [8]
- Bounded CCA from Cramer et al. [5]
- Detectable CCA from from Hohenberger et al. [9]
- Replayble CCA from Canetti et al. [4]

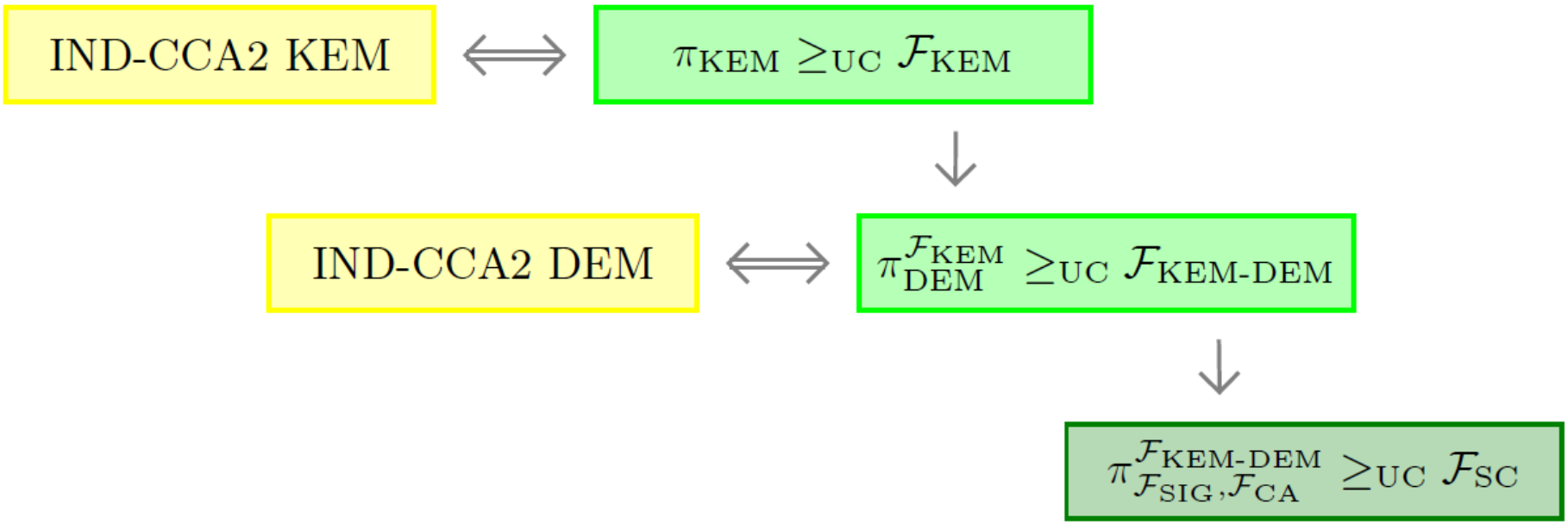
# Related Work's Main Motivation

**A CCA2 secure hybrid PKE $\neq$ Our Motivation**

Moreover, these works consider only the "Single Message Transfer" scenario (e.g., secure e-mail communication)

# Related Work on KEMs and Secure Channels in Universal composability (UC)

Session communication scenario from KEMs by Nagao, Manabe and Okamoto [12] (e.g., SSL, IPSec, SSH)




$\rightarrow$ Is the $\text{CCA2}_{\text{KEM}}$ security necessary?

# Contribution

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We introduce two formal notions

- Sender-binding Key encapsulation mechanism (SB-KEM)

  $\mathit{gen} : 1^\lambda \mapsto (sk, pk), \quad \mathit{enc} : (pk, S) \mapsto (K, C), \quad \mathit{dec} : (sk, S, C) \mapsto K$

- Indistinguishability under Sender-binding chosen plaintext attack (IND-SB-CPA) for SB-KEMs

# Single Message Scenario

$$\text{SB-CPA KEM} + \text{OT DEM} \Rightarrow \text{SB-CPA SBE}$$

From [2] we may conclude that this encryption realizes a secure channel in a $F_{AUTH}$ hybrid model.

