Broadcast-Optimal Two Round MPC with Asynchronous Peer-to-Peer Channels

Ivan Damgård[1], *Divya Ravi*[1,2], *Luisa Siniscalchi*[3], *Sophia Yakoubov*[1]

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[1]Aarhus University, [2]University of Amsterdam, [3]DTU

Broadcast-Optimal Two Round MPC

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Grace

x_G

Bruce

x_B

Alan

x_A

Broadcast-Optimal Two Round MPC

$y = f(x_A, x_B, x_G)$

Grace

x_G

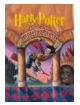
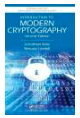
Bruce

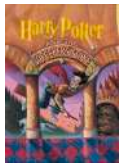
x_B

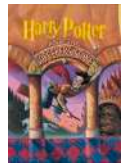
Alan

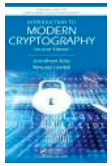
x_A

Broadcast-Optimal Two Round MPC

y = should we read  or  for book club?







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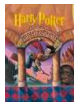
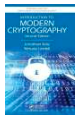
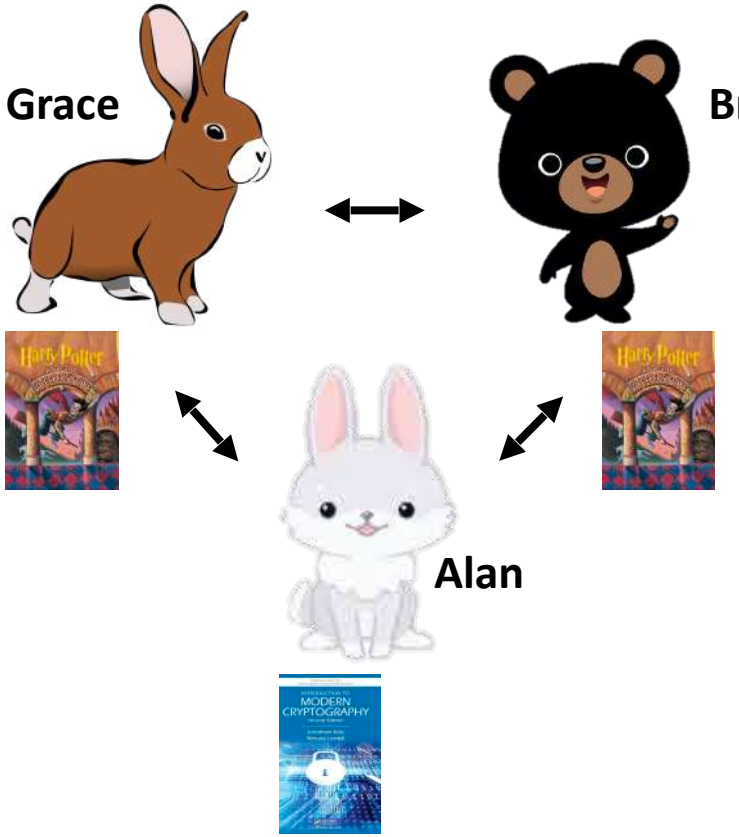
y = should we read  or  for book club?



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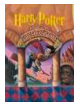
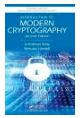
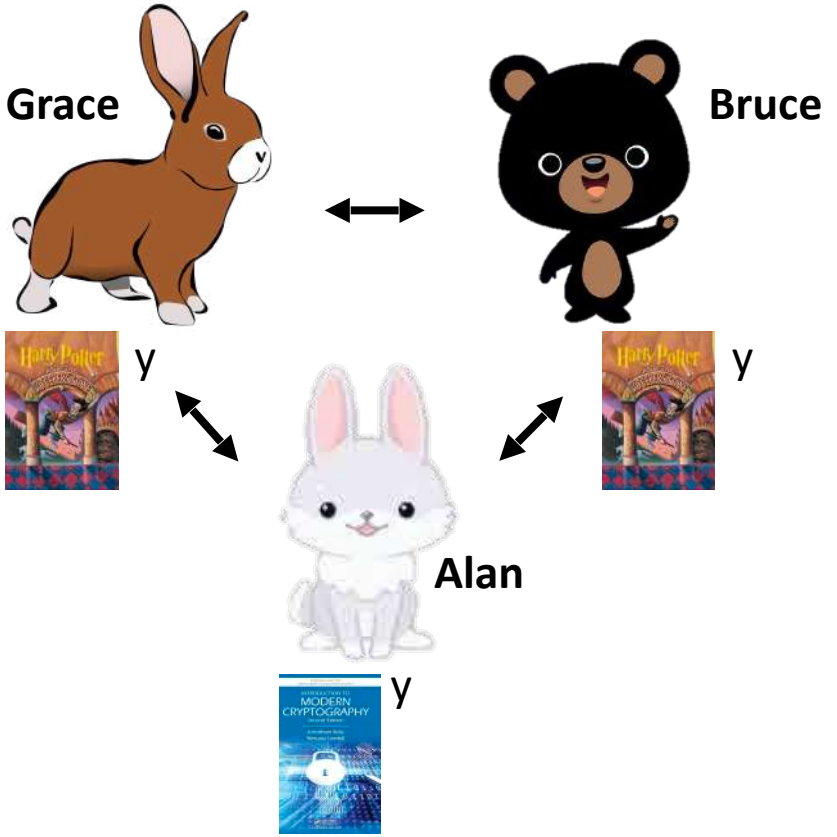
y = should we read  or  for book club?



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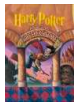
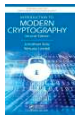
y = should we read  or  for book club?

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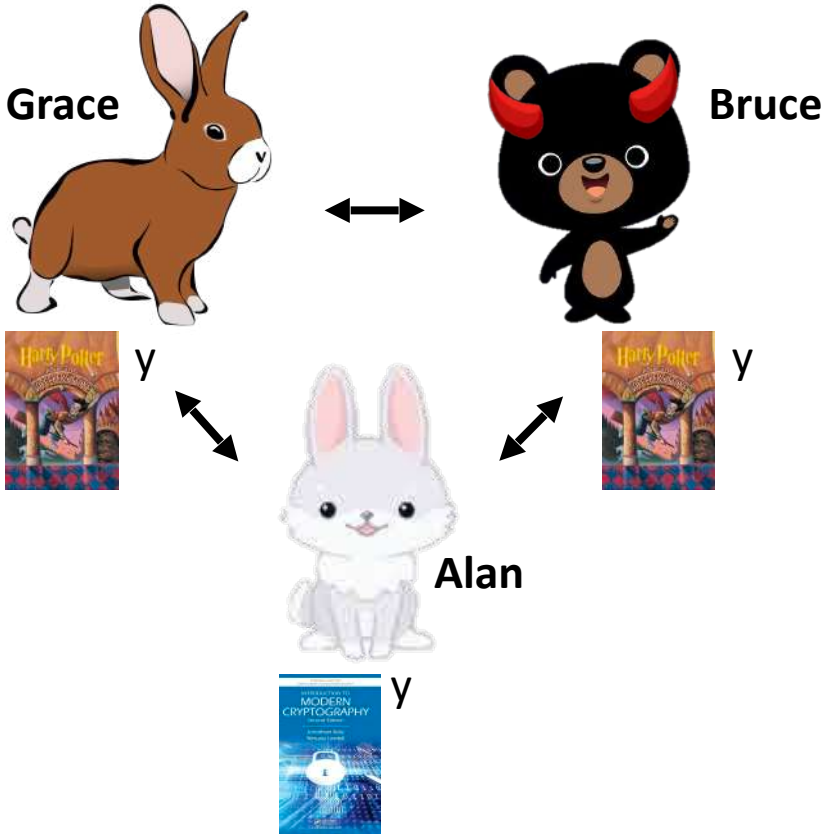

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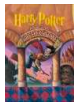
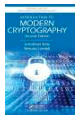
y = should we read  or  for book club?

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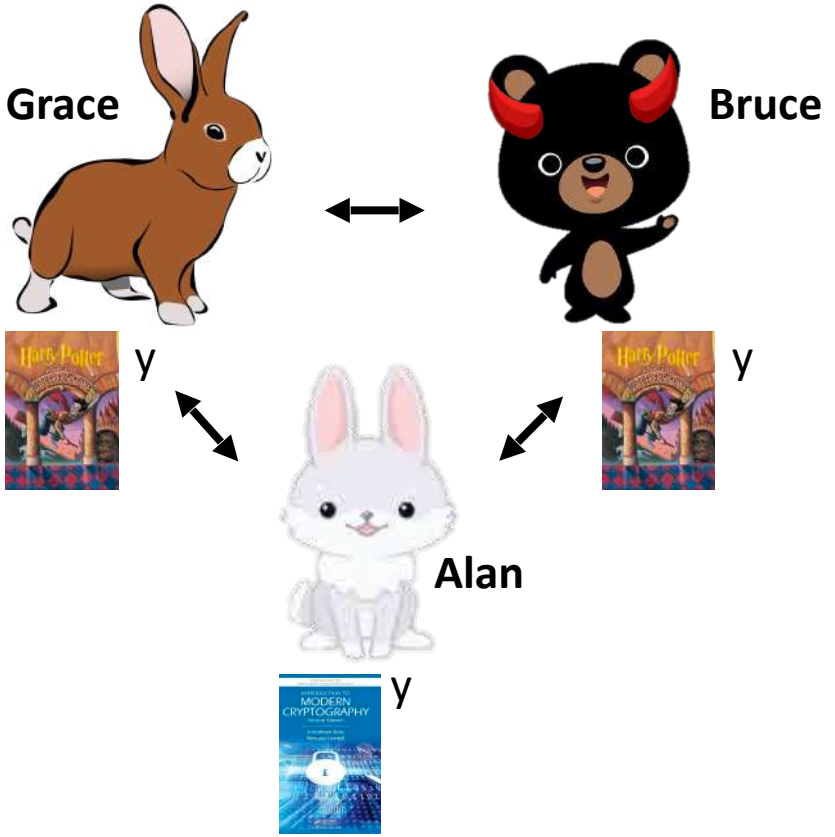
- Correctness



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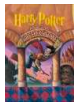
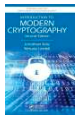
y = should we read  or  for book club?

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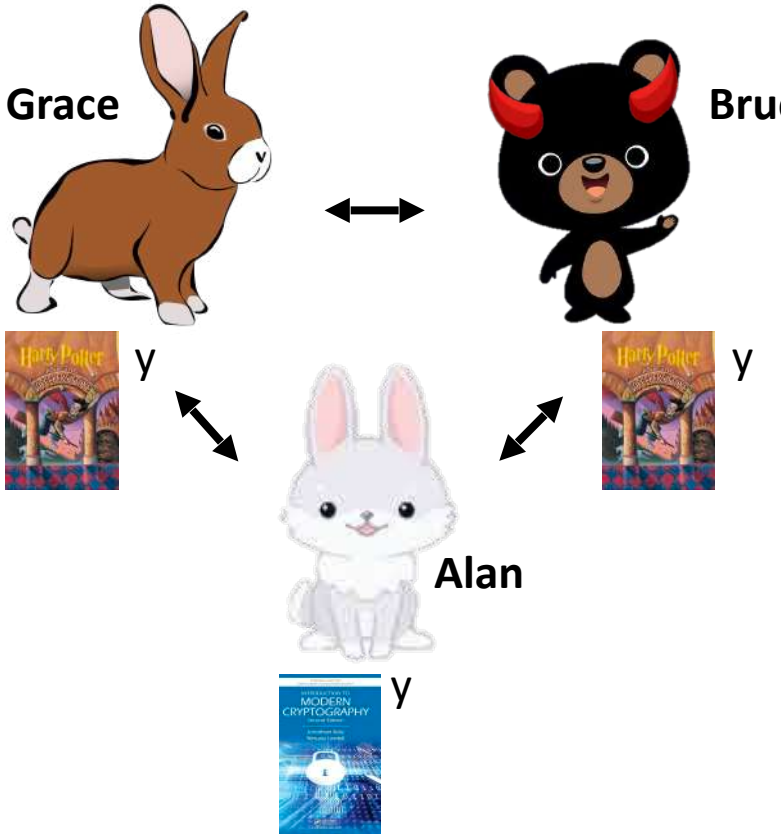
Stronger



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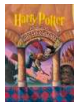
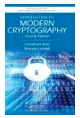
y = should we read  or  for book club?

