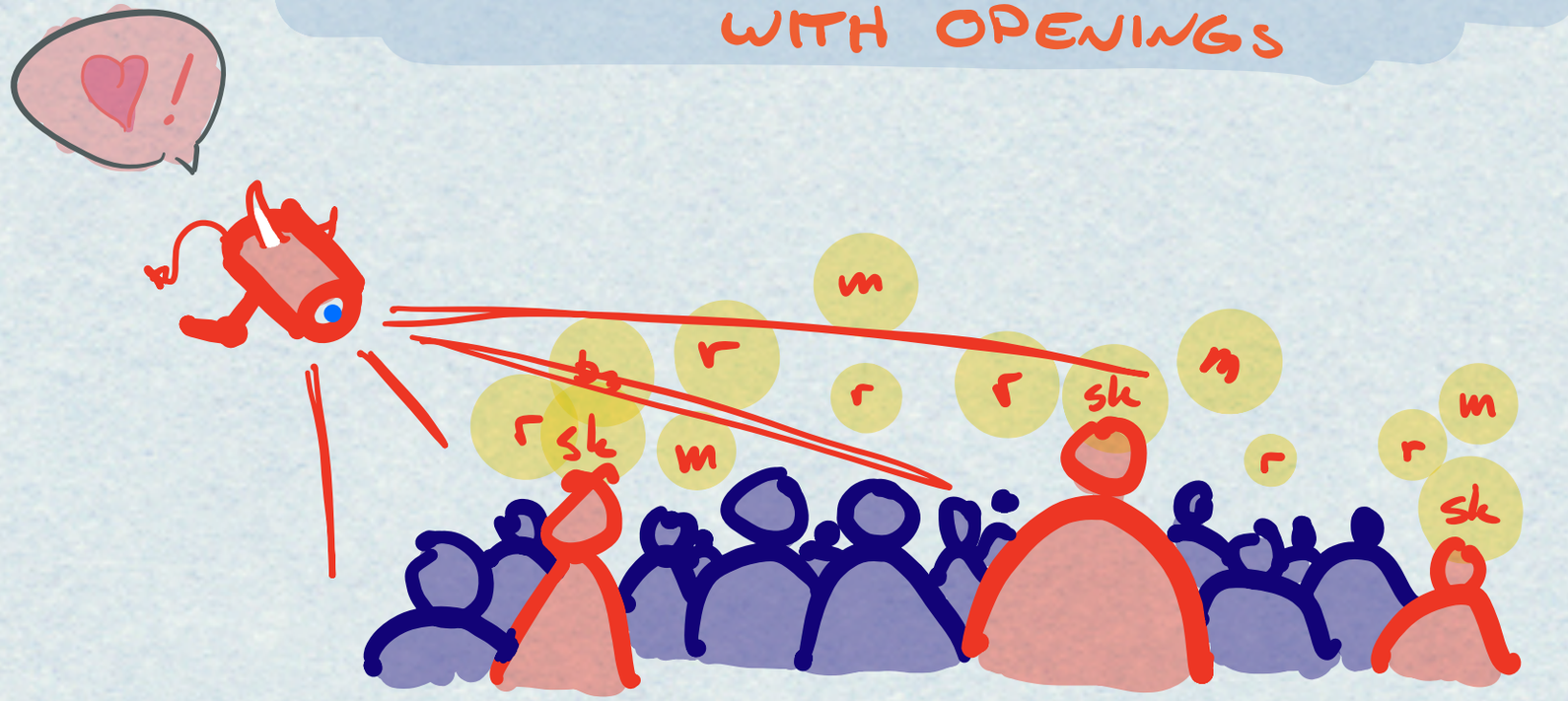
SoK: Public-Key Encryption with Openings



Hans Heum

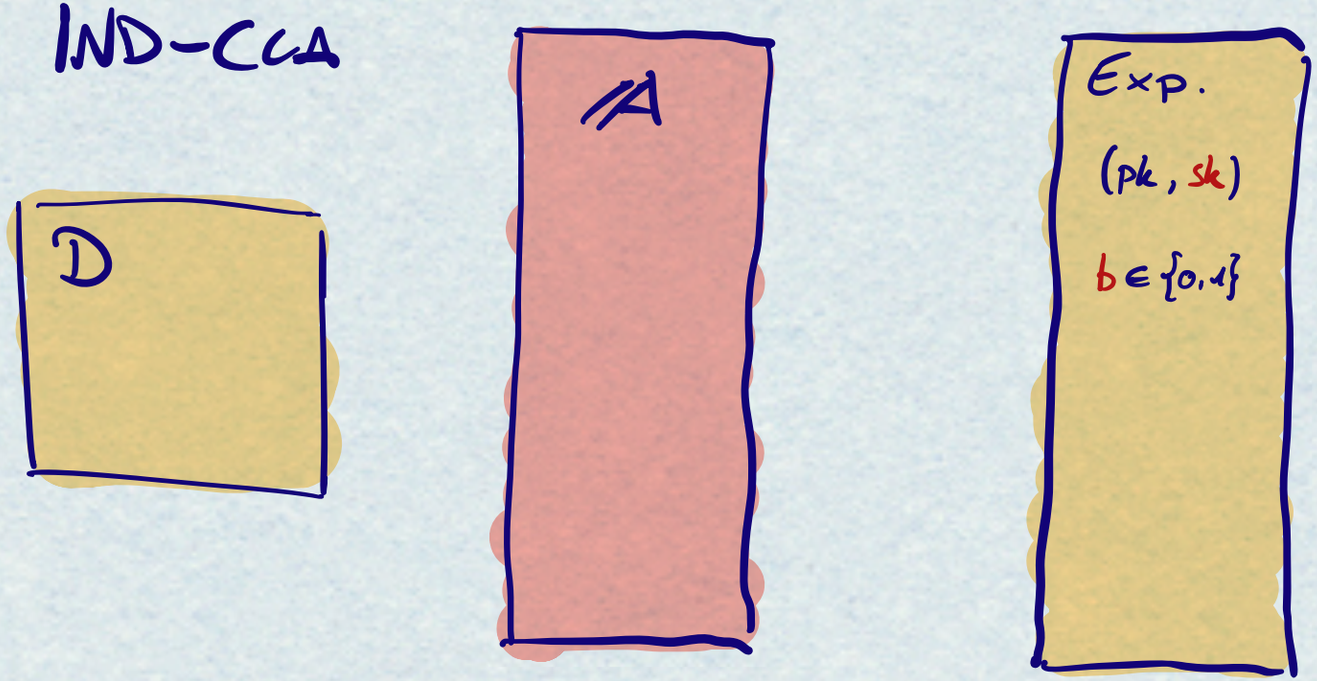
NTNU

with Carlo Brunetta and Martijn Stam

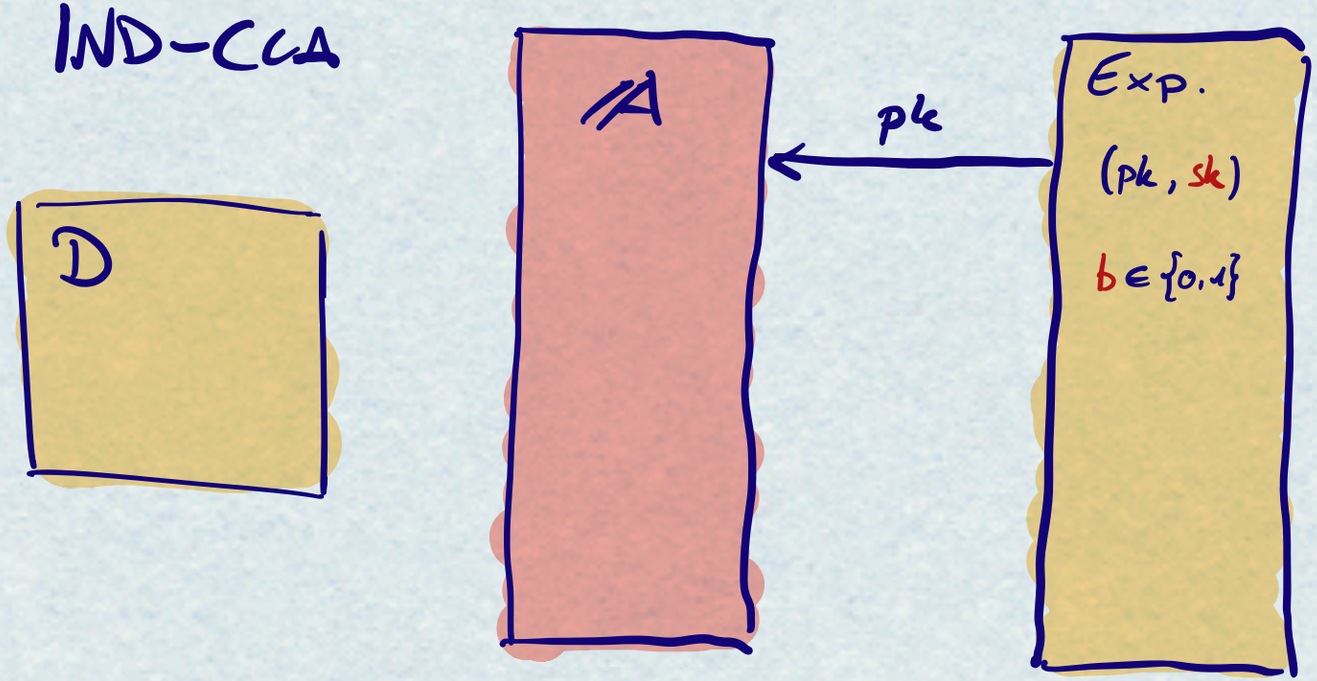
Simula UiB

Standard Security: Indistinguishability against Chosen-Ciphertext Attacks

IND-CCA



STANDARD SECURITY: INDISTINGUISHABILITY AGAINST CHOSEN-CIPHERTEXT ATTACKS



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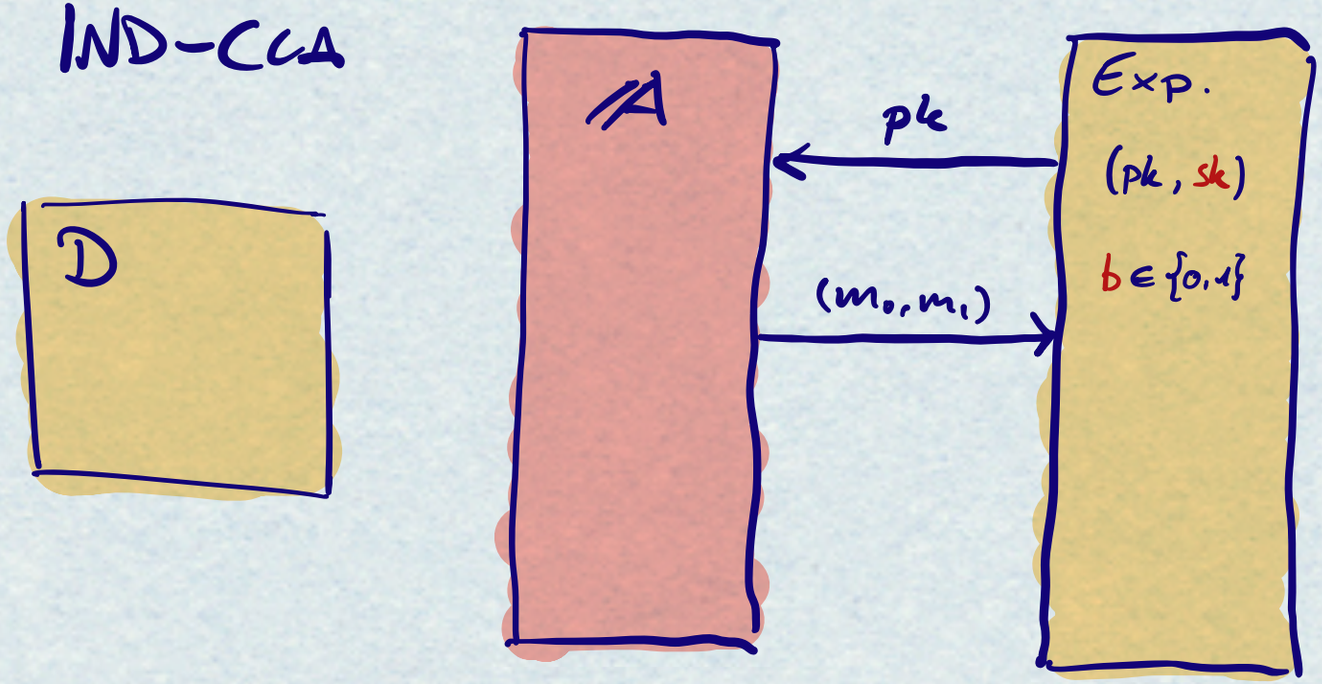