# Session Communication Scenario

We generalize and relax the results from Nagao, Manabe and Okamoto [12].

$$\pi_{\mathrm{MSC}}^{\mathcal{F}_{\mathrm{AUTH}}} \geq_{\mathrm{UC}} \mathcal{F}_{\mathrm{MSC}}$$

# Intuition of IND-SB-CPA$_{\text{SB-KEM}}$

- IND-SB-CPA$_{\text{SB-KEM}}$ requires
  - **non-malleability of the sender identity** $\rightarrow$ decaps oracle $\mathcal{O}_{\text{SB-CPA}}$
  - **semantic security of the message** $\rightarrow$ indistinguishability experiment
- The authenticated channel protects the rest

# Definition of IND-SB-CPA$_{\text{SB-KEM}}$

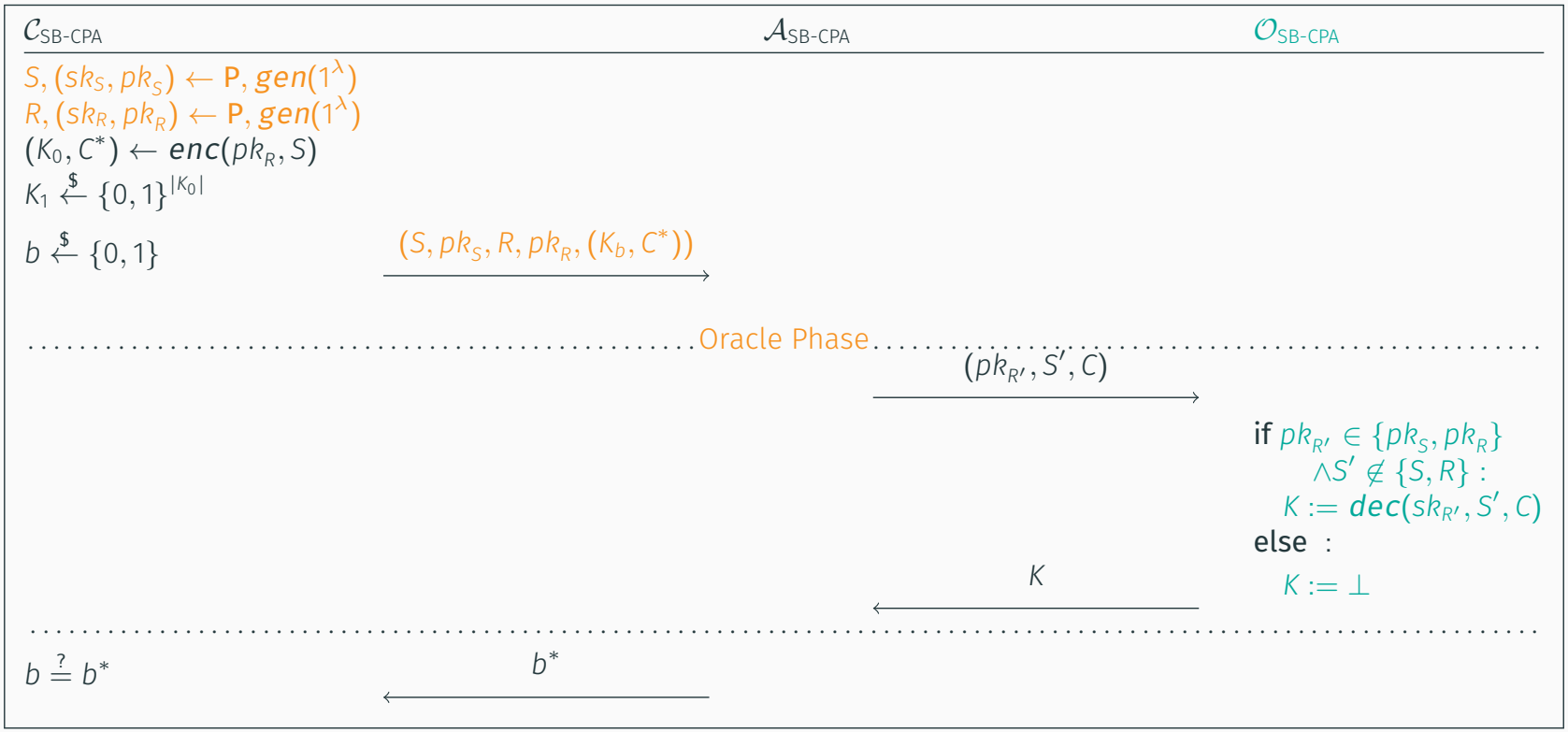
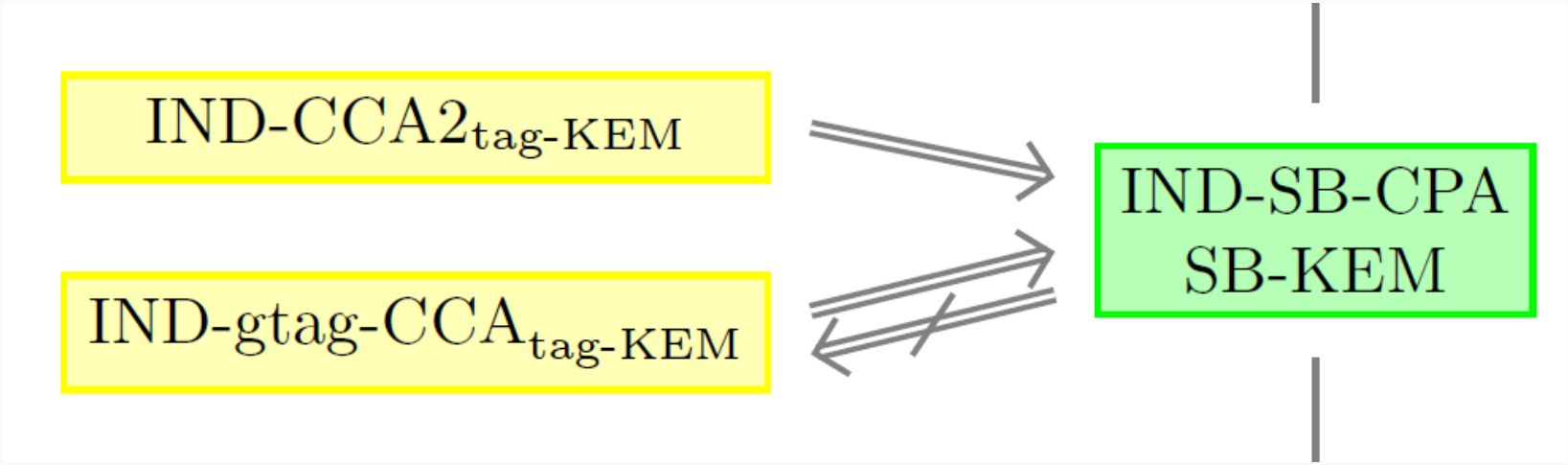