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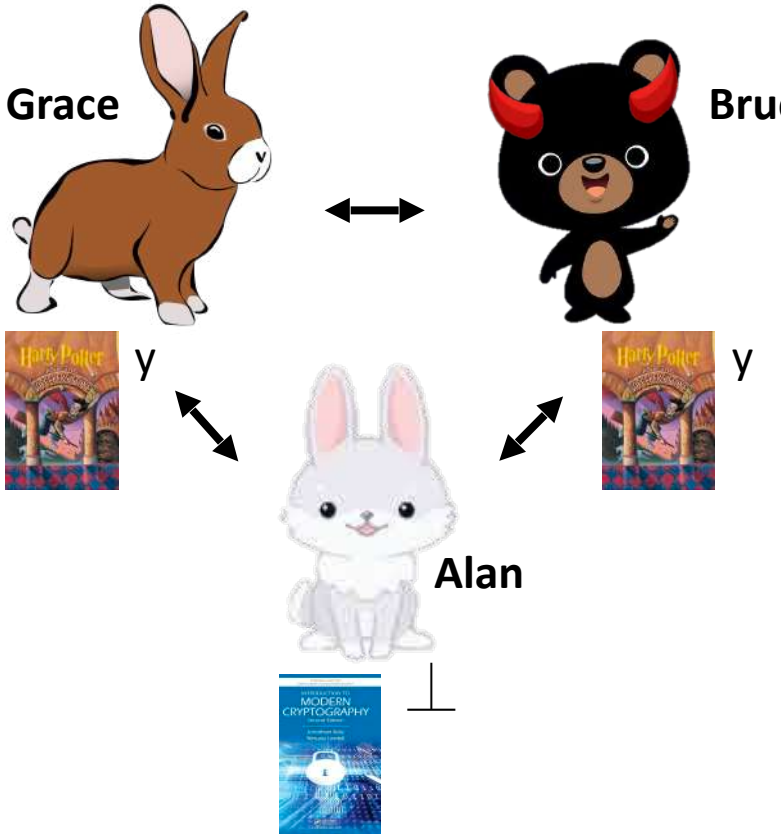
  - **Selective Abort**

Stronger



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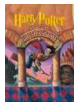
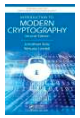
y = should we read  or  for book club?

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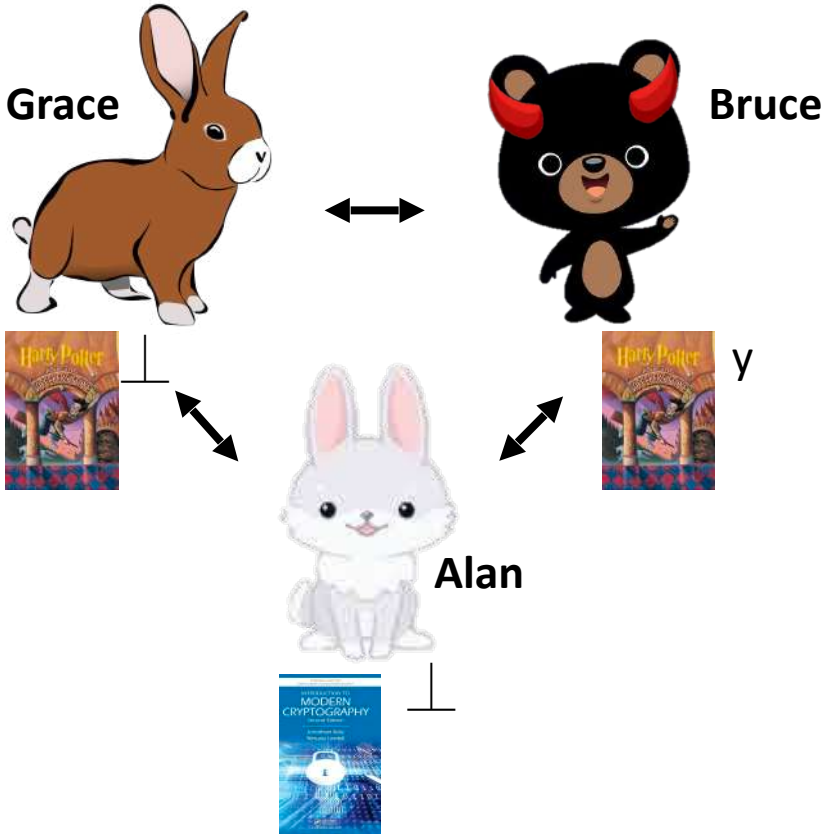
  - **Unanimous Abort**

Stronger



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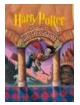
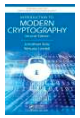
y = should we read  or  for book club?

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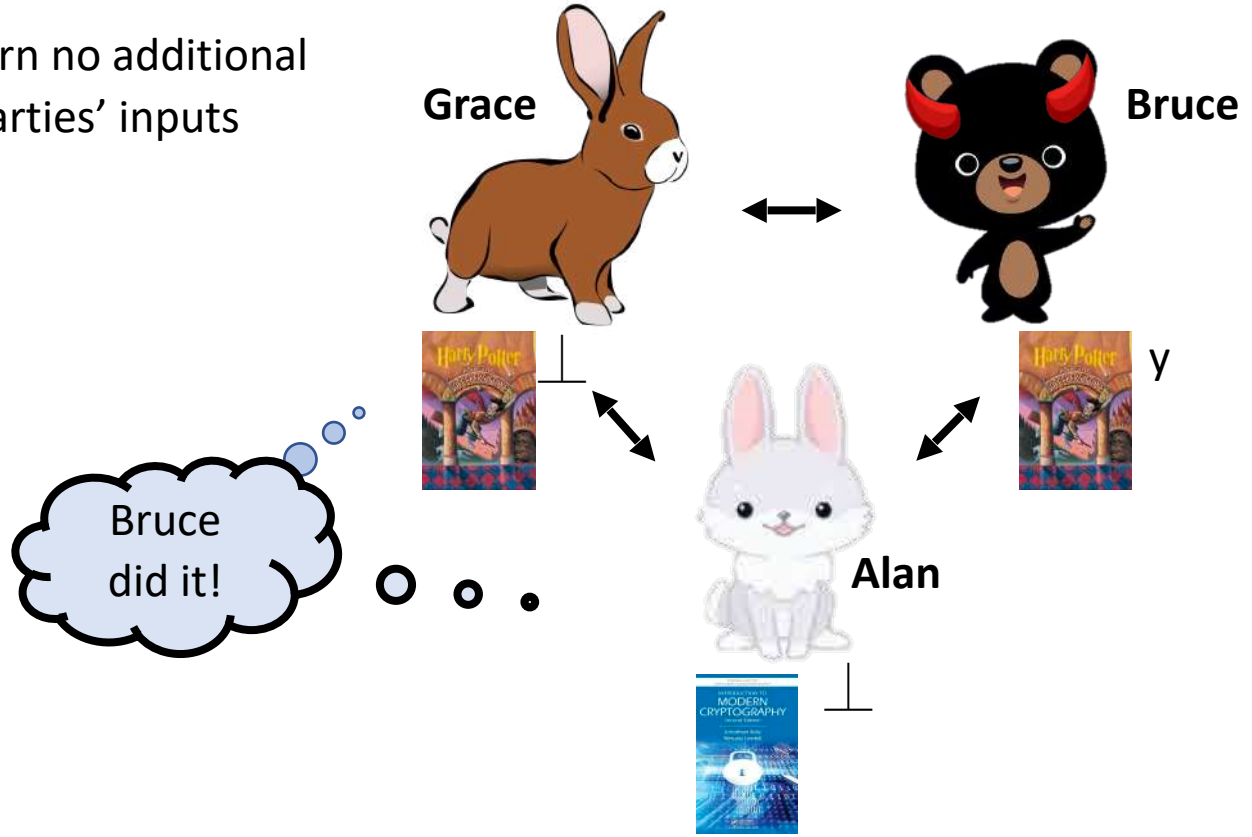
- Correctness:
  - Selective Abort
  - Unanimous Abort
  - **Identifiable Abort**

Stronger



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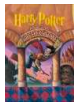
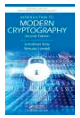
y = should we read  or  for book club?

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- Correctness:
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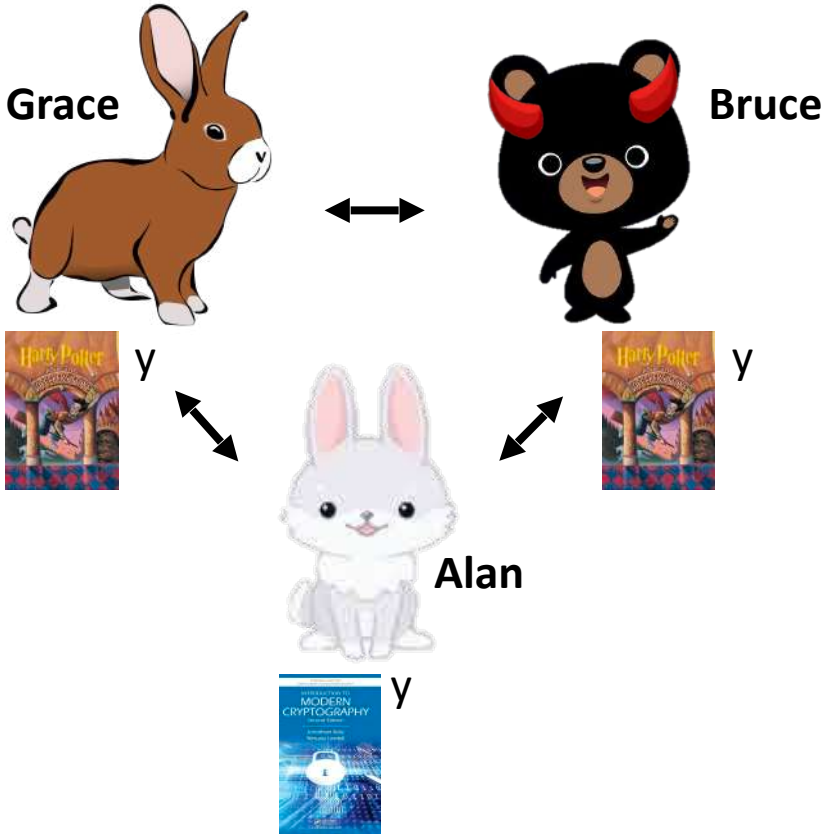
  - Identifiable Abort
  - **Guaranteed Output Delivery**

Stronger



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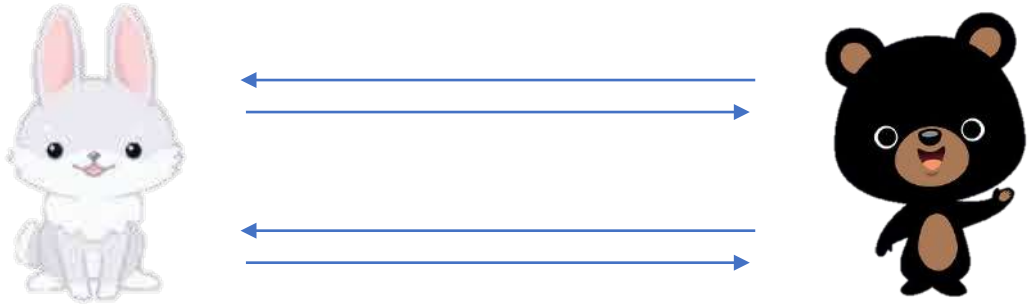

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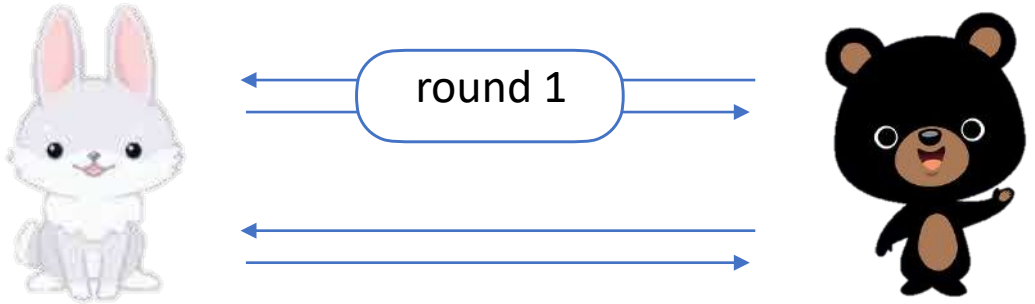