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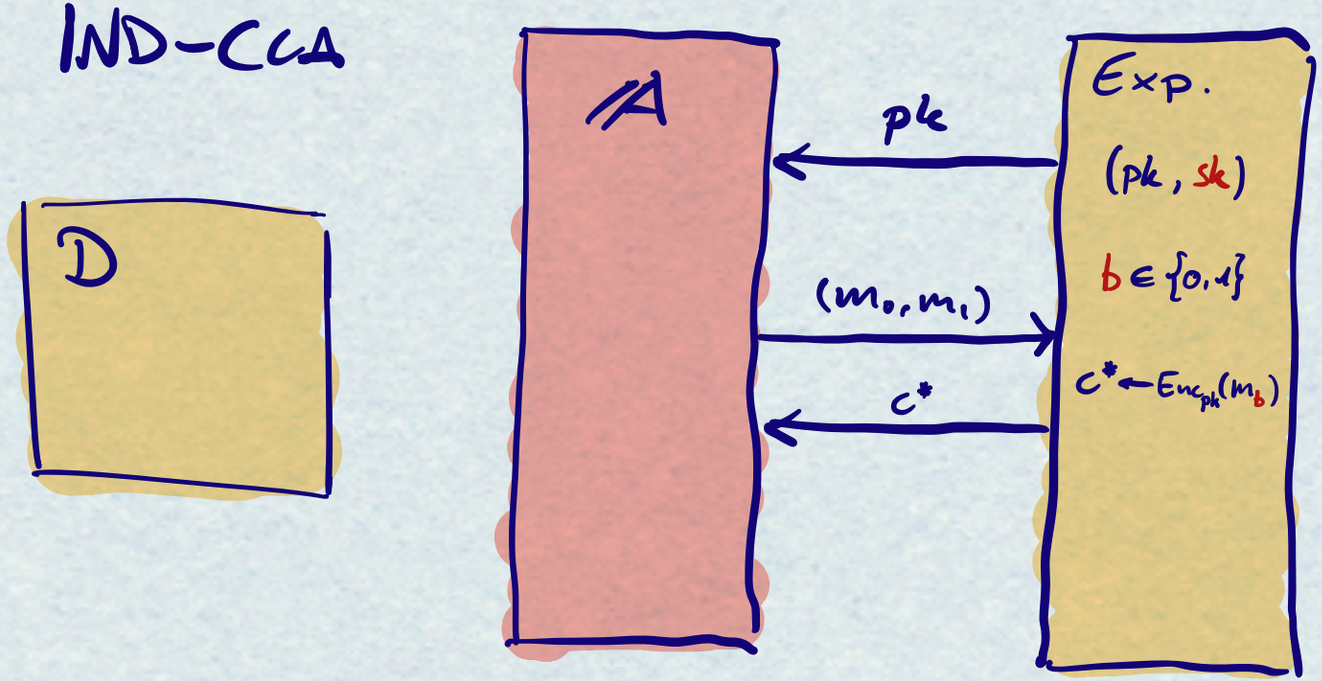

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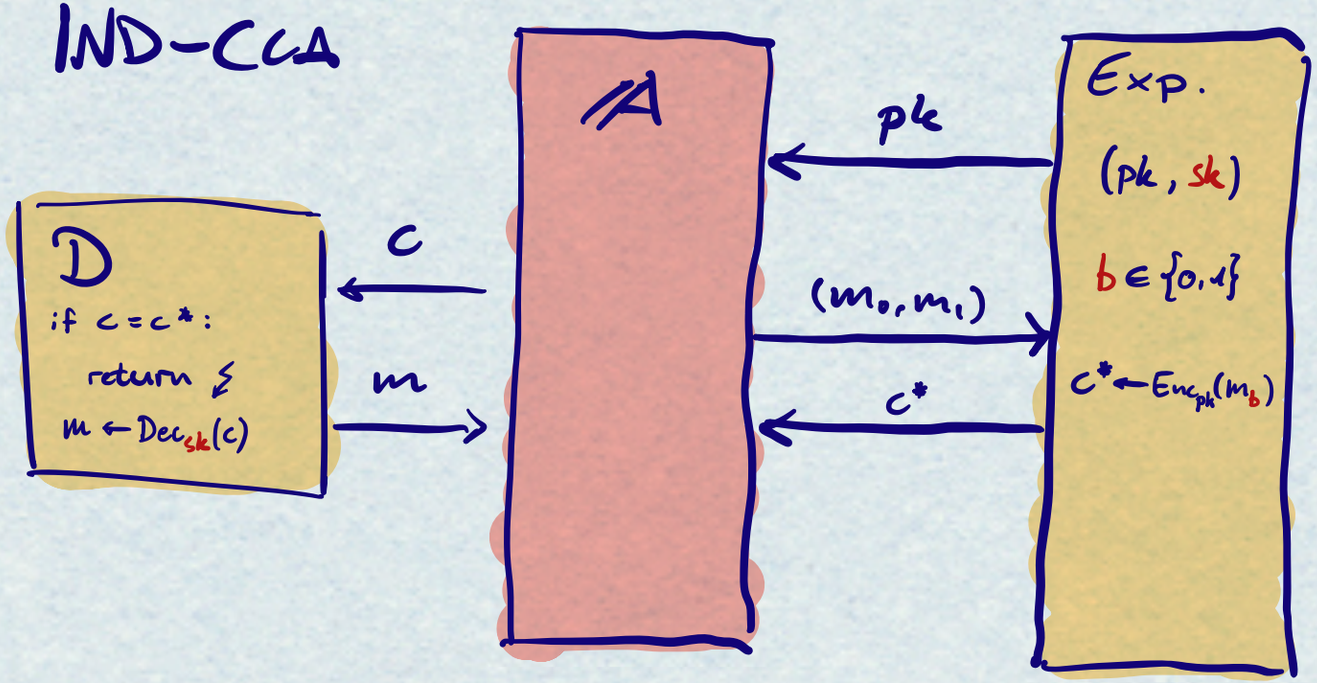

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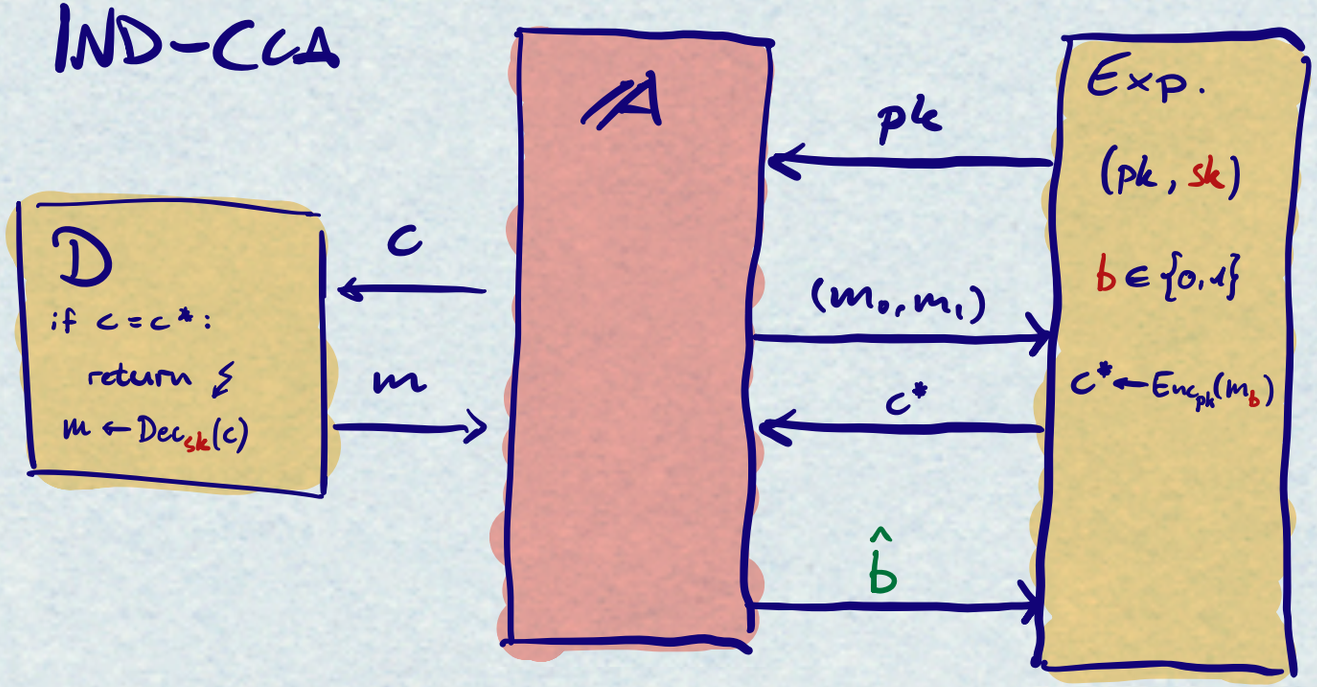

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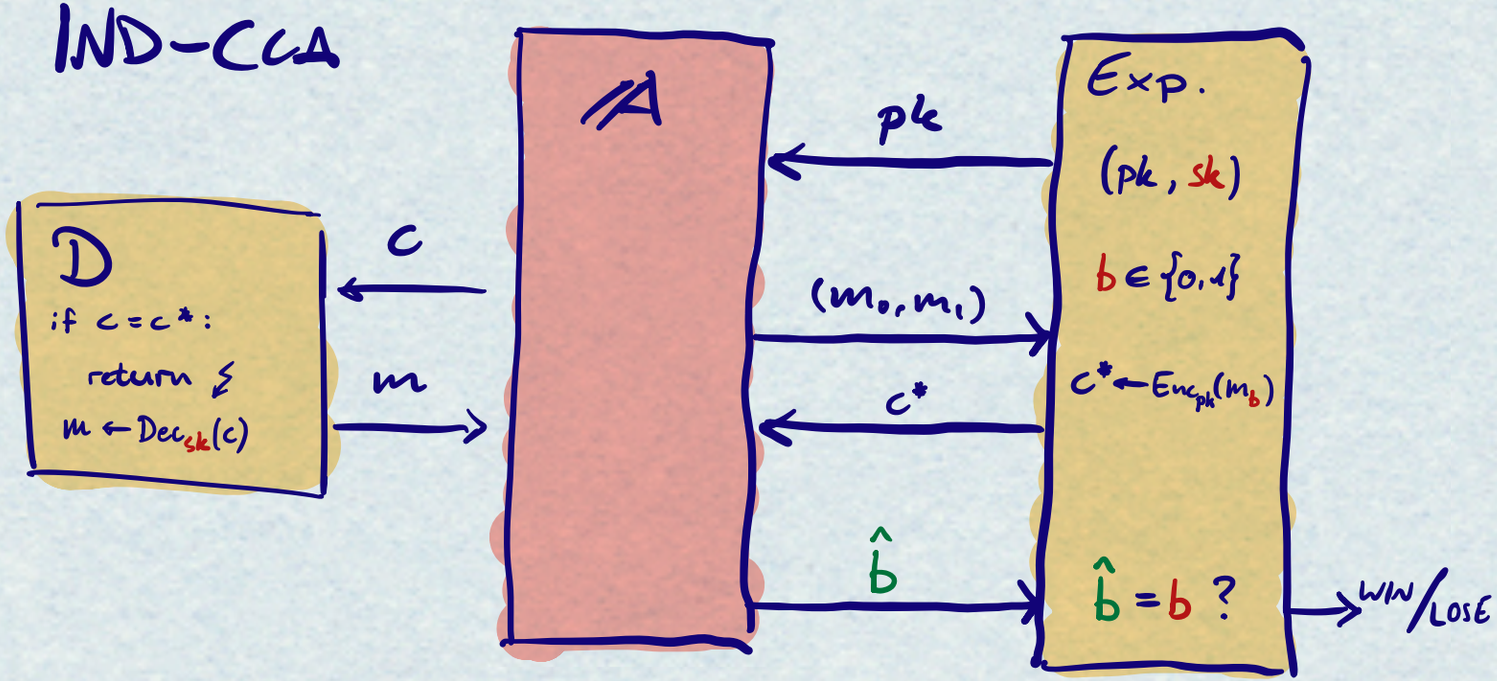
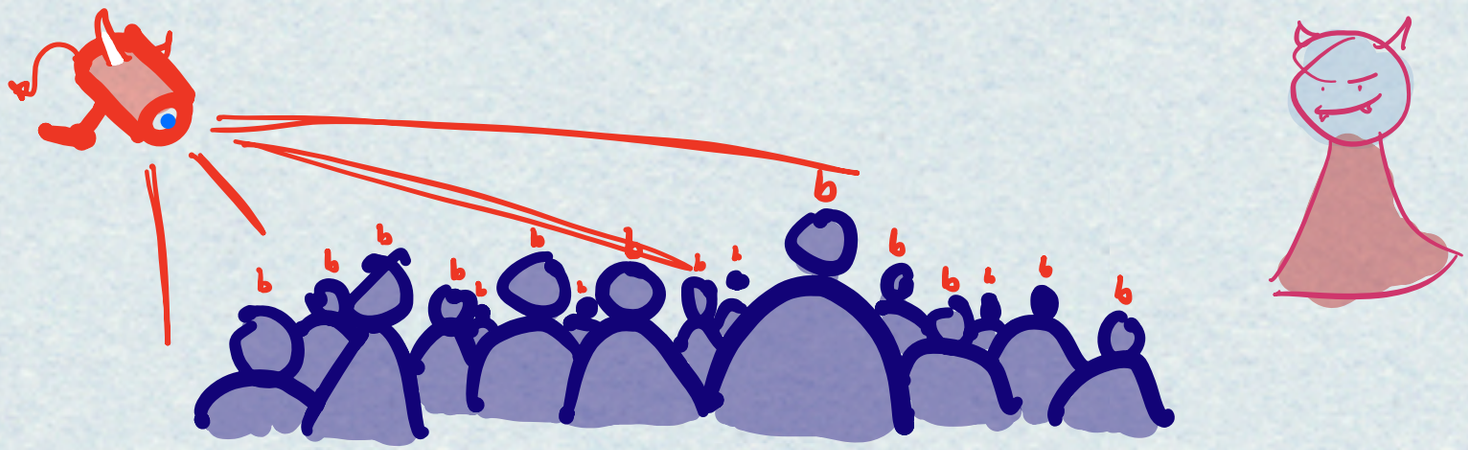


MULTI-USER SECURITY :



A CAN NOW ASK FOR SEVERAL CHALLENGES TO ANY OF n USERS. MORE REALISTIC!