**Figure 1:** The IND-SB-CPA$_{\text{SB-KEM}}$ Game for SB-CPA$_{\text{SB-KEM}}$

# How weak is IND-SB-CPA$_{\text{SB-KEM}}$?

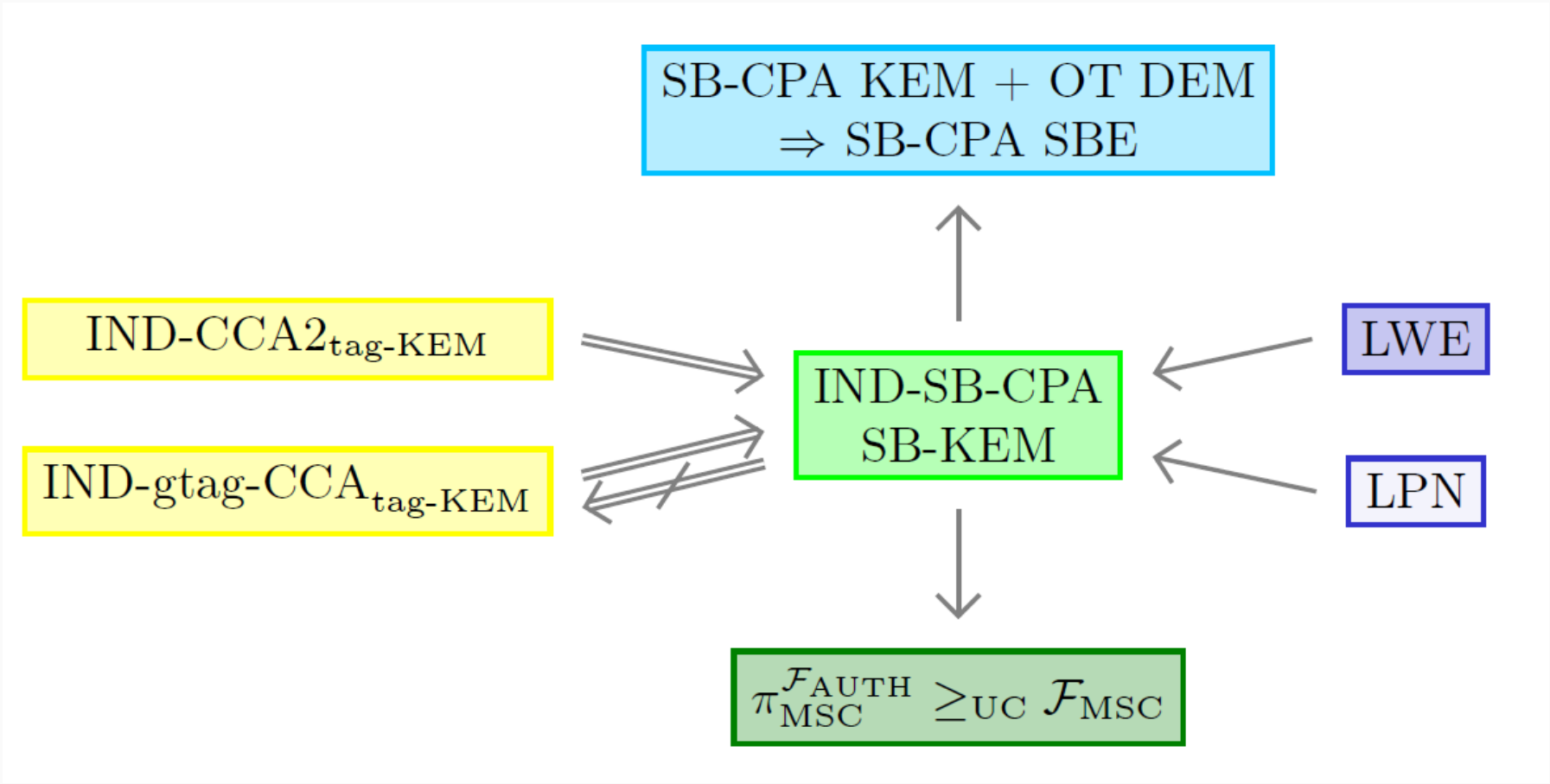


# Conclusion

# Frequent Misunderstandings

- IND-SB-CPA$_{\text{SB-KEM}}$ is **not** a replacement of CCA2
- IND-SB-CPA$_{\text{SB-KEM}}$ is **not** limited to constructions in the standard model

# Summary


SB-CPA KEM + OT DEM
⇒ SB-CPA SBE
IND-CCA2tag-KEM
IND-gtag-CCAtag-KEM
IND-SB-CPA
SB-KEM
LWE
LPN
$\pi_{\mathrm{MSC}}^{\mathcal{F}_{\mathrm{AUTH}}} \geq_{\mathrm{UC}} \mathcal{F}_{\mathrm{MSC}}$

Questions?

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# Summary

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