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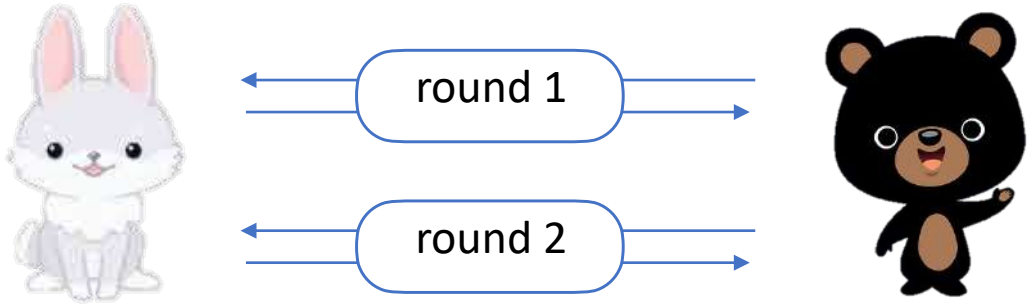
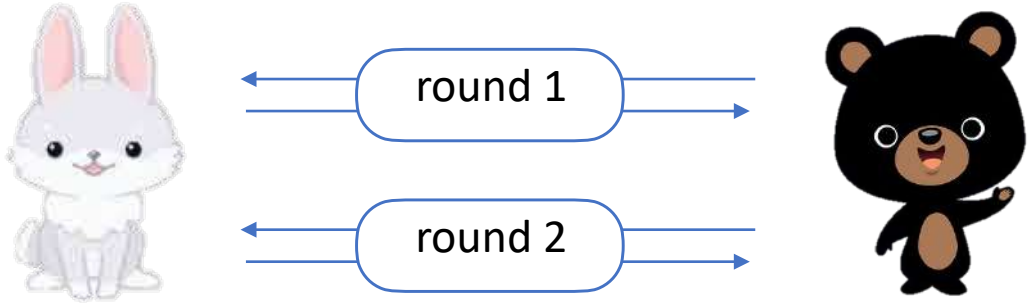


Broadcast-Optimal Two Round MPC

- Rounds are expensive!
  - At least two rounds needed for MPC



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- Broadcast is expensive!
  - Takes many rounds, or
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- Most two-round MPC:
  - Does not use broadcast (gets weaker guarantees - e.g. selective abort)
  - Uses broadcast in both rounds (expensive)

Broadcast-Optimal Two Round MPC

which of the two rounds do we *really* need broadcast in?

Broadcast-Optimal Two Round MPC

which of the two rounds do we *really* need broadcast in?

	Dishonest majority	Honest majority
PKI	[CGZ20]	[DMRS**Y**21]
No PKI		[DRS**Y**23]

PKI: public key infrastructure

Broadcast-Optimal Two Round MPC

which of the two rounds do we *really* need broadcast in?

	Dishonest majority	Honest majority
PKI	[CGZ20]	[DRSY23]
No PKI		

Assumes Synchronous Channels

PKI: public key infrastructure

Synchronous communication

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Guaranteed to be delivered within one round

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Asynchronous communication

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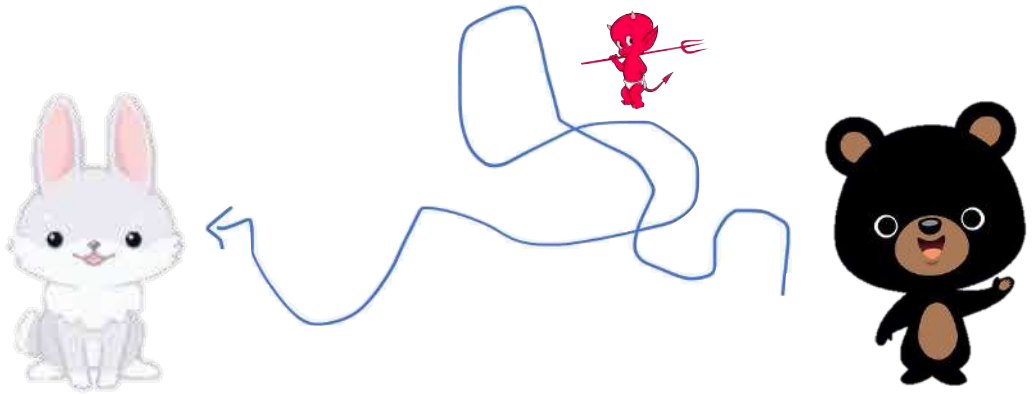

Arbitrarily delayed by adversary

Synchronous communication

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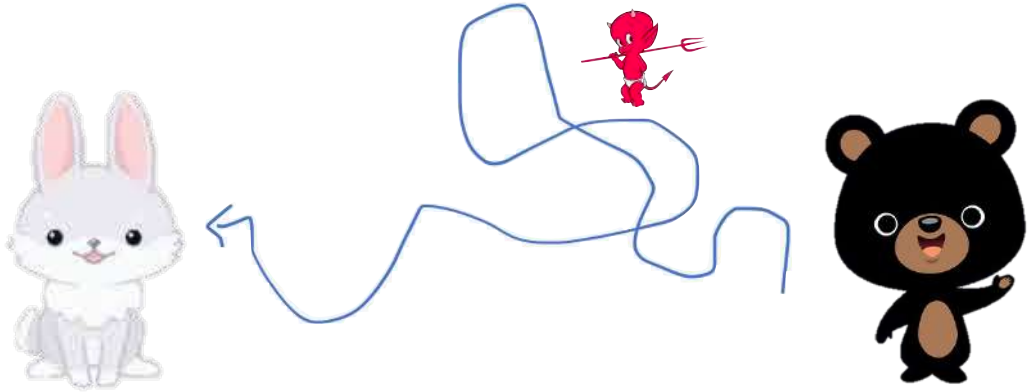
Asynchronous communication



Arbitrarily delayed by adversary

Honest parties never know whether…

- message was never sent, or
- It was delayed

Broadcast-Optimal Two Round MPC
with Asynchronous Peer-to-Peer Rounds

first round \ Second round	asynchronous P2P	BC
asynchronous P2P	impossible with standard definitions of security	
BC		well-studied

Broadcast-Optimal Two Round MPC with Asynchronous Peer-to-Peer Rounds

Second round

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Broadcast-Optimal Two Round MPC with Asynchronous Peer-to-Peer Rounds

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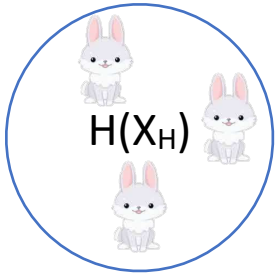
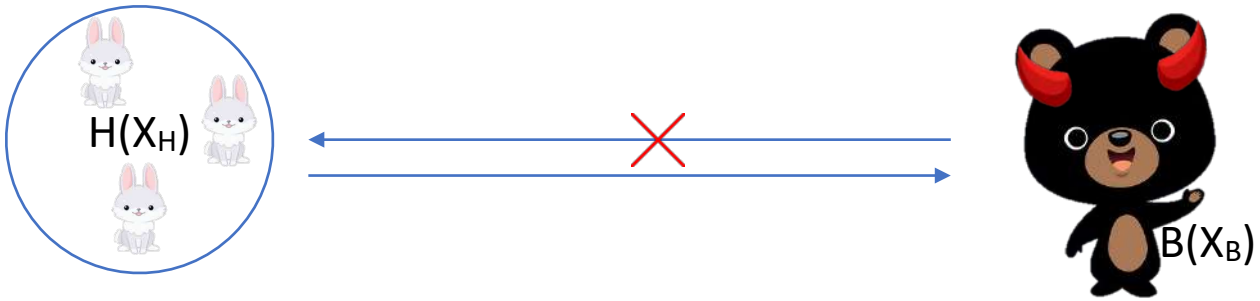


Impossibility of asyncP2P, BC

round 1: asyncP2P

round 2: BC

Impossibility of asyncP2P, BC



round 1: asyncP2P

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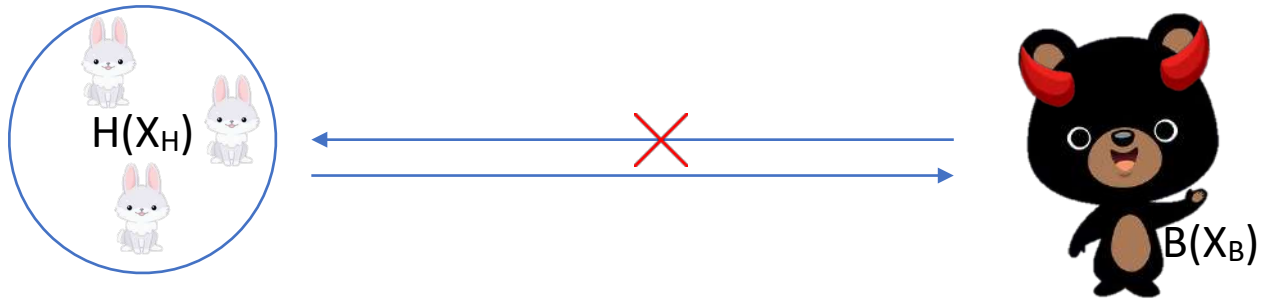
- Nothing H says depends on X_B

Impossibility of asyncP2P, BC



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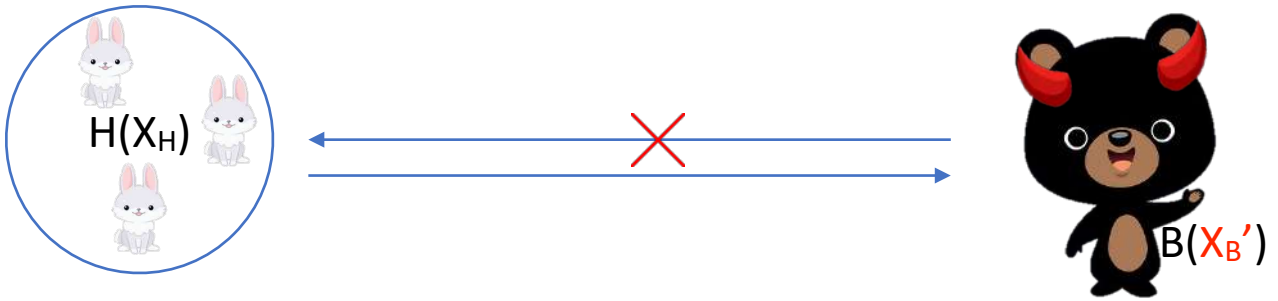

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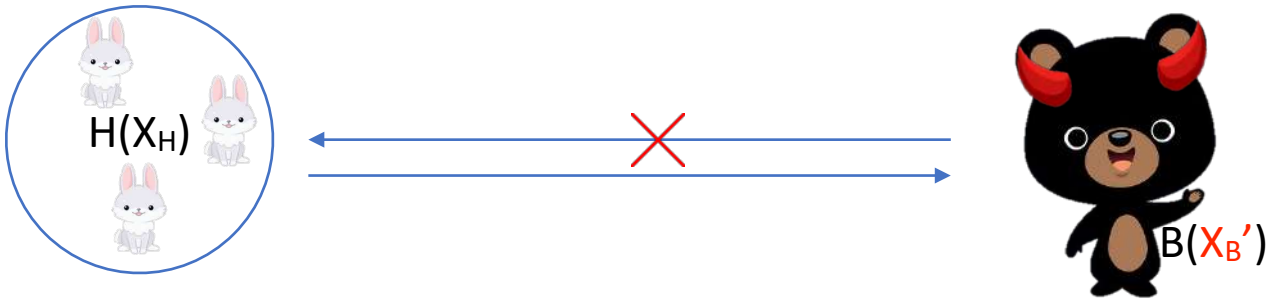