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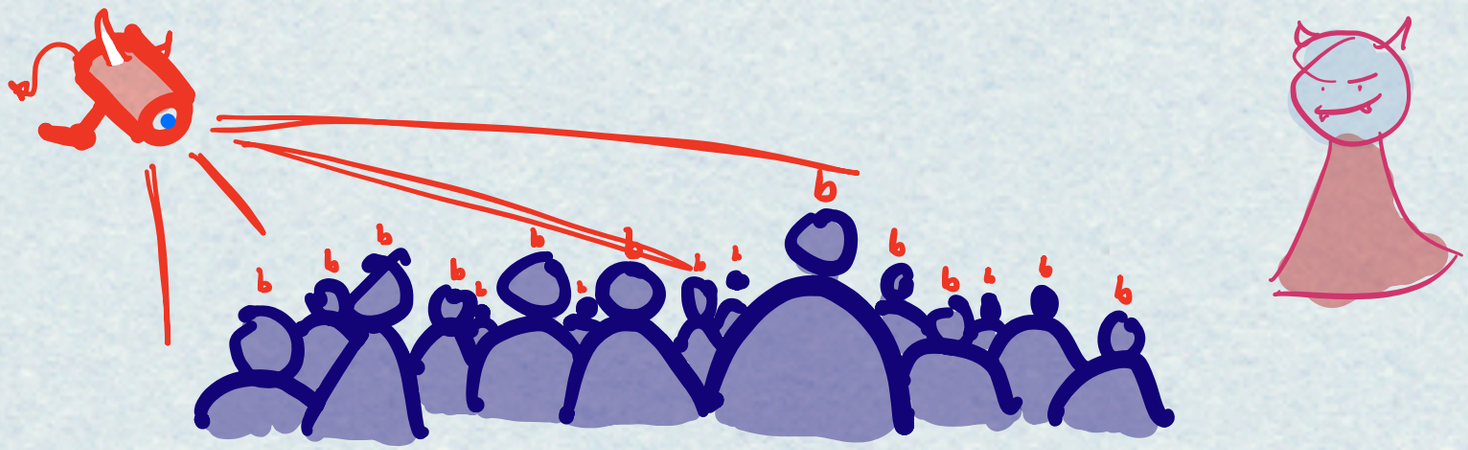

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= STRONGER SECURITY MODEL.

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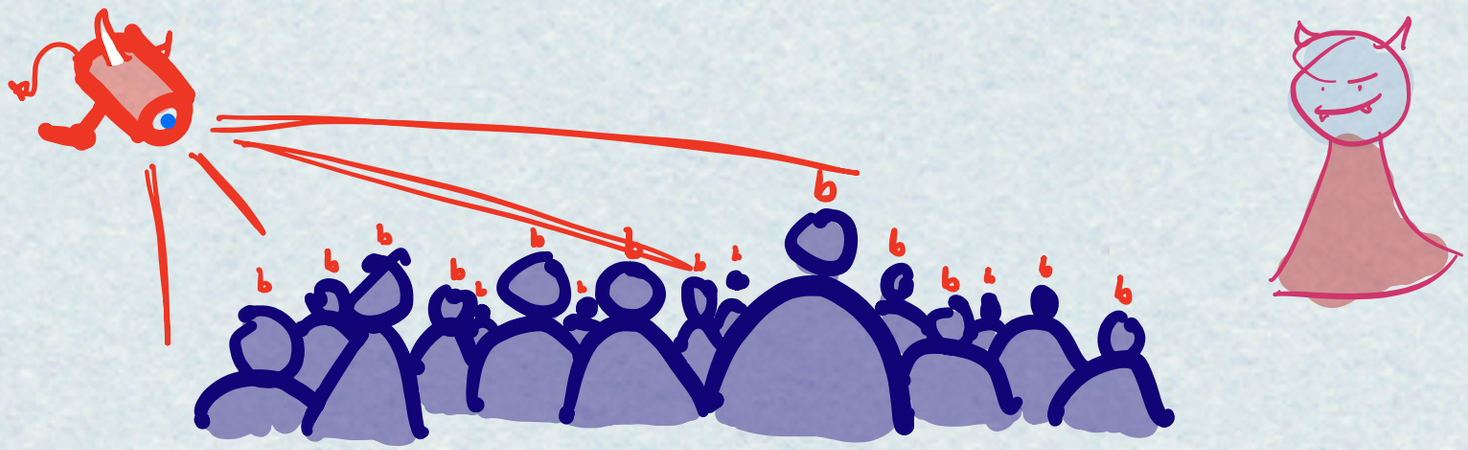


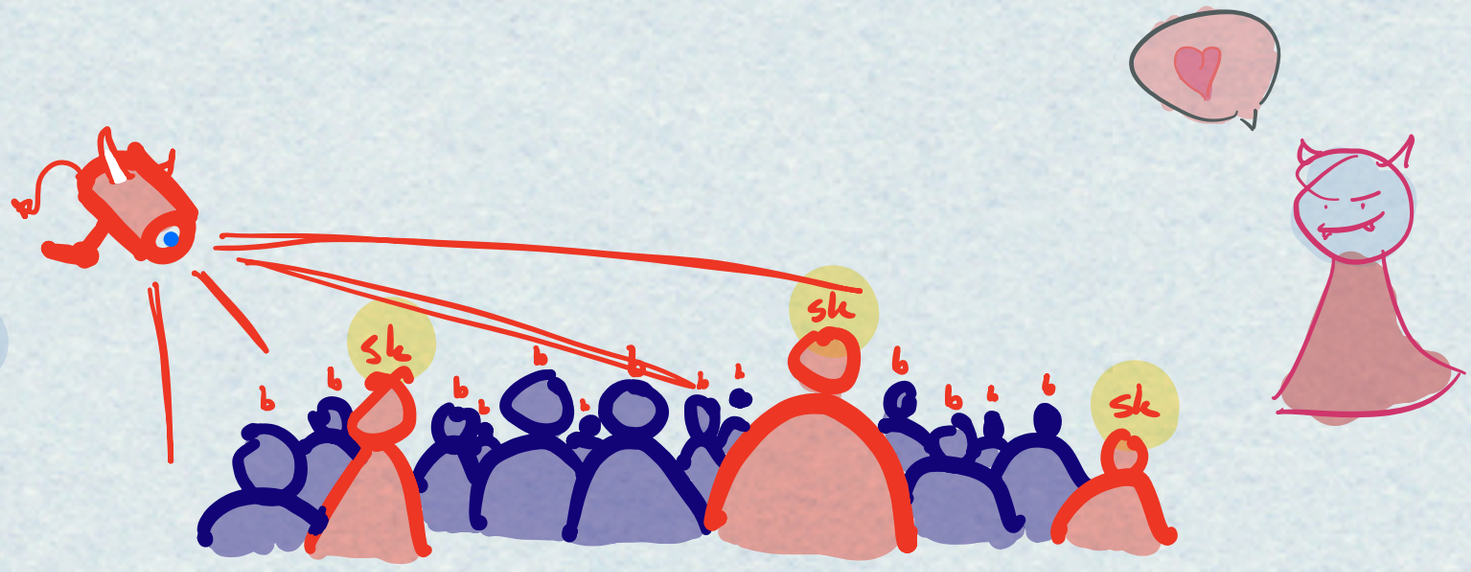
$\mathcal{A}$ CAN NOW ASK FOR SEVERAL CHALLENGES TO ANY OF n USERS. MORE REALISTIC!

THE GAME IS EASIER FOR $\mathcal{A}$ TO WIN

= STRONGER SECURITY MODEL.

$\mathcal{A}$ STILL ONLY NEEDS TO GUESS A SINGLE BIT!

Multi-User Security : With corruptions



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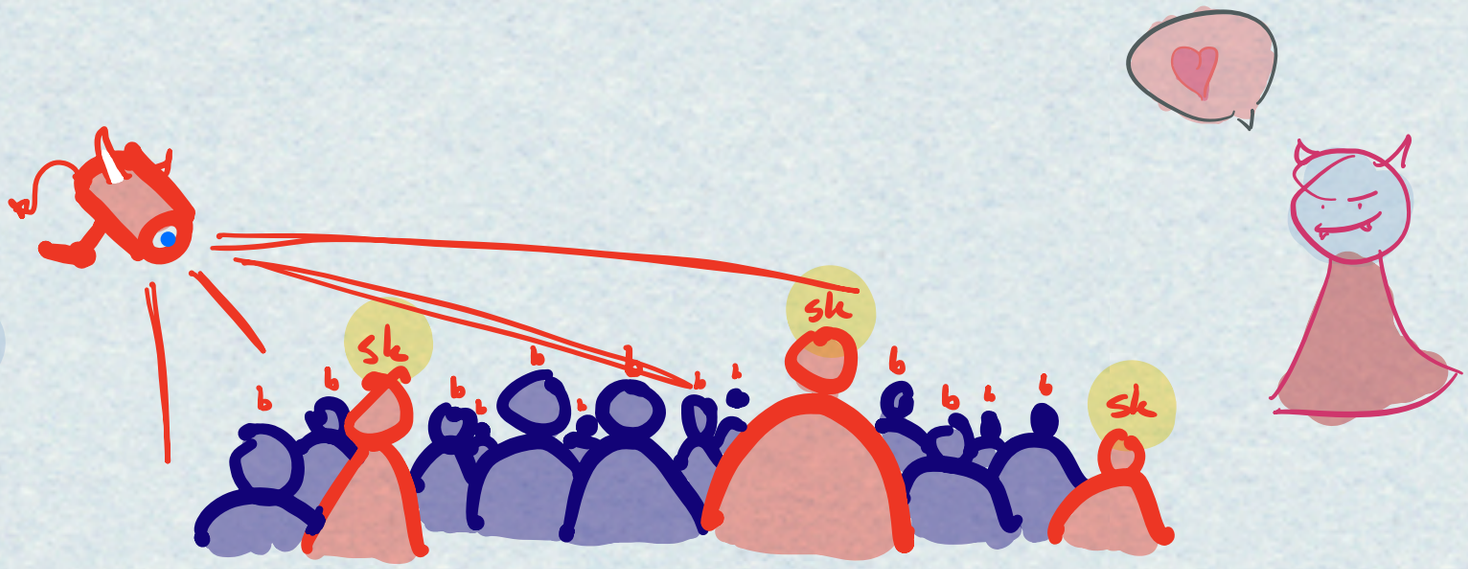

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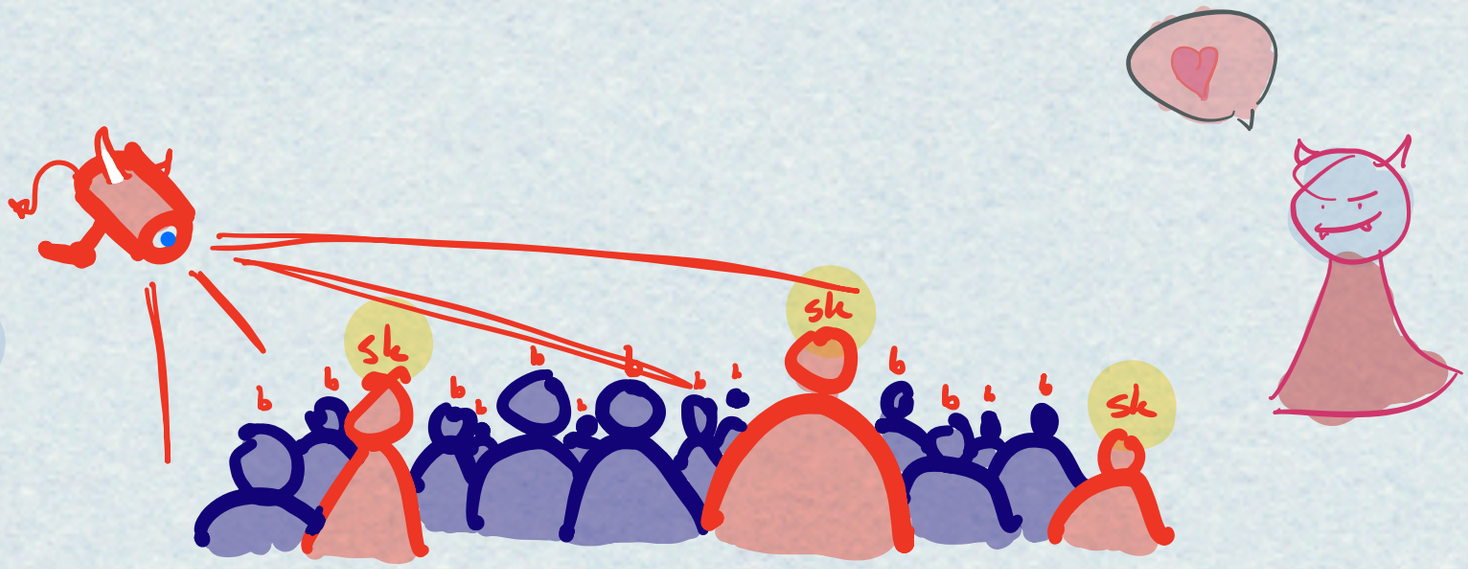