round 1: asyncP2P

round 2: BC

(t_d,t_m)-asynchrony

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deafness threshold

muteness threshold

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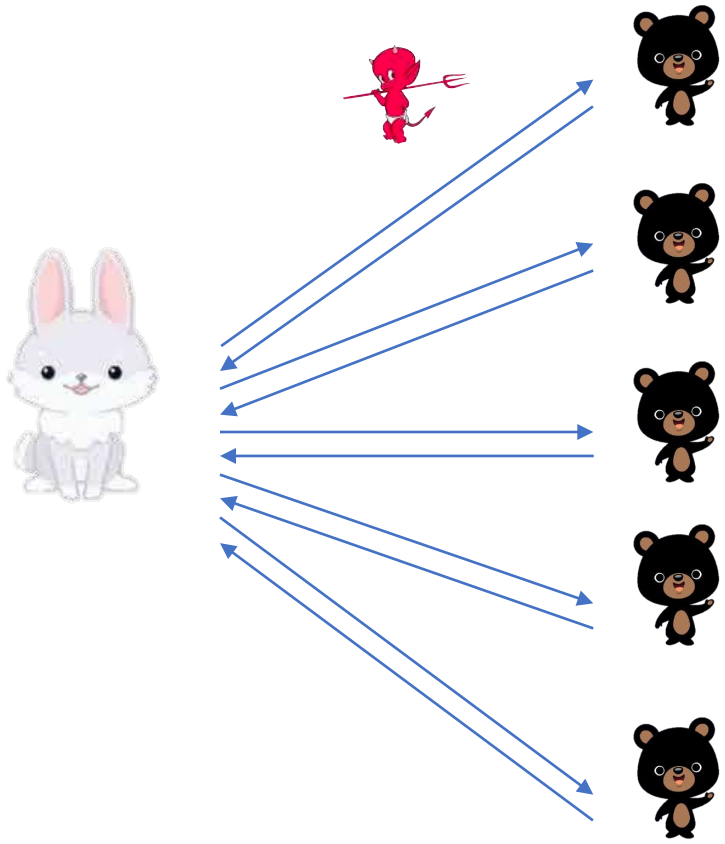
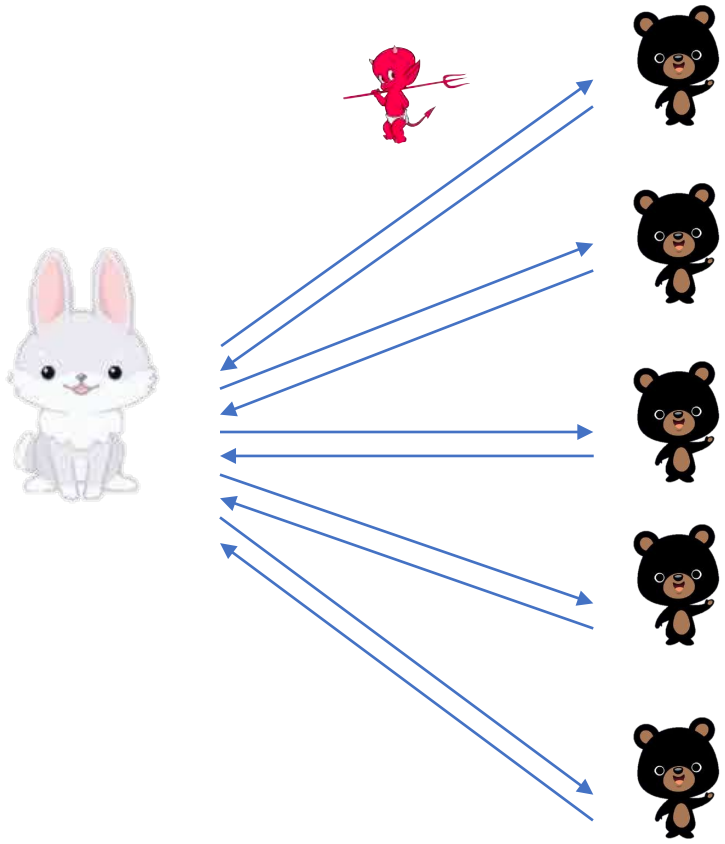


(t_d,t_m)-asynchrony

deafness threshold

muteness threshold

- $t_d = 2$



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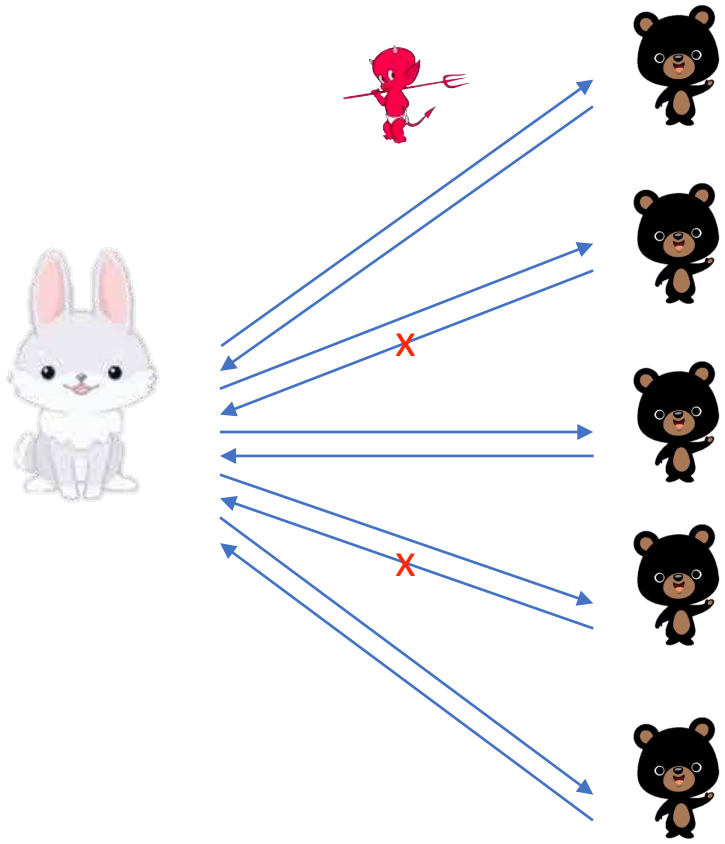

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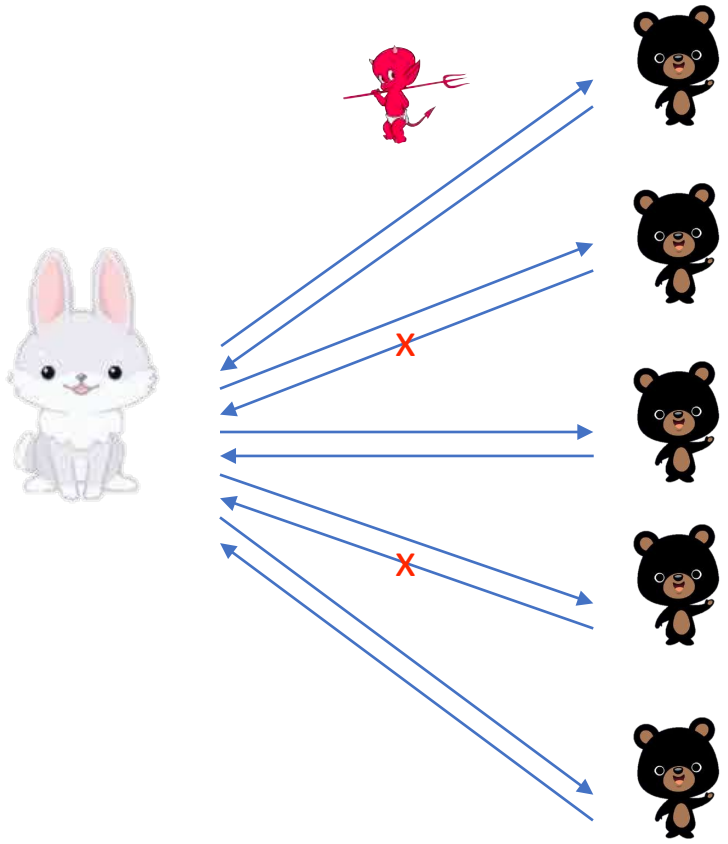

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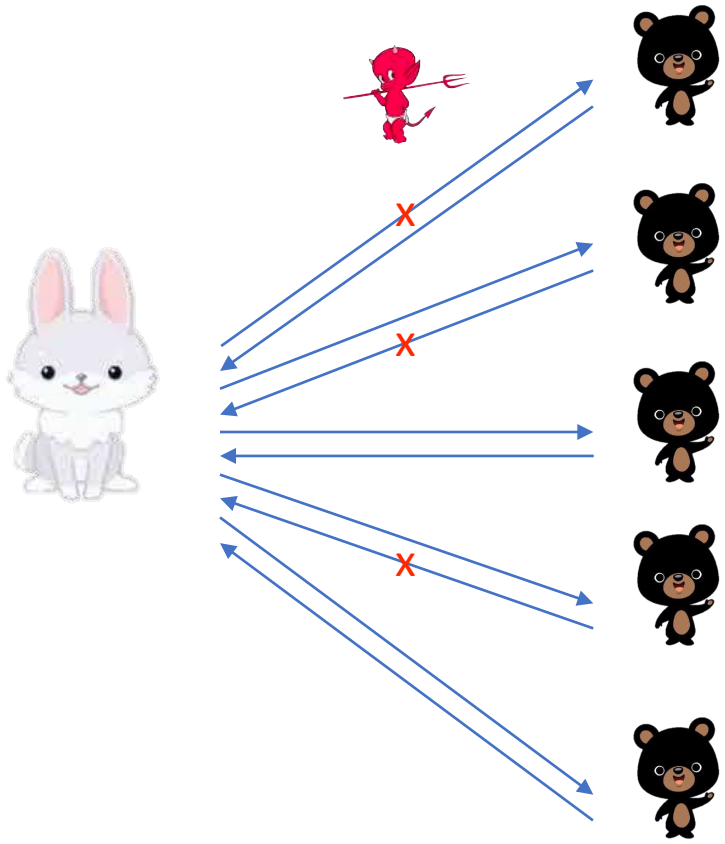
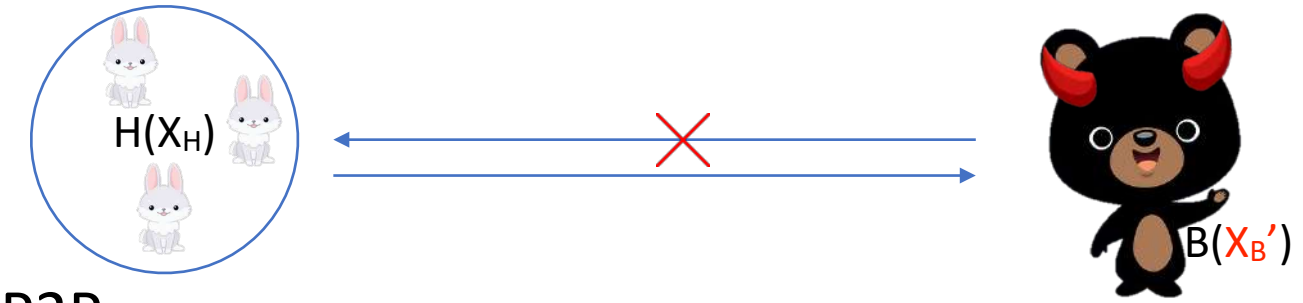
- $t_d = 2$
- $t_m = 1$



(t_d,t_m)-asyncP2P, BC

with PKI

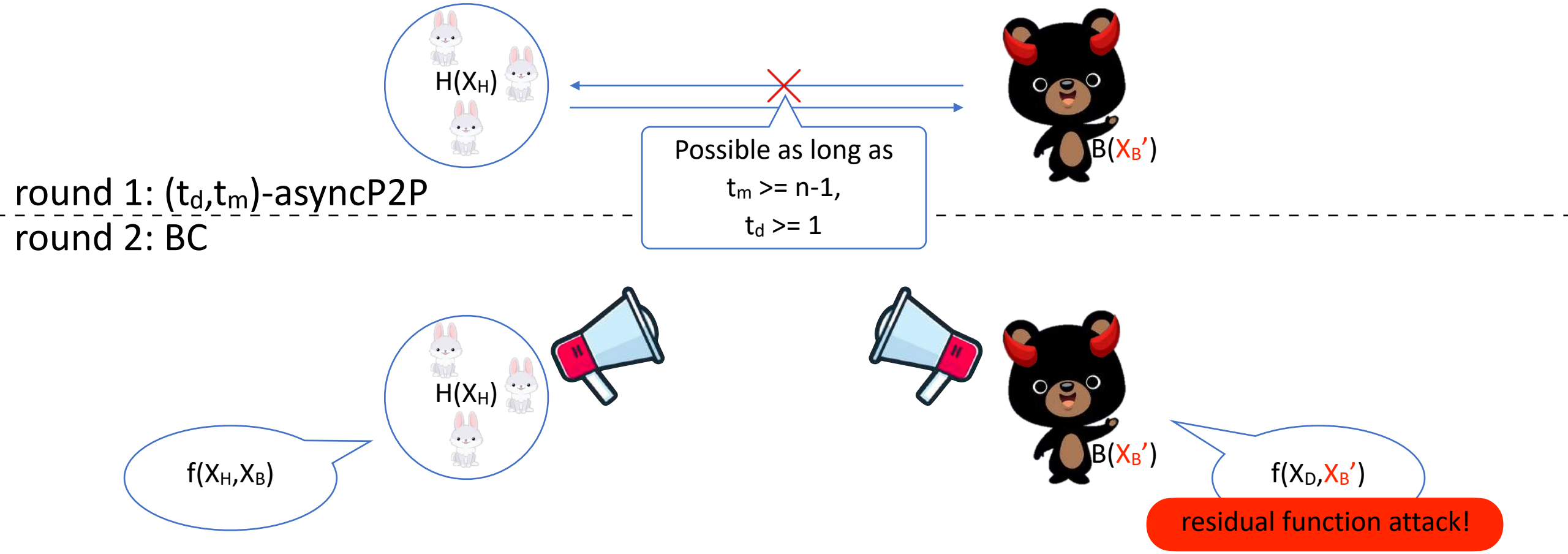


round 1: (t_d,t_m)-asyncP2P

round 2: BC

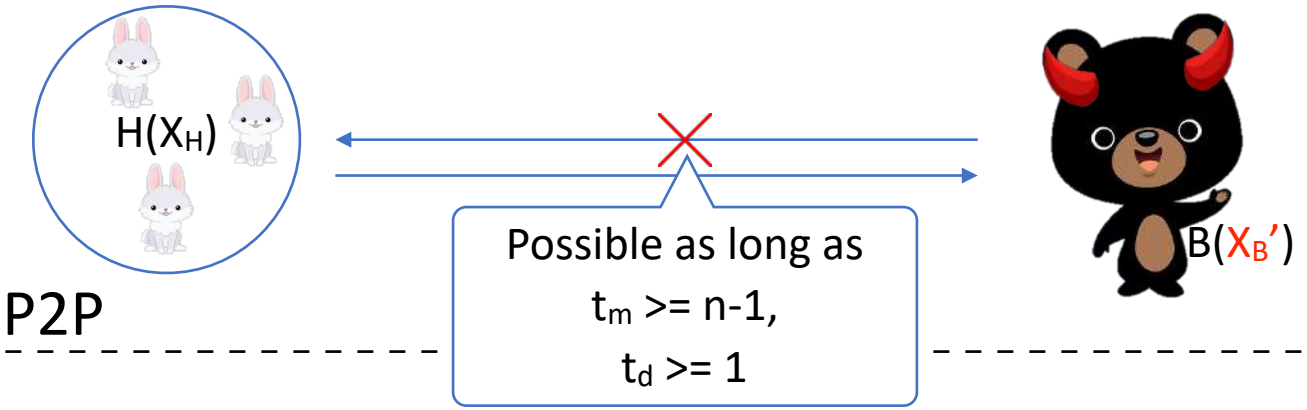
(t_d,t_m)-asyncP2P, BC

with PKI



(t_d,t_m)-asyncP2P, BC

with PKI

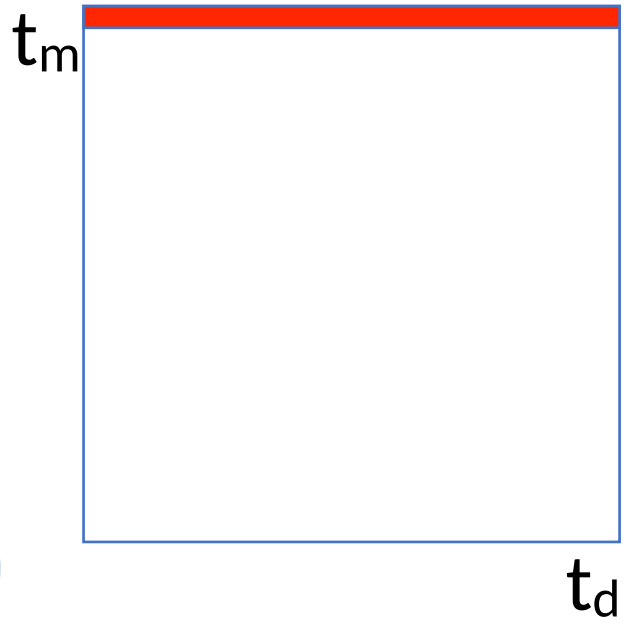


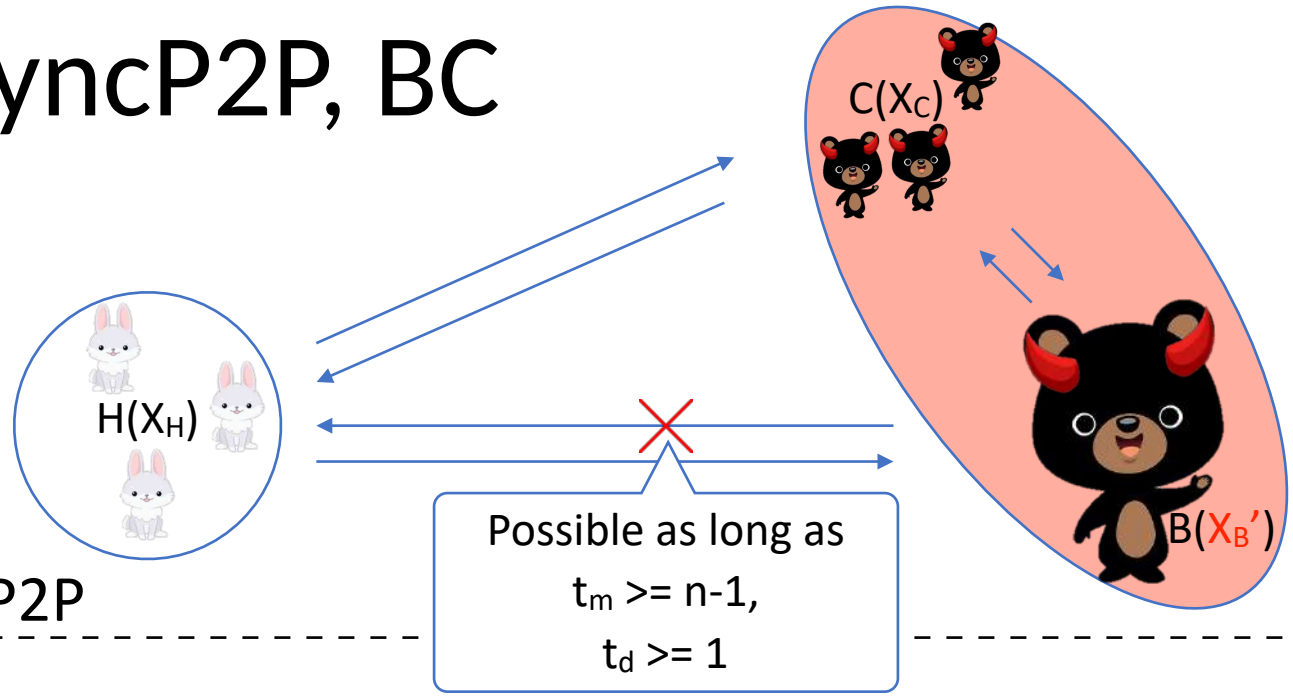
round 1: (t_d,t_m)-asyncP2P

round 2: BC

(t_d,t_m)-asyncP2P, BC

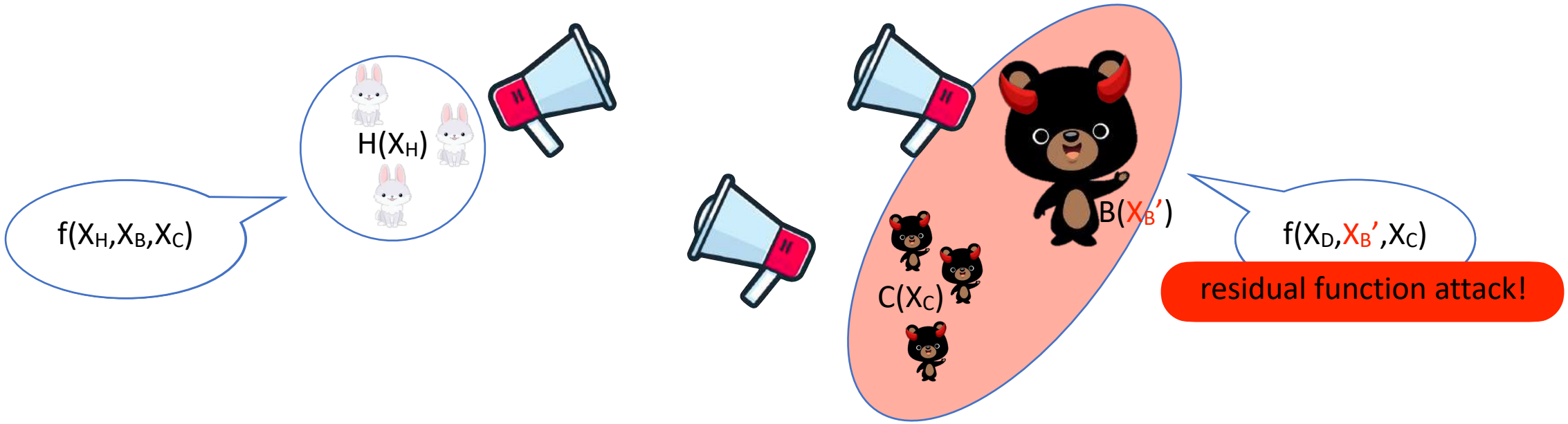
with PKI