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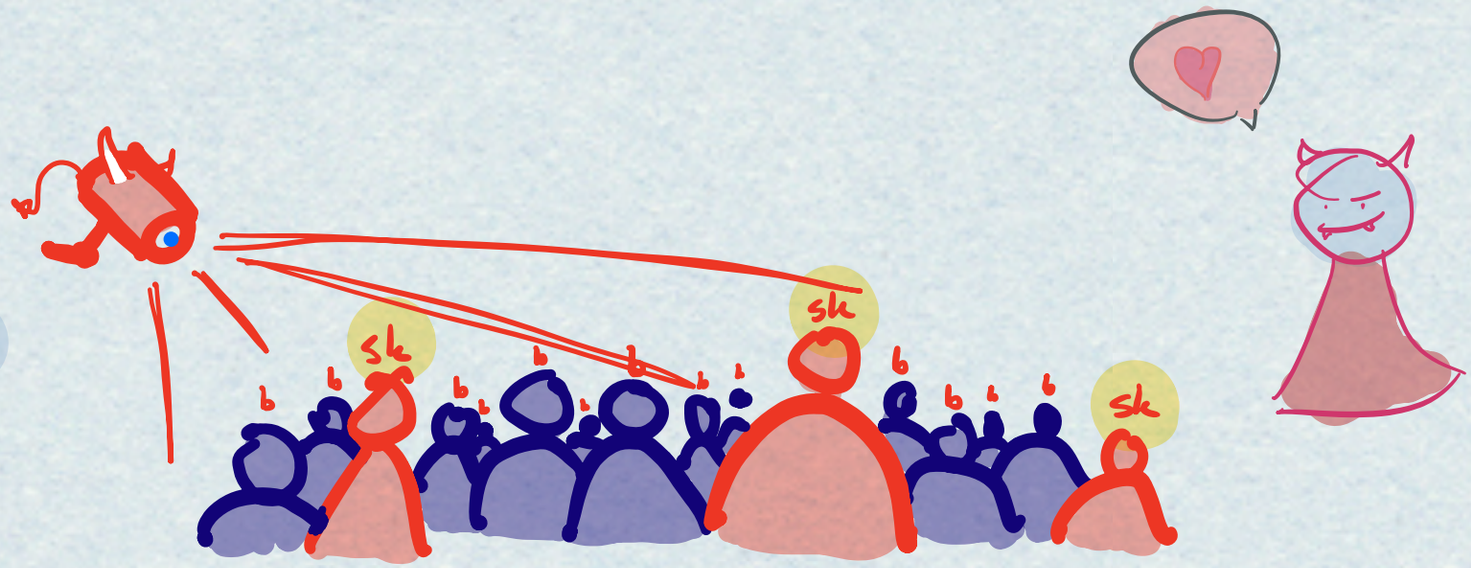

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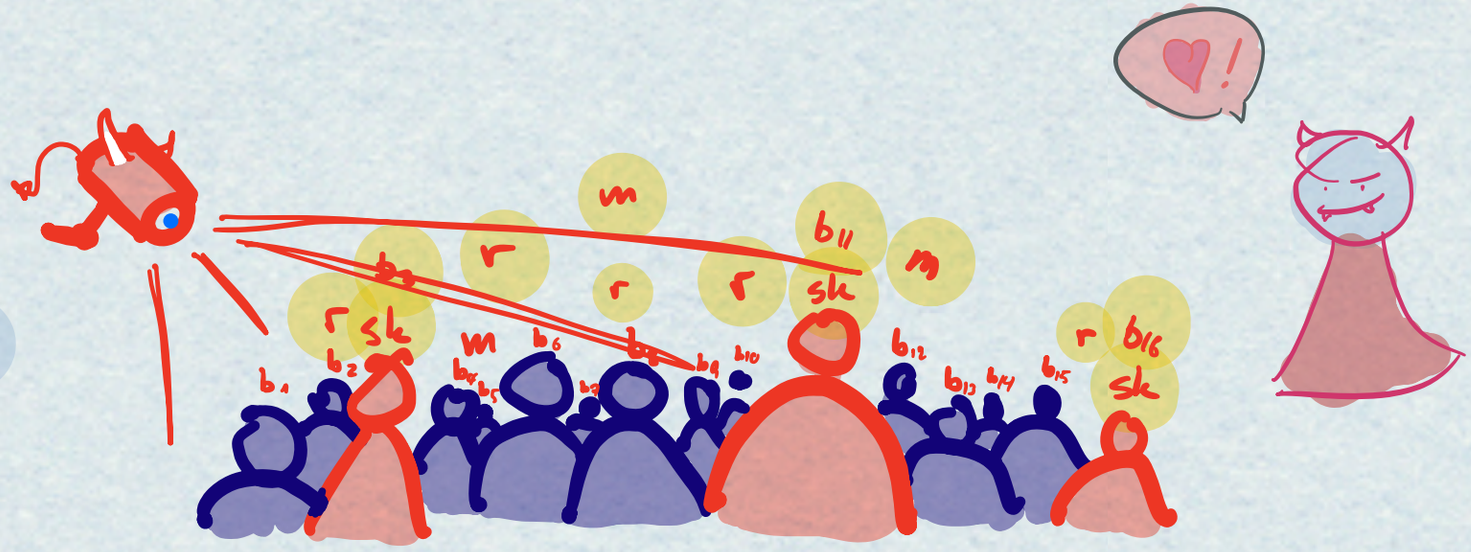
UNREALISTIC REQUIREMENT?

MULTI-USER SECURITY WITH MULTIPLE CHALLENGE BITS



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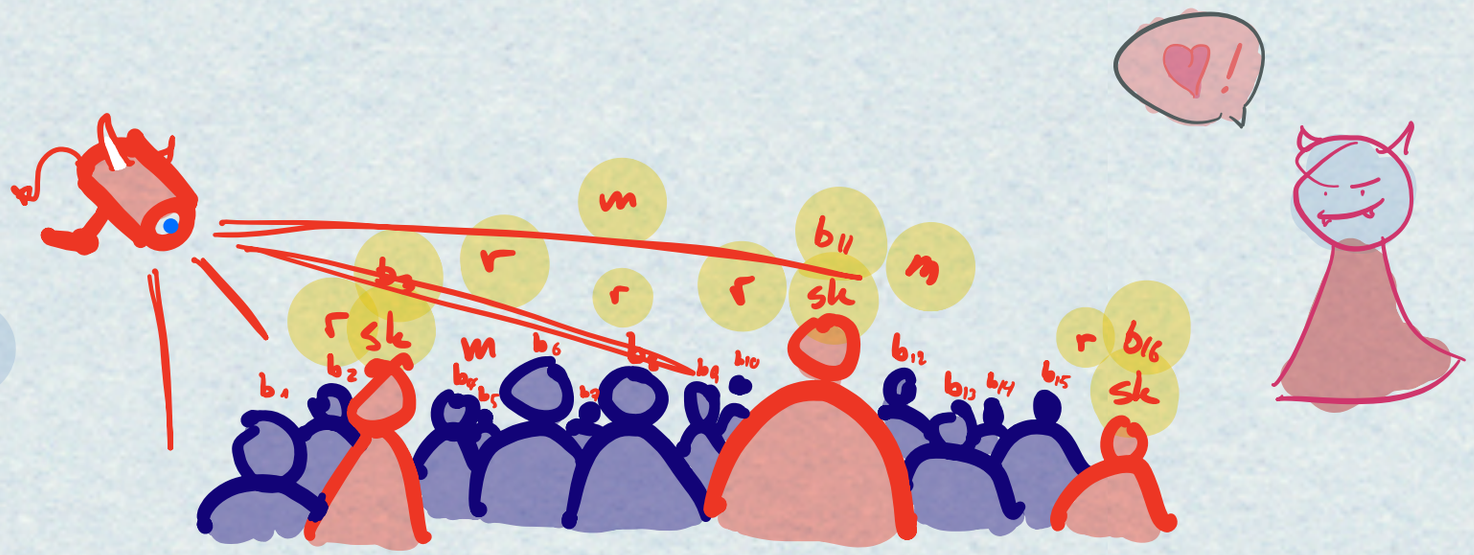

WITH MULTIPLE BITS, $\mathcal{A}$ CAN ALSO COMPROMISE CHALLENGES TO LEARN THE RANDOMNESS USED, AND THE MESSAGE.

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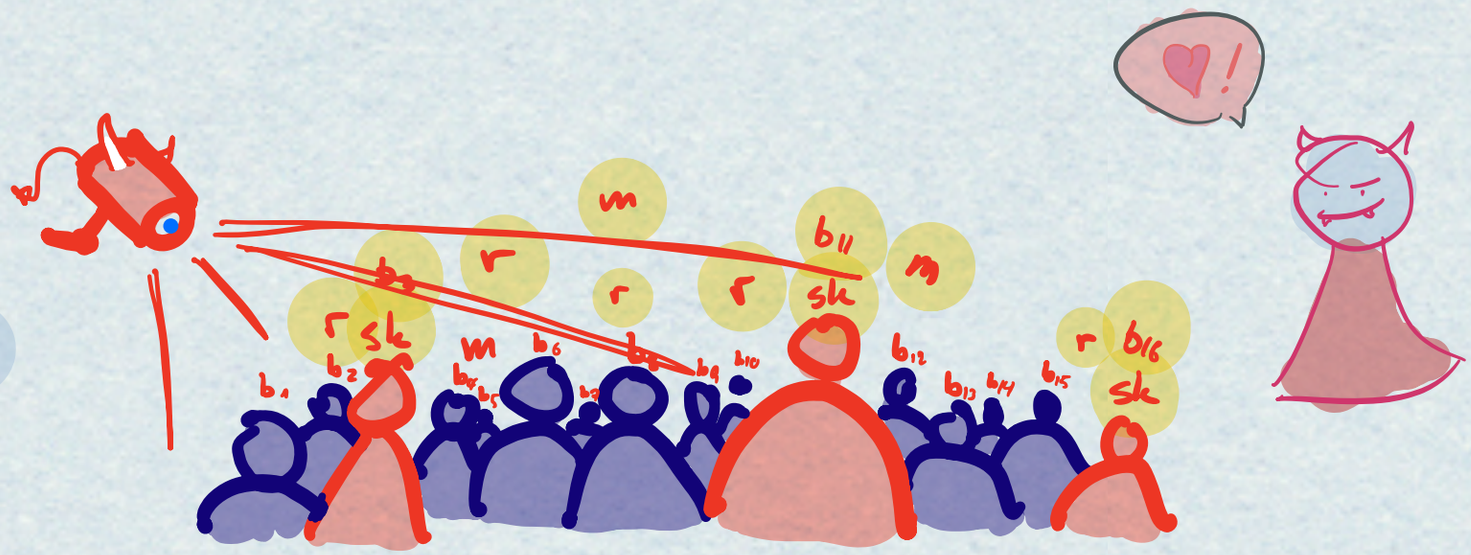

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EVEN MORE REALISTIC ! AND STILL (NON-TIGHTLY) EQUIVALENT TO IND-CCA (DHIES)

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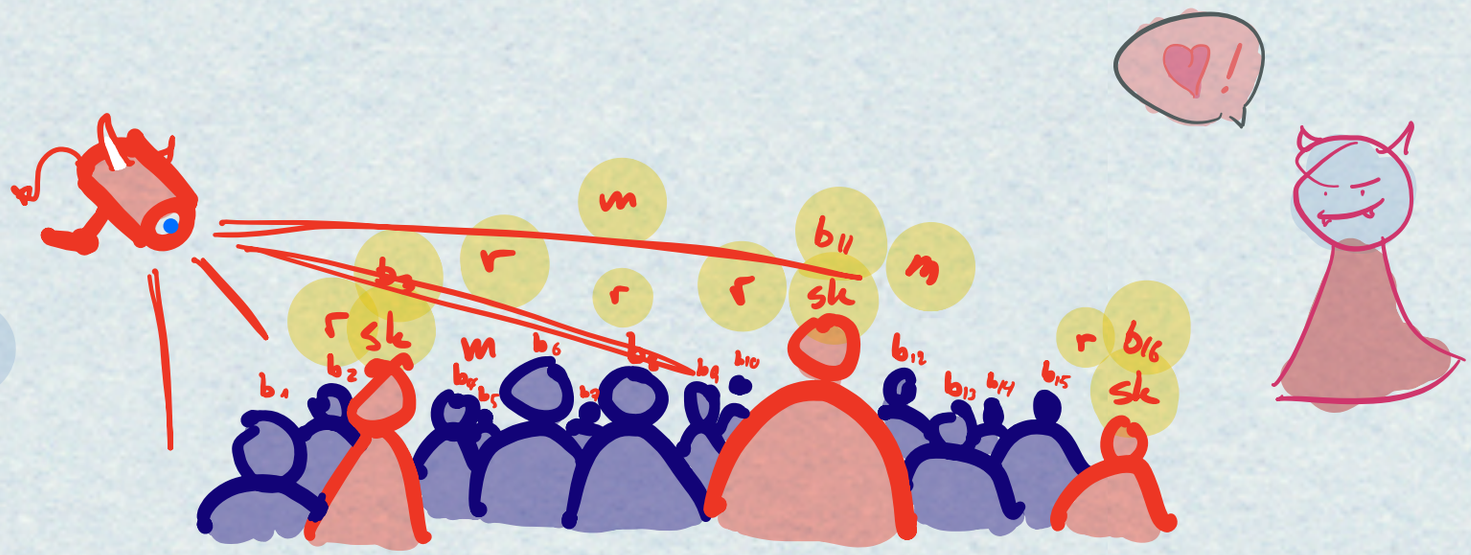