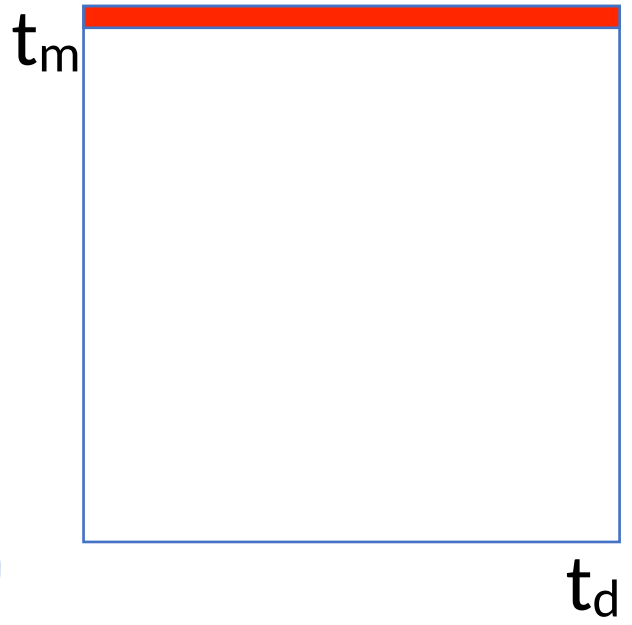
round 1: (t_d,t_m)-asyncP2P

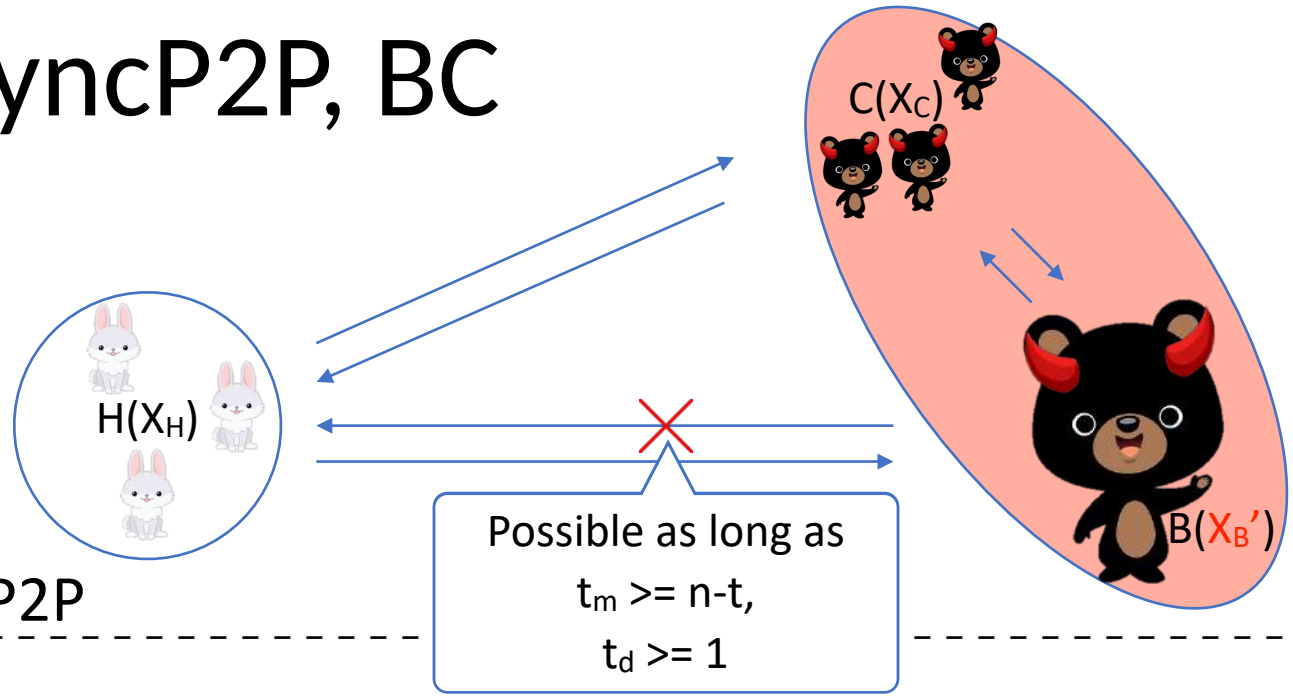
round 2: BC



(t_d,t_m)-asyncP2P, BC

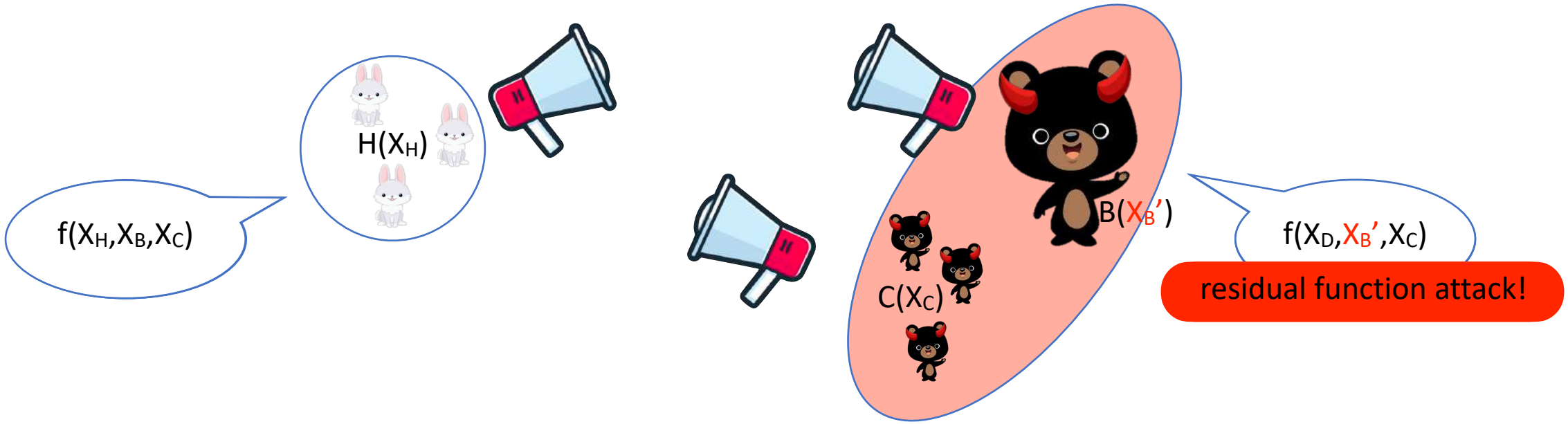
with PKI





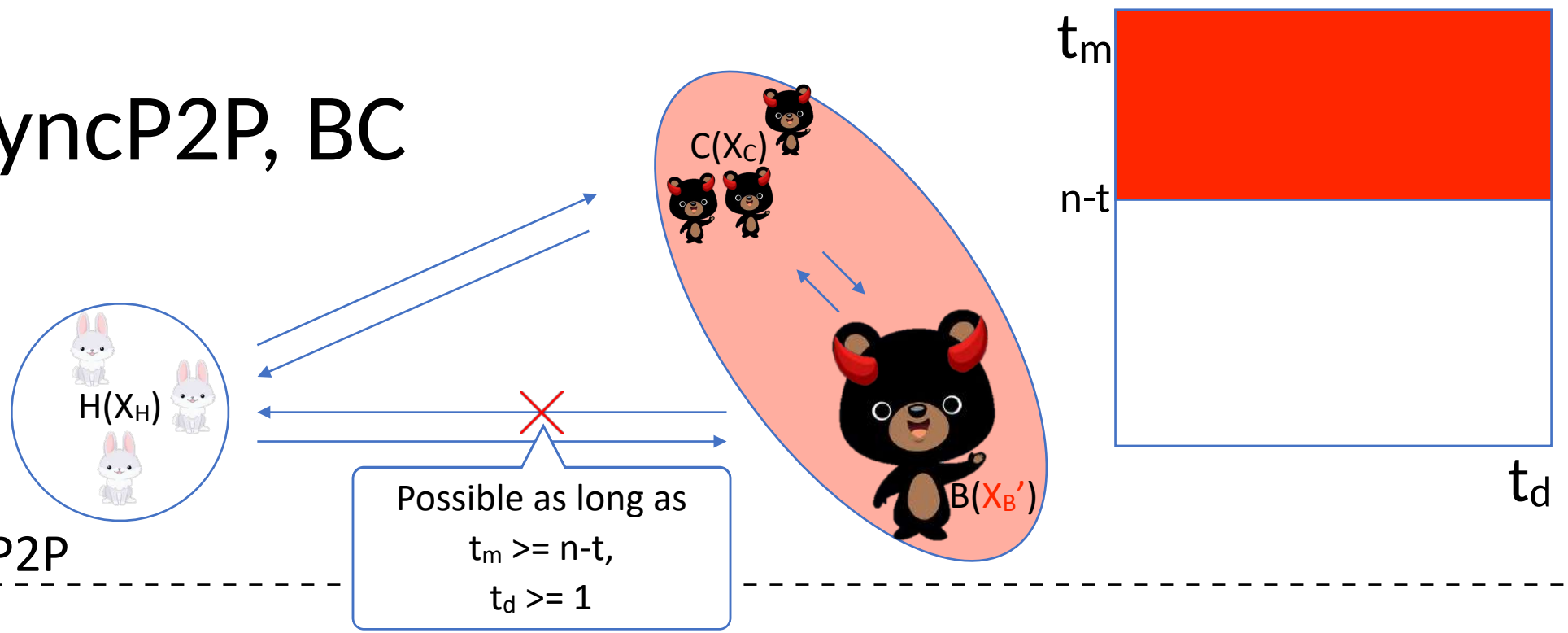
round 1: (t_d,t_m)-asyncP2P

round 2: BC



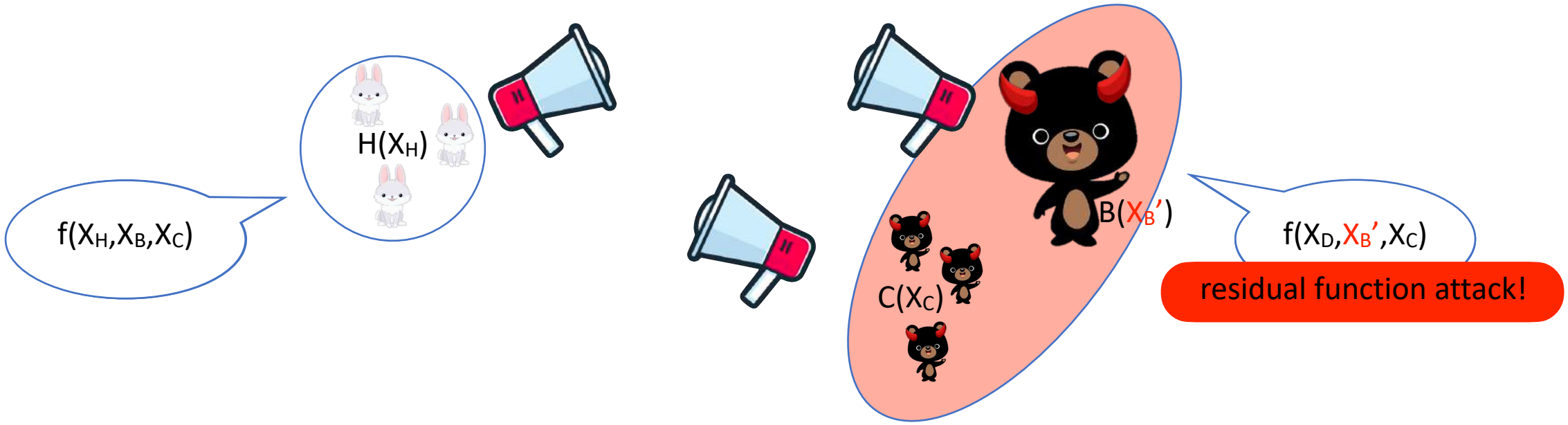
(t_d,t_m)-asyncP2P, BC

with PKI



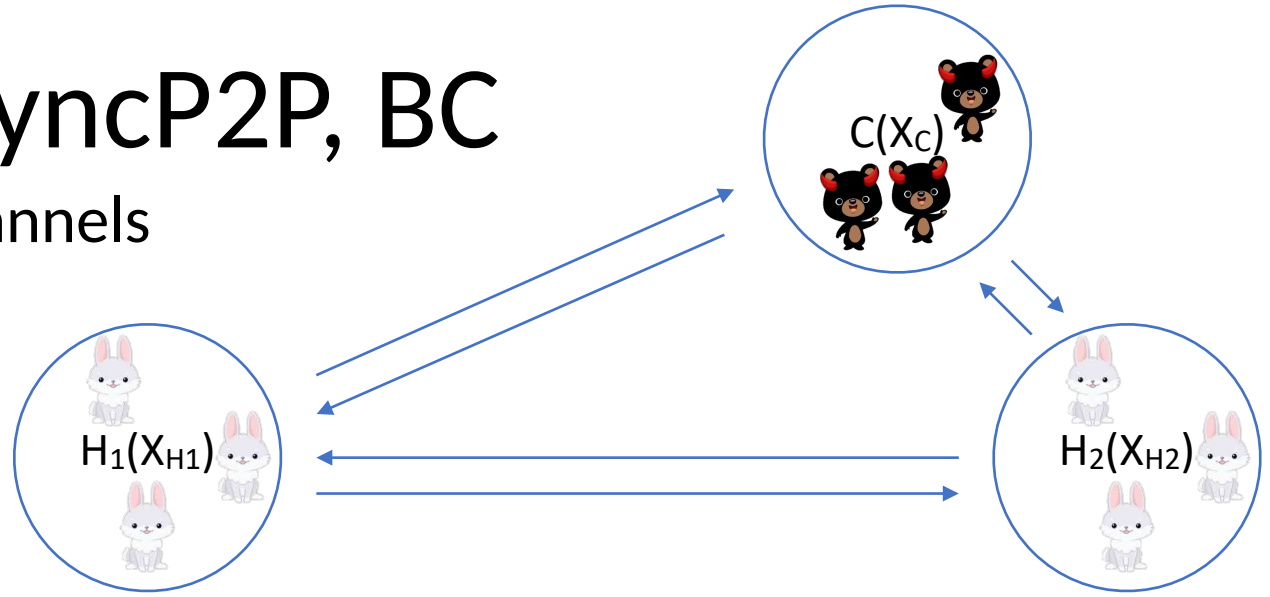
round 1: (t_d,t_m)-asyncP2P

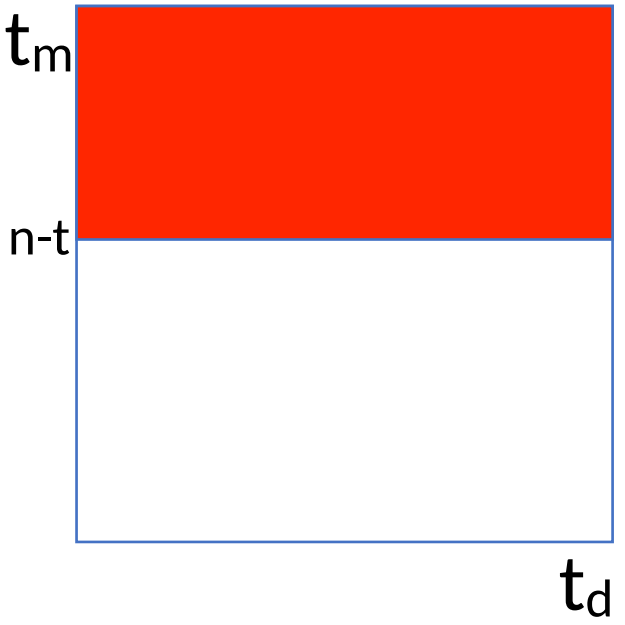
round 2: BC



(t_d,t_m)-asyncP2P, BC

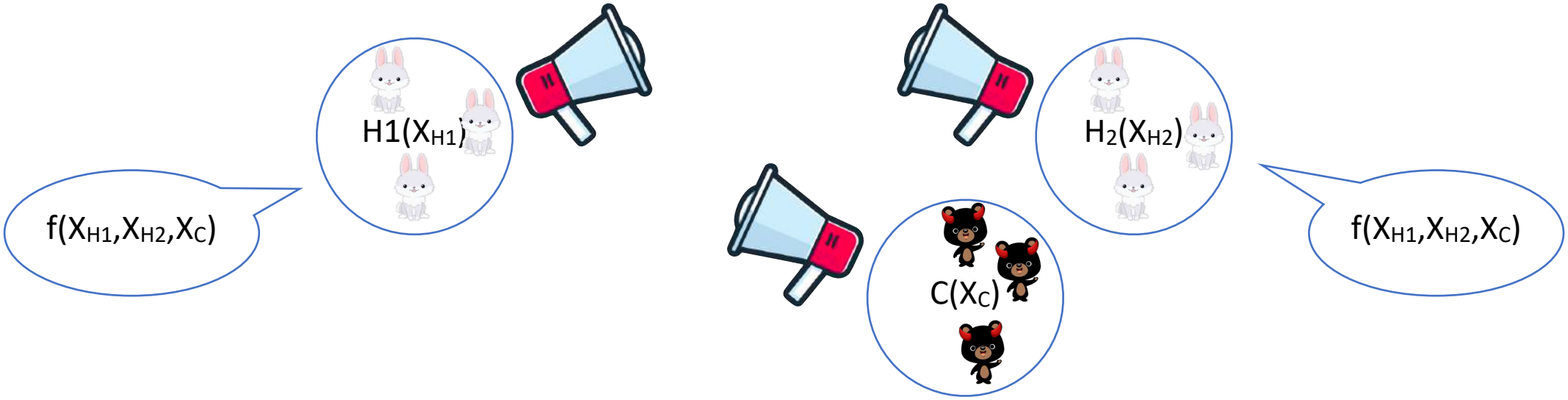
with private channels





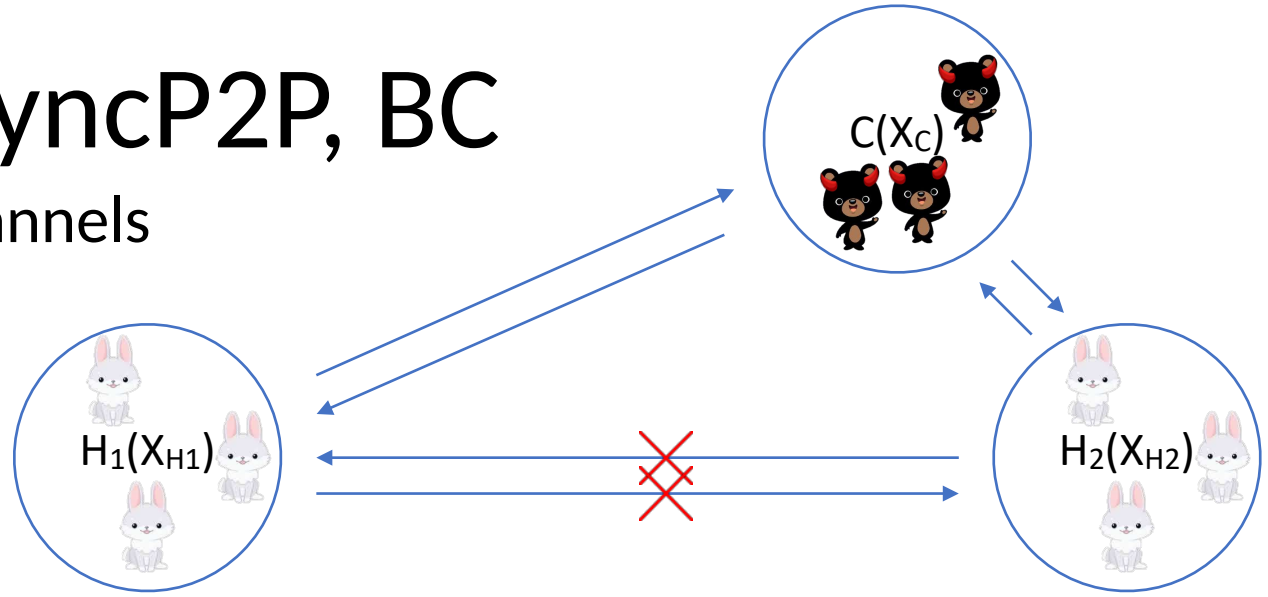
round 1: (t_d,t_m)-asyncP2P

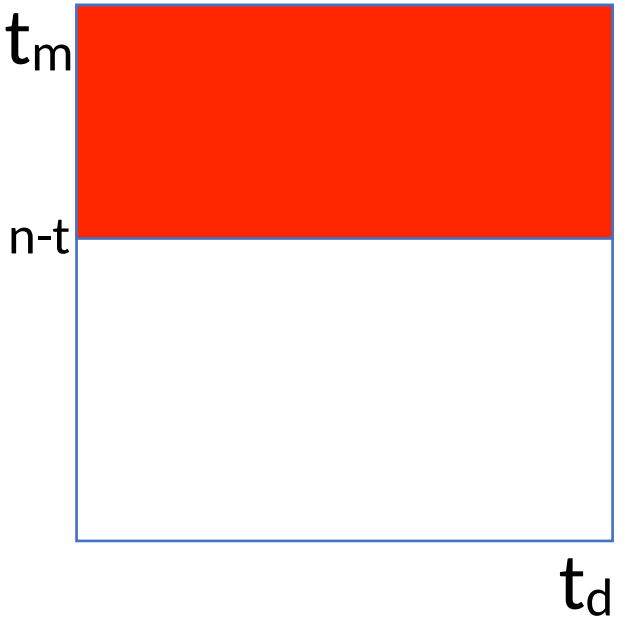
round 2: BC



(t_d,t_m)-asyncP2P, BC

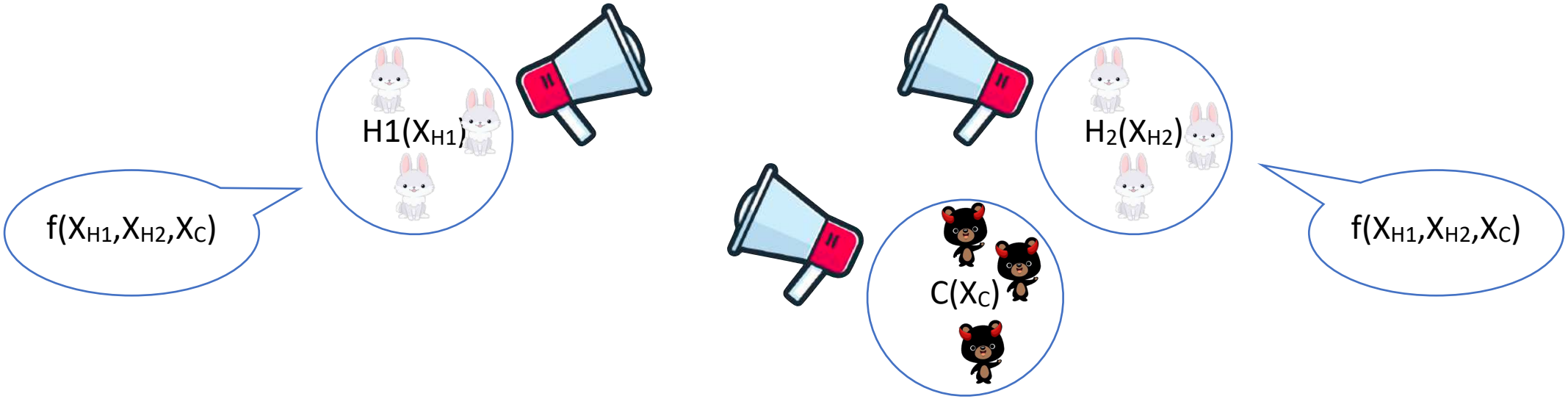
with private channels





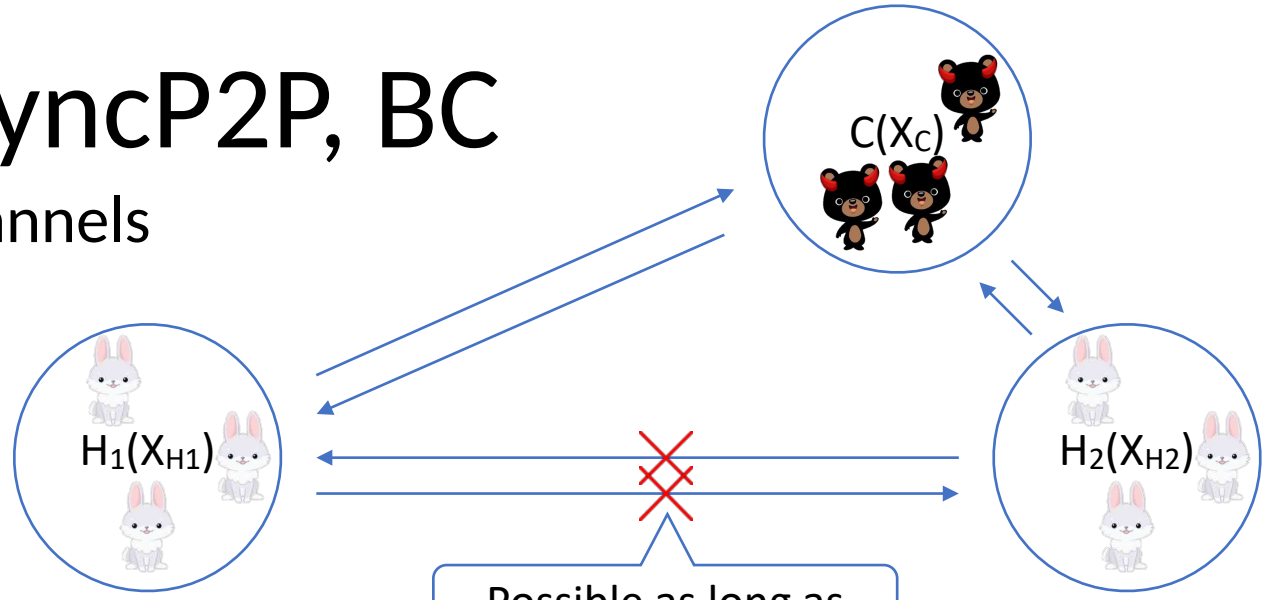
round 1: (t_d,t_m)-asyncP2P

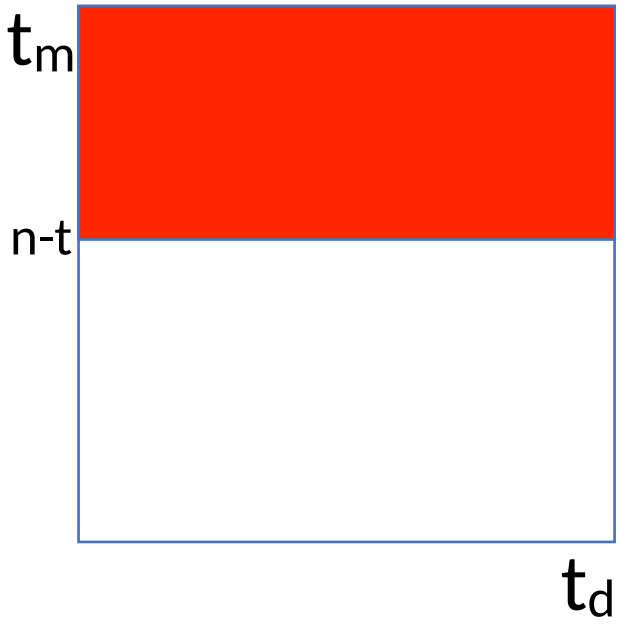