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Hazay, Patra, Warinschi, AC'15

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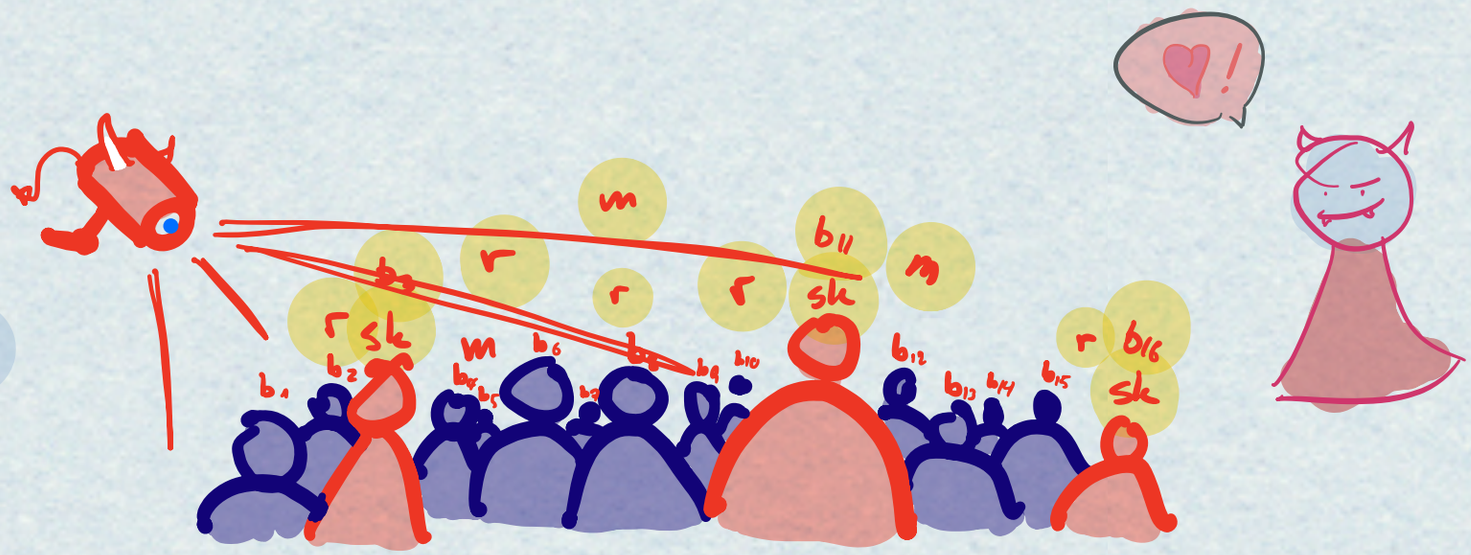

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"SELECTIVE OPENING ATTACKS" Hazay, Patra, Warinschi, AC'15

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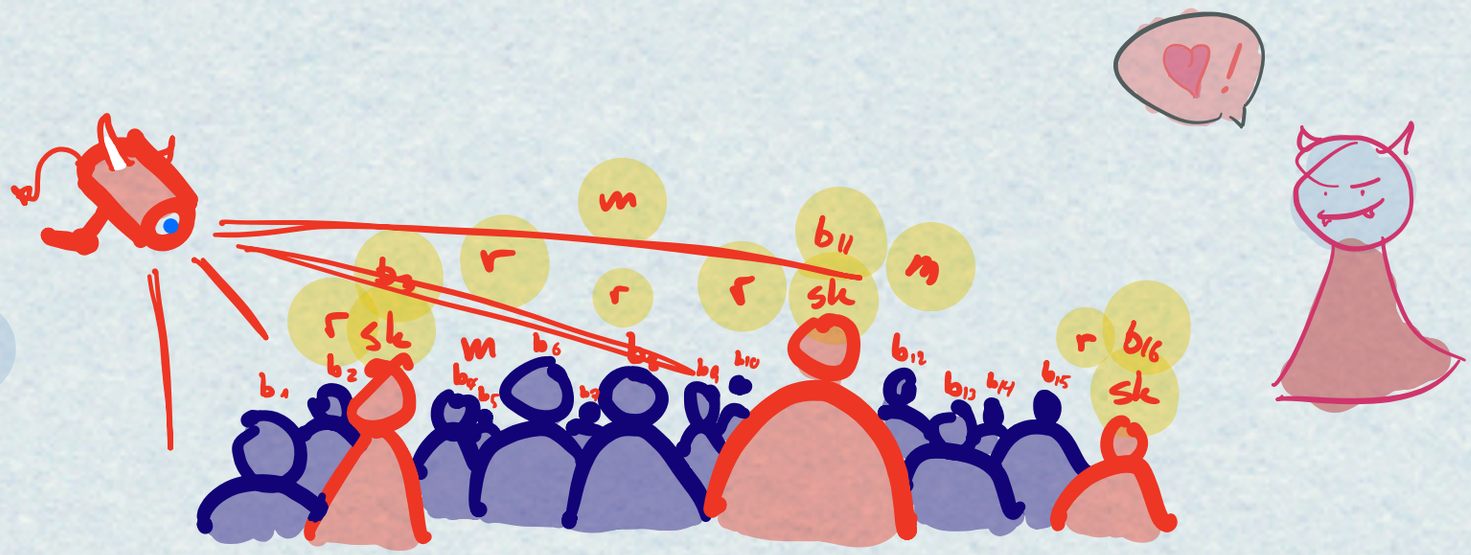

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SOA ⇕ IND-CCA ?

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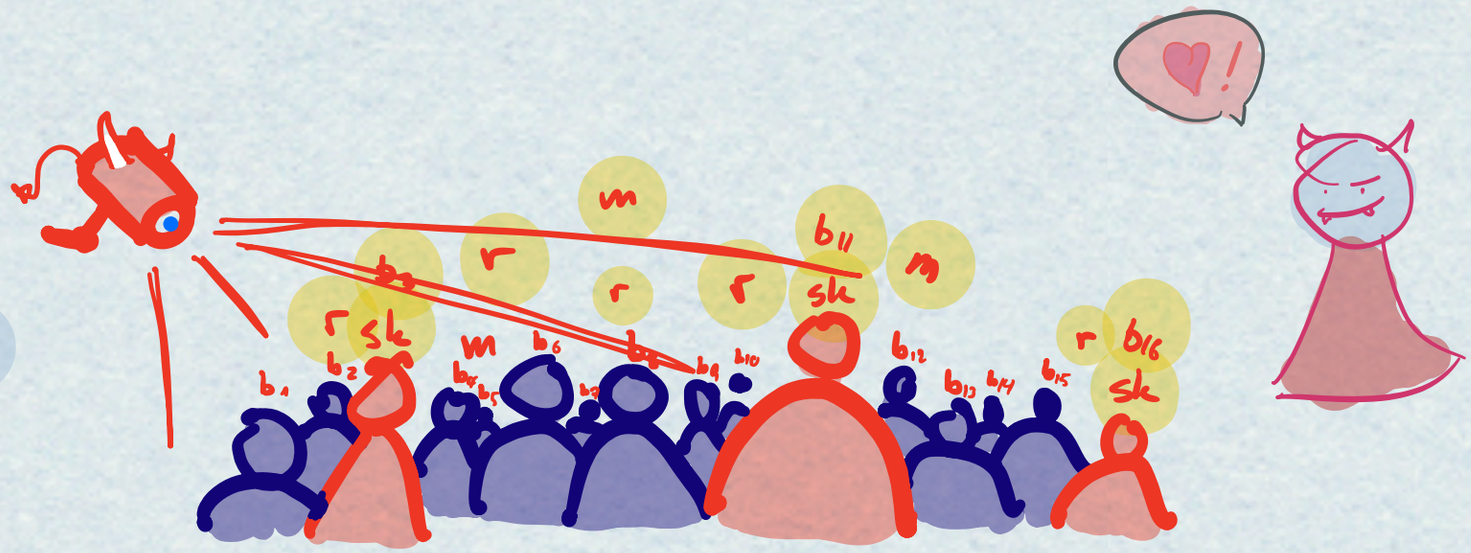

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Camenisch, Lehmann, Neven, Sametin, CSF'17

SOA ⇕ IND-CCA ?

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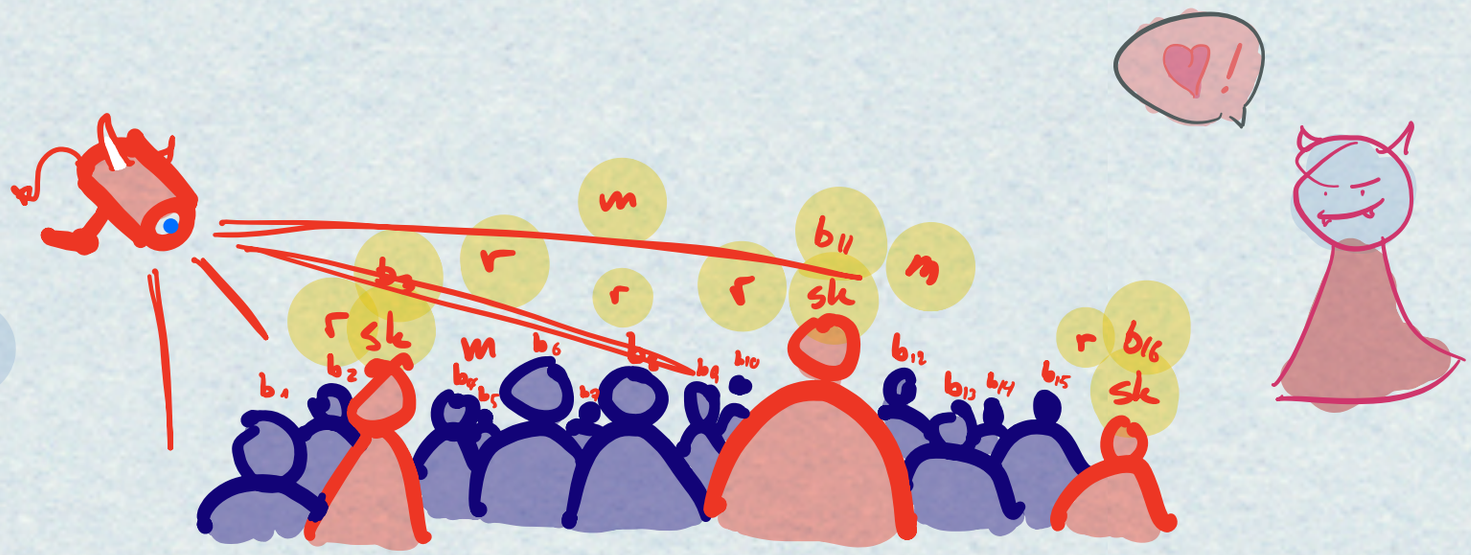

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SOA ⇕ IND-CCA ?

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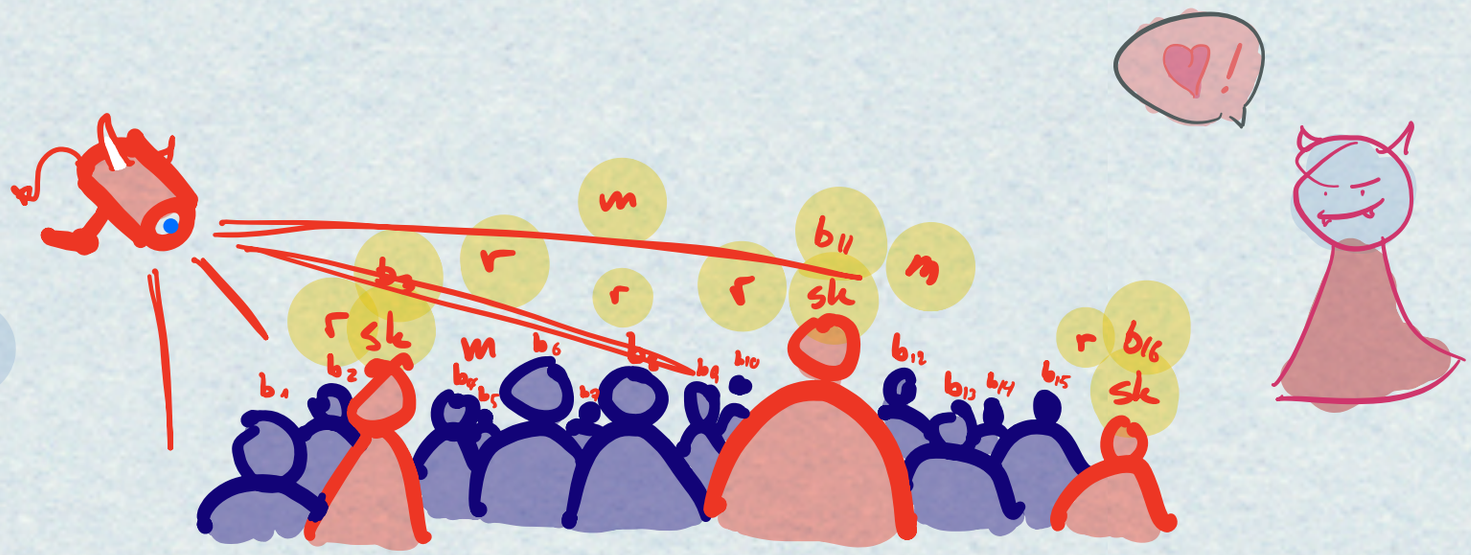

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Camenisch, Lehmann, Neven, Sanchez, CSF'17

"NON-COMMITTING ENCRYPTION"

UNACHIEVABLE IN THE STANDARD MODEL ??

4 PHILOSOPHIES OF SECURITY

WITHOUT COMPROMISE

WITH COMPROMISE

A PRIORI INDISTINGUISHABILITY:

A POSTERIORI INDISTINGUISHABILITY:

A POSTERIORI SIMULATABILITY:

A PRIORI SIMULATABILITY:

4 PHILOSOPHIES OF SECURITY

WITHOUT COMPROMISE | WITH COMPROMISE

A PRIORI INDISTINGUISHABILITY:

$\rightsquigarrow \forall m_0, m_1, c: \Pr[C = c \mid M = m_0] = \Pr[C = c \mid M = m_1]$

A POSTERIORI INDISTINGUISHABILITY:

A POSTERIORI SIMULATABILITY:

A PRIORI SIMULATABILITY:

4 PHILOSOPHIES OF SECURITY

	WITHOUT COMPROMISE	WITH COMPROMISE
A PRIORI INDISTINGUISHABILITY:	IND-CCA	

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A POSTERIORI INDISTINGUISHABILITY:

A POSTERIORI SIMULATABILITY:

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WITHOUT COMPROMISE — WITH COMPROMISE

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A POSTERIORI SIMULATABILITY:

A PRIORI SIMULATABILITY:

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A POSTERIORI INDISTINGUISHABILITY: (KEM-IND LIKE)

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A POSTERIORI SIMULATABILITY:

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4 PHILOSOPHIES OF SECURITY

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A POSTERIORI SIMULATABILITY:

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A POSTERIORI INDISTINGUISHABILITY:	(KEM-IND LIKE)	
A POSTERIORI SIMULATABILITY:	SEMANTIC SECURITY	
A PRIORI SIMULATABILITY:		

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4 PHILOSOPHIES OF SECURITY

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4 PHILOSOPHIES OF SECURITY

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A POSTERIORI INDISTINGUISHABILITY:	(KEM-IND LIKE)	
A POSTERIORI SIMULATABILITY:	SEMANTIC SECURITY	
A PRIORI SIMULATABILITY:	UNIVERSAL COMPOSABILITY	

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WITHOUT CORRUPTIONS, ALL* EQUIVALENT $\rightsquigarrow$ JUST USE IND-CCA!

4 PHILOSOPHIES OF SECURITY

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A PRIORI INDISTINGUISHABILITY:	IND-CCA	MULTI-USER IND-CCA WITH CORRUPTIONS
A POSTERIORI INDISTINGUISHABILITY:	(KEM-IND LIKE)	INDISTINGUISHABILITY-BASED SOA (ISO)
A POSTERIORI SIMULATABILITY:	SEMANTIC SECURITY	SIMULATABILITY-BASED SOA (SSO)
A PRIORI SIMULATABILITY:	UNIVERSAL COMPOSABILITY	NON-COMMITTING ENCRYPTION (NCE)

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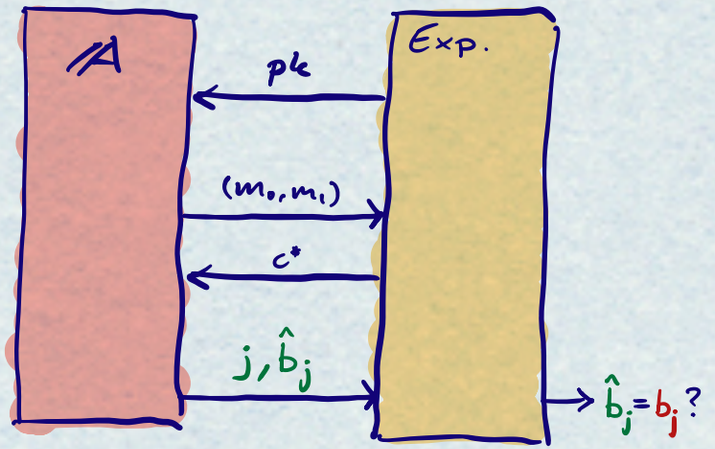
4 PHILOSOPHIES OF SECURITY

A PRIORI INDISTINGUISHABILITY (IND)



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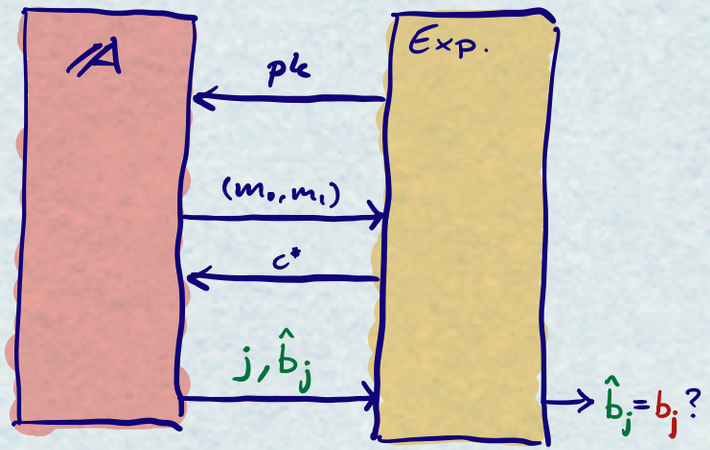
A POSTERIORI SIMULATABILITY (SSO)

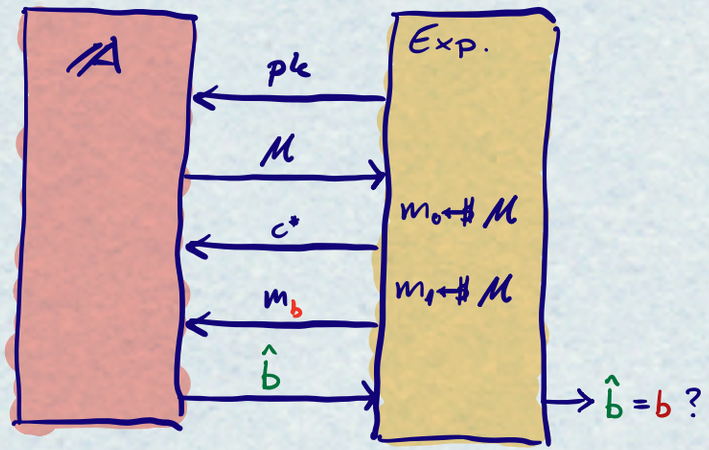
A PRIORI SIMULATABILITY (NCE)

4 PHILOSOPHIES OF SECURITY

A PRIORI INDISTINGUISHABILITY (IND)



A POSTERIORI INDISTINGUISHABILITY (ISO)



A POSTERIORI SIMULATABILITY (SSO)

A PRIORI SIMULATABILITY (NCE)

4 PHILOSOPHIES OF SECURITY

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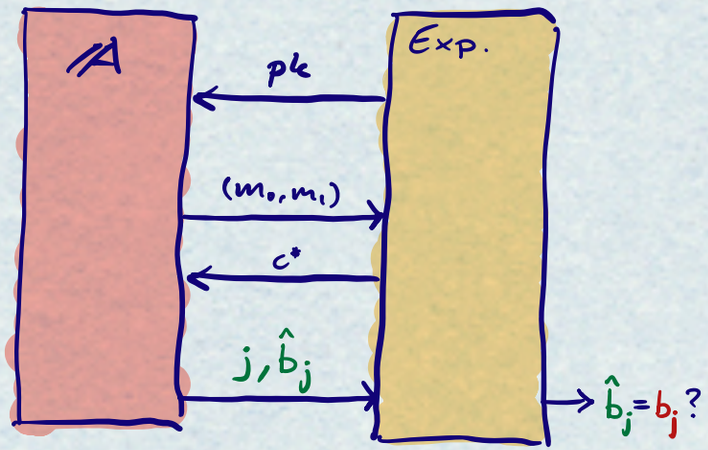
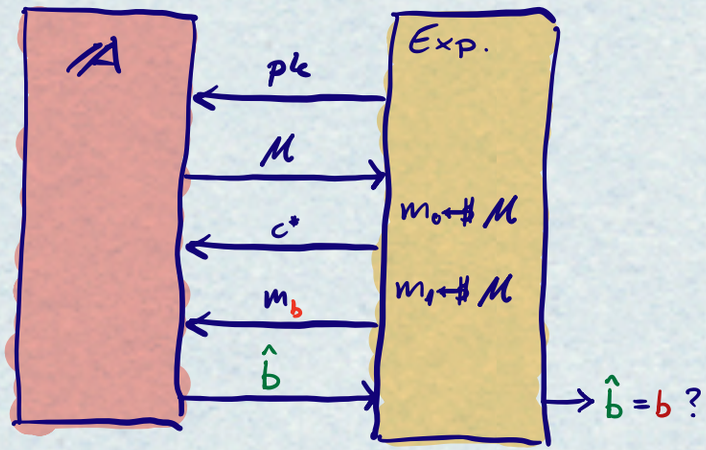
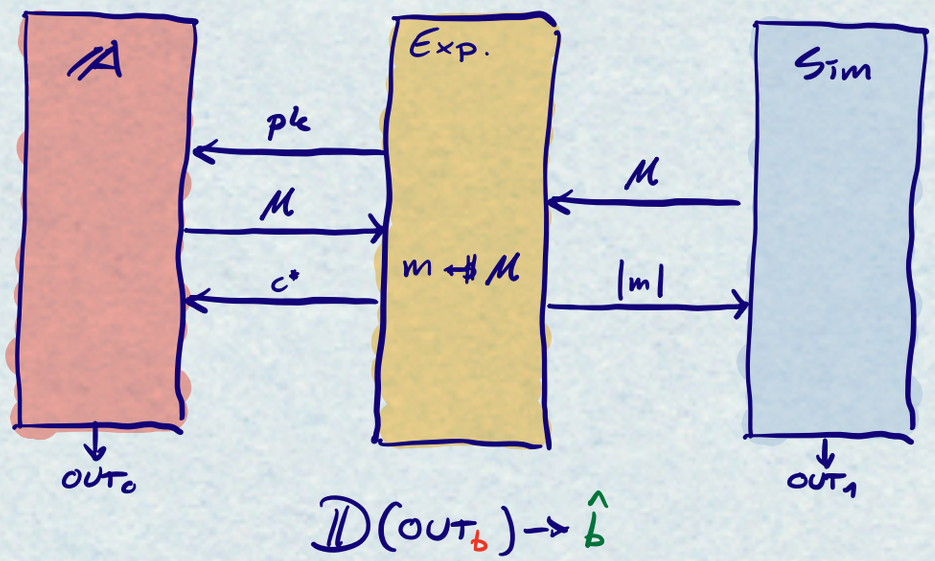


A POSTERIORI INDISTINGUISHABILITY (ISO)



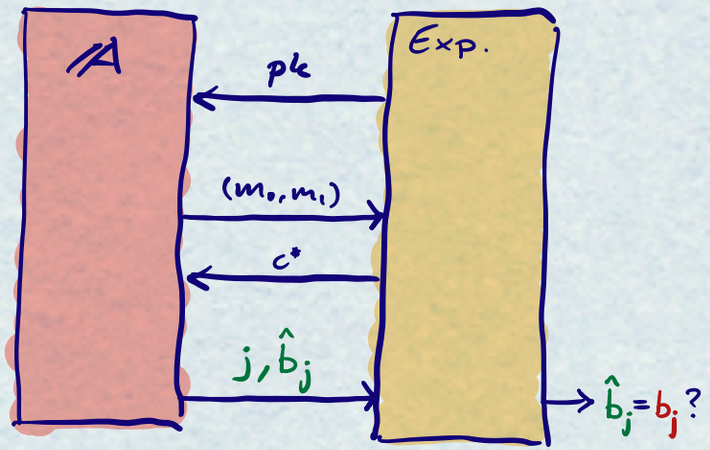
A POSTERIORI SIMULATABILITY (SSO)



A PRIORI SIMULATABILITY (NCE)

4 PHILOSOPHIES OF SECURITY

A PRIORI INDISTINGUISHABILITY (IND)



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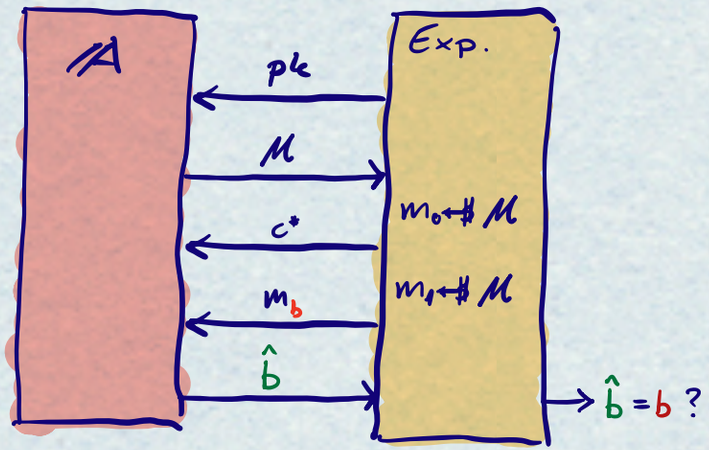