round 2: BC



(t_d,t_m)-asyncP2P, BC

with private channels

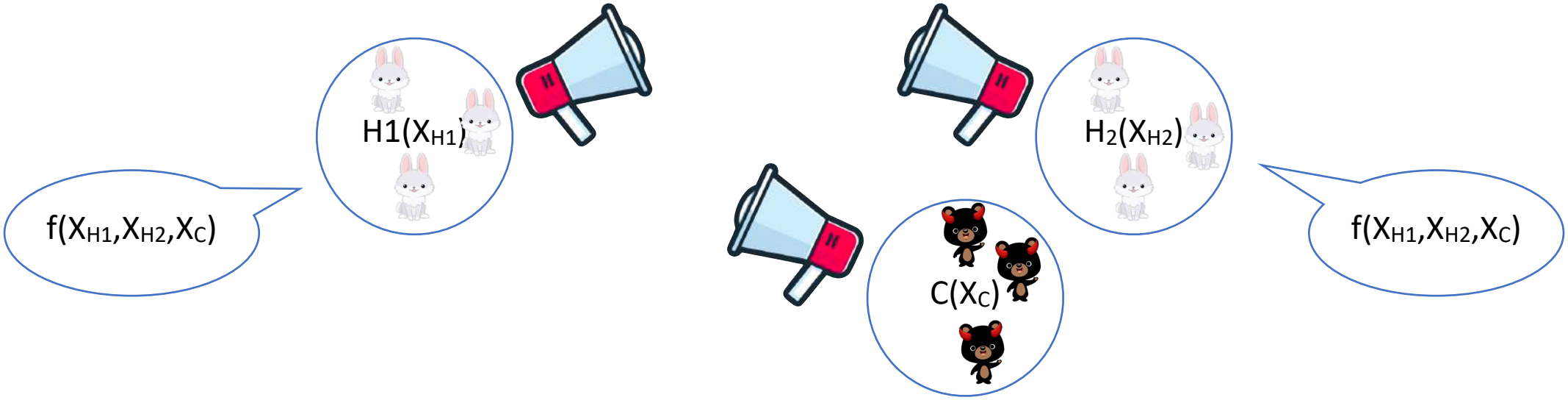




Possible as long as
$t_m >= (n-t)/2$,
$t_d >= (n-t)/2$

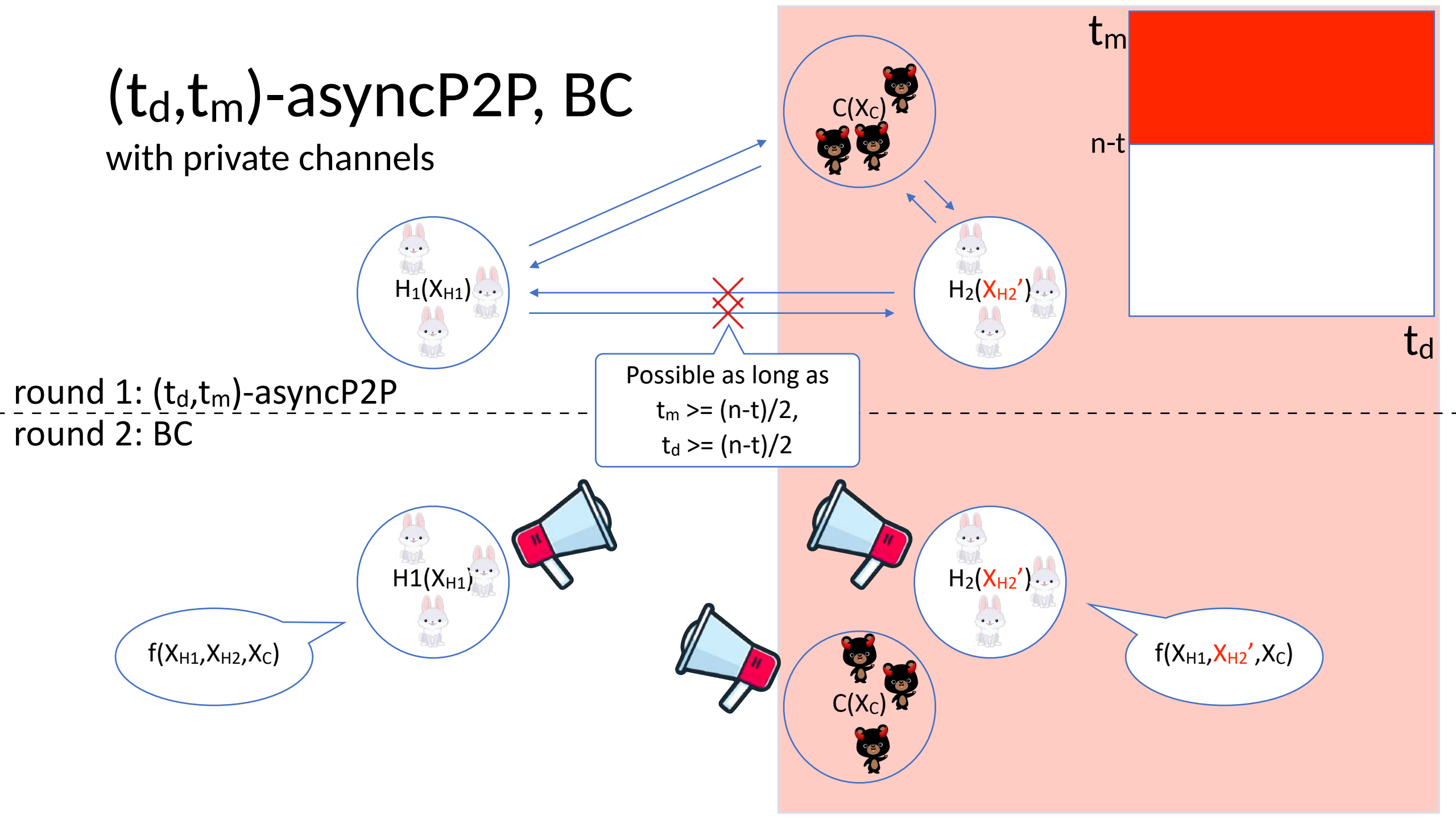
round 1: (t_d,t_m)-asyncP2P

round 2: BC



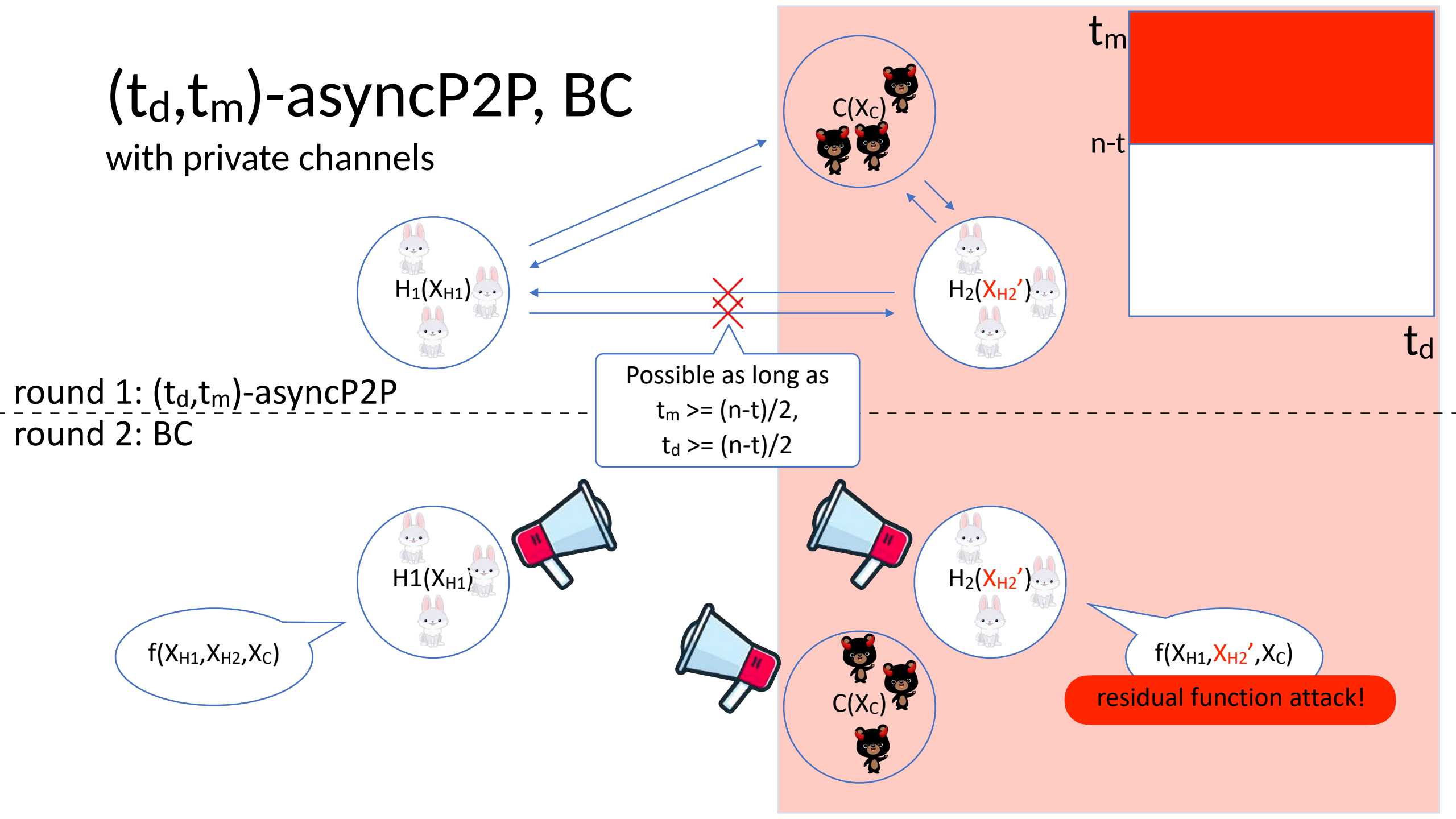
(t_d,t_m)-asyncP2P, BC

with private channels



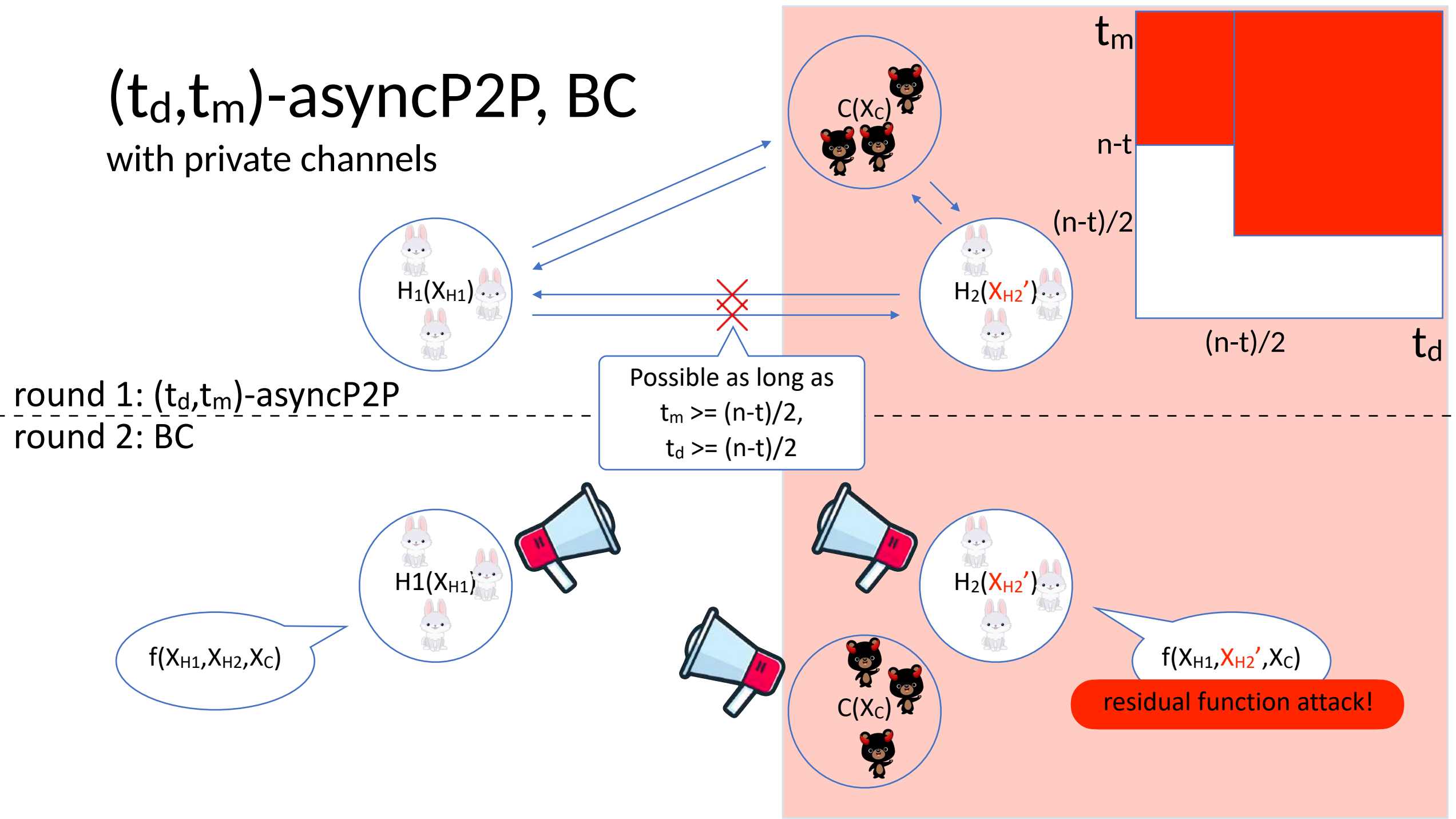
(t_d,t_m)-asyncP2P, BC

with private channels