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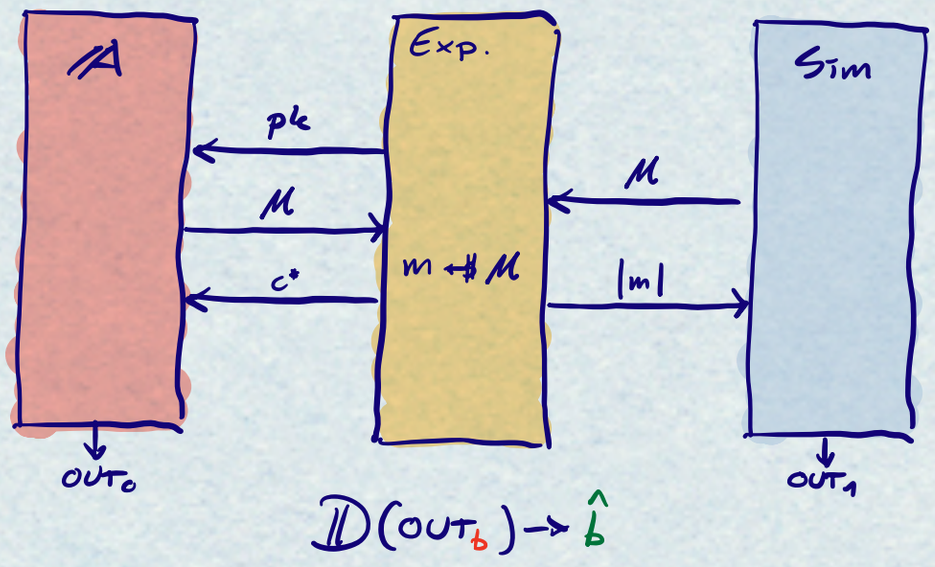
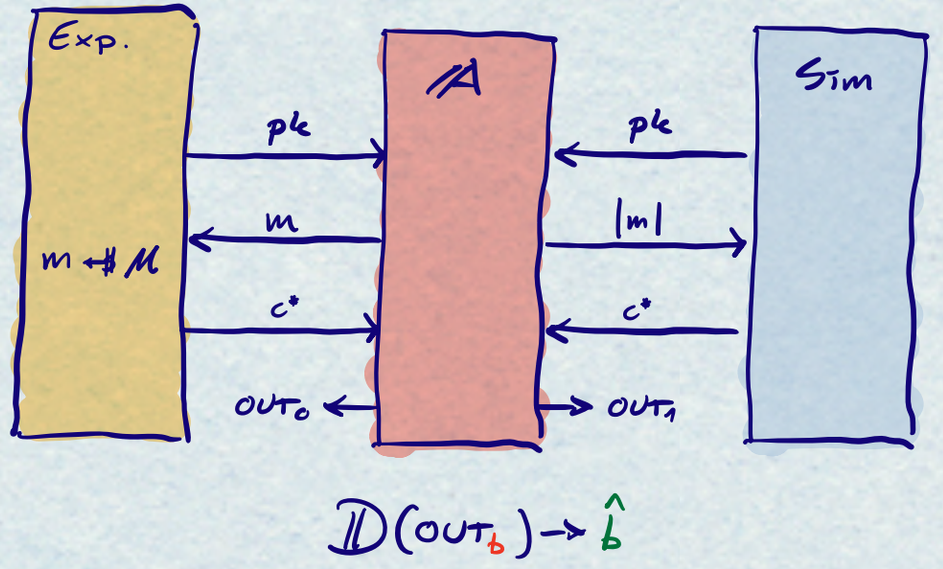


A PRIORI SIMULATABILITY (NCE)



4 KINDS OF CORRUPTION A.K.A. "OPENING"

TRANSMISSION OPENING (◇): MESSAGE LEAKS

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SENDER OPENING (⊙): MESSAGE AND RANDOMNESS LEAKS

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SENDER OPENING (⊙): MESSAGE AND RANDOMNESS LEAKS

RECEIVER OPENING (★): SECRET KEY LEAKS

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BI-OPENING (✪): ALL OF THE ABOVE LEAK

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COMBINING: $\{\text{IND}, \text{ISO}, \text{SSO}, \text{NCE}\} - \{\text{CPA}, \text{CCA}\} - \{◇, ⊙, ★, ✪\}$

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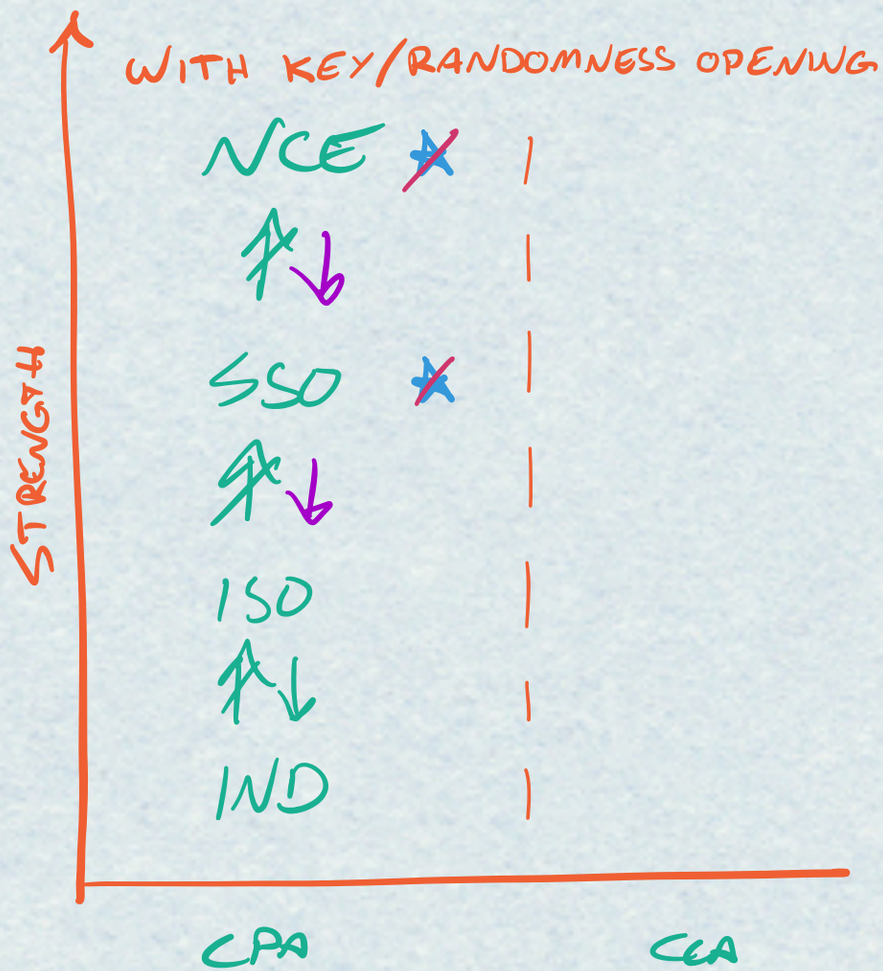
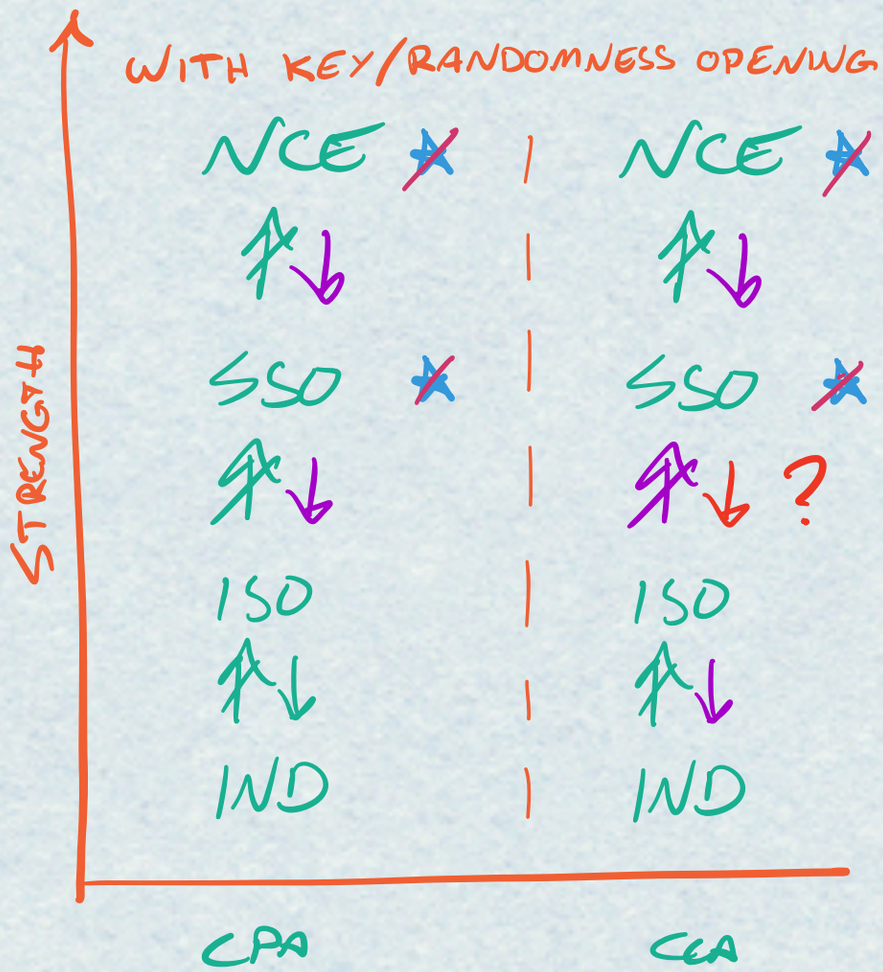
The Hierarchy



PURPLE = NOVEL, RED = OPEN, ~~X~~ = STANDARD MODEL UNACHIEVABLE

The Hierarchy



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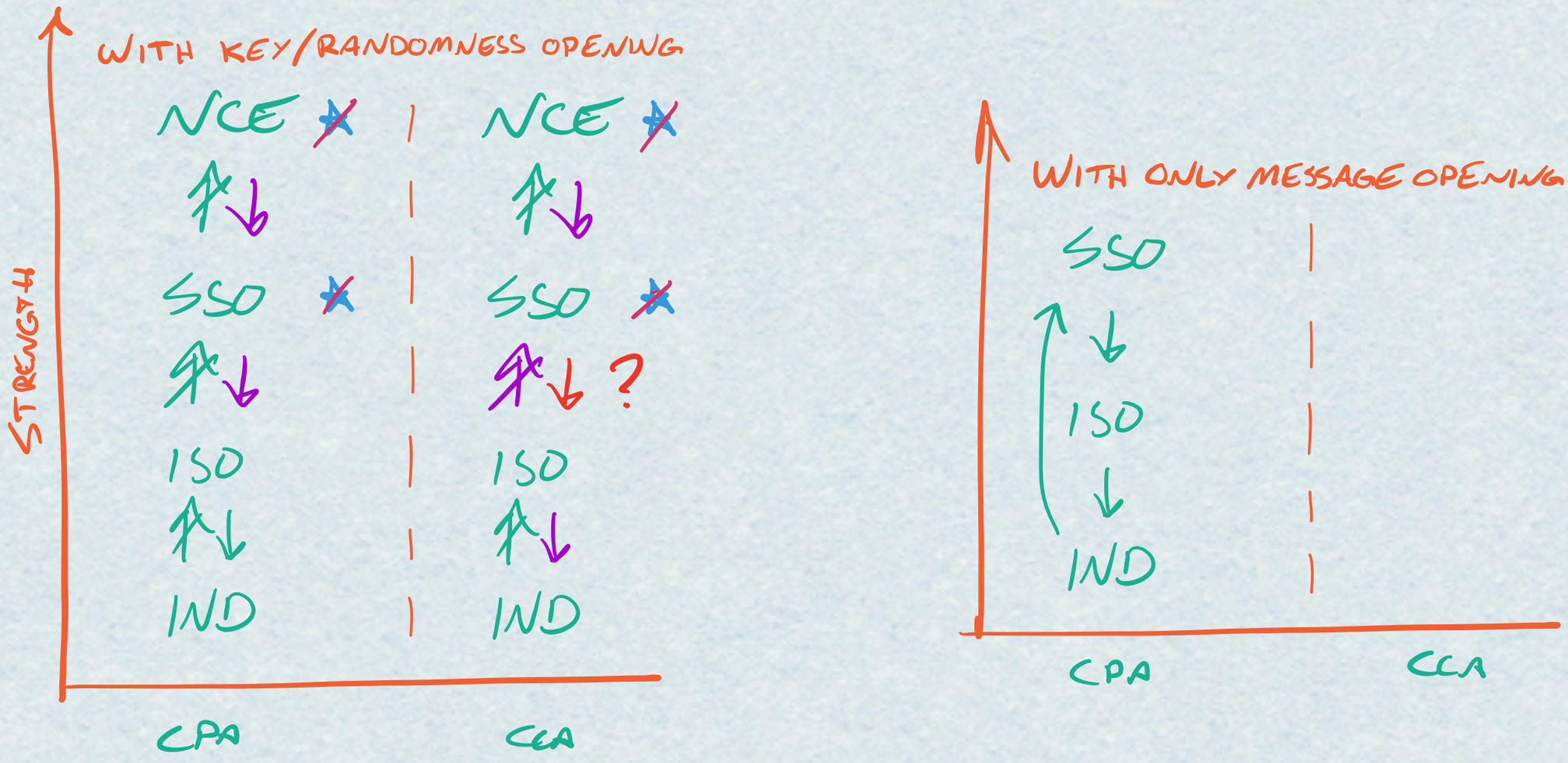
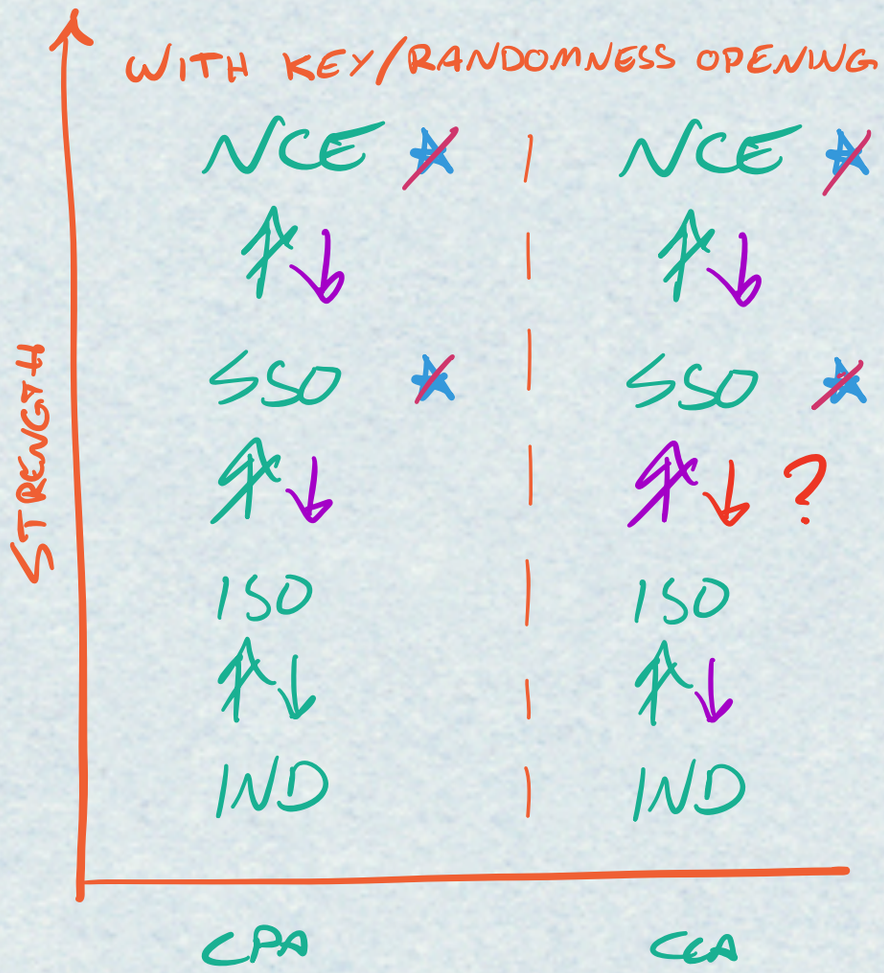
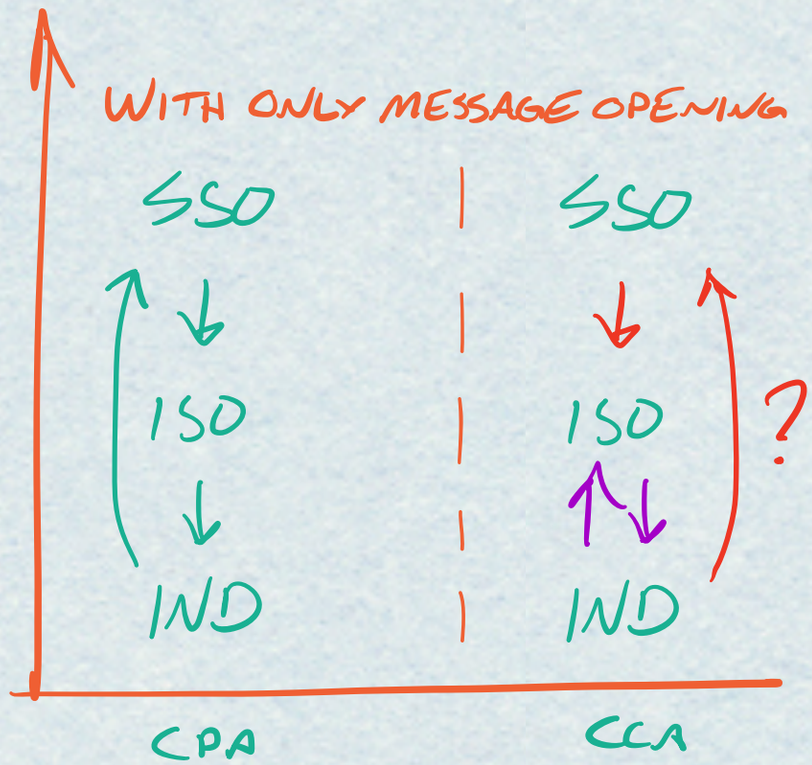


Purple = novel, Red = open, ✗ = standard model unachievable

The Hierarchy





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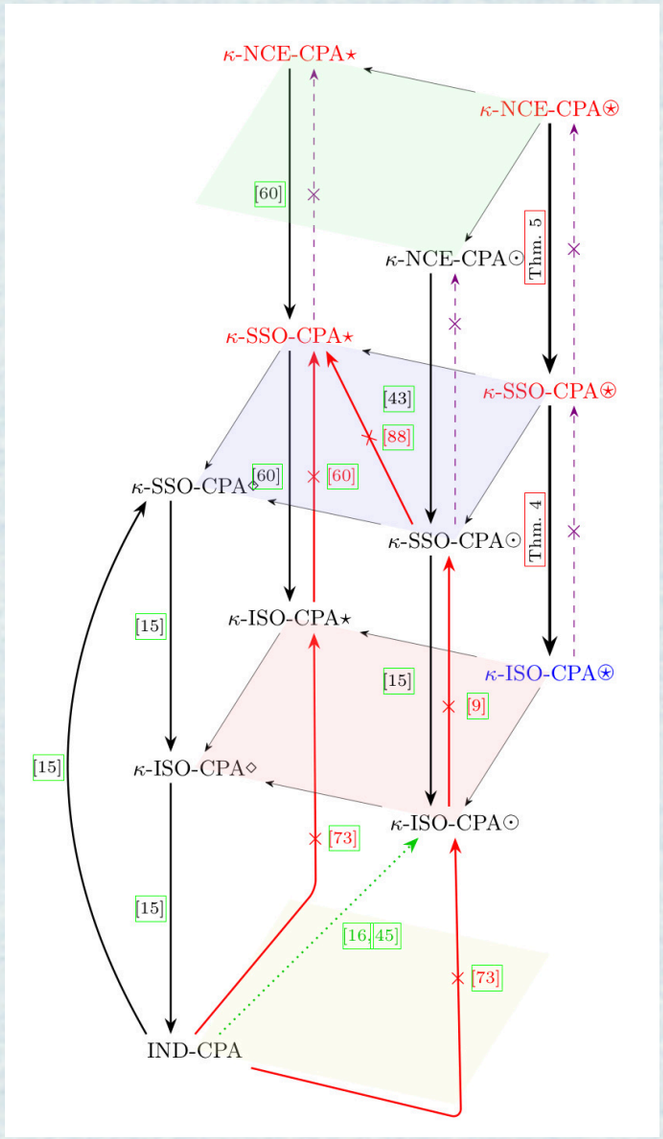
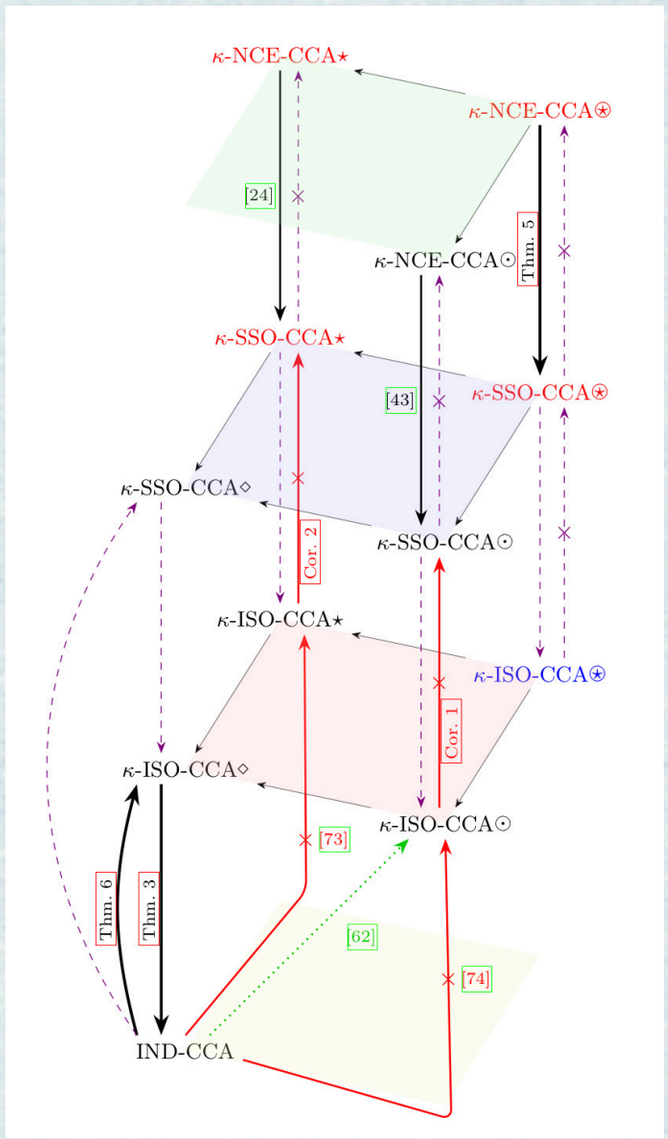
RELATIONS

CPA:



CCA:



ACHIEVABILITY

	◇	○	☆	⊛
IND	=	=	=	=
ISO	=			
SSO	=			
NCE	(=)			

= : IND-CCA EQUIVALENT

✓ : ACHIEVED IN THE STANDARD MODEL

∪ : UNACHIEVABLE IN THE STANDARD MODEL

ACHIEVABILITY

	◇	○	★	✪
IND	=	=	=	=
ISO	=	√	√	?
SSO	=	√		
NCE	(=)	√		

= : IND-CCA EQUIVALENT

√ : ACHIEVED IN THE STANDARD MODEL

∪ : UNACHIEVABLE IN THE STANDARD MODEL

ACHIEVABILITY

	◇	○	★	⊛
IND	=	=	=	=
ISO	=	√	√	?
SSO	=	√	U	U
NCE	(=)	√	U	U

= : IND-CCA EQUIVALENT

√ : ACHIEVED IN THE STANDARD MODEL

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Conclusion

So... which model of corruptions is the right one?

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Short answer: stop worrying and use IND-CCA(✪)

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SO... WHICH MODEL OF CORRUPTIONS IS THE RIGHT ONE?

SHORT ANSWER: STOP WORRYING AND USE IND-CCA(★)

... UNLESS YOU NEED TO OPEN CHALLENGES
AND STAY SINGLE-CHALLENGE-BIT

CONCLUSION

SO... WHICH MODEL OF CORRUPTIONS IS THE RIGHT ONE?

SHORT ANSWER: STOP WORRYING AND USE IND-CCA(★)

... UNLESS YOU NEED TO OPEN CHALLENGES
AND STAY SINGLE-CHALLENGE-BIT

THEN: USE IND-CCA(★)!

CONCLUSION

SO... WHICH MODEL OF CORRUPTIONS IS THE RIGHT ONE?

SHORT ANSWER: STOP WORRYING AND USE IND-CCA(★)

... UNLESS YOU NEED TO OPEN CHALLENGES
AND STAY SINGLE-CHALLENGE-BIT

THEN: USE ISO-CCA(★)!

... UNLESS YOUR MESSAGE SPACE IS NOT
EFFICIENTLY CONDITIONALLY RESAMPLEABLE

Conclusion

So... which model of corruptions is the right one?

Short answer: Stop worrying and use IND-CCA(⋆)

... unless you need to open challenges
and stay single-challenge-bit

Then: use ISO-CCA⋆!

... unless your message space is not
efficiently conditionally resampleable

Then: use SSO-CCA⋆!

Conclusion

So... which model of corruptions is the right one?

Short answer: Stop worrying and use IND-CCA(⋆)

... unless you need to open challenges
and stay single-challenge-bit

Then: use ISO-CCA(⋆)!

... unless your message space is not
efficiently conditionally resampleable

Then: use SSO-CCA(⋆)!

... unless you need to avoid message sampling

Conclusion

So... which model of corruptions is the right one?

Short answer: Stop worrying and use IND-CCA(★)

... unless you need to open challenges
AND stay single-challenge-bit

Then: use ISO-CCA★!

... Unless your message space is not
efficiently conditionally resampleable

Then: use SSO-CCA★!

... unless you need to avoid message sampling

Then: use NCE-CCA★!

Thank You!

Questions?

Hans.Heum@ntnu.no

New Discord server:
Understanding Chen's Algorithm

bitly

Already >350 members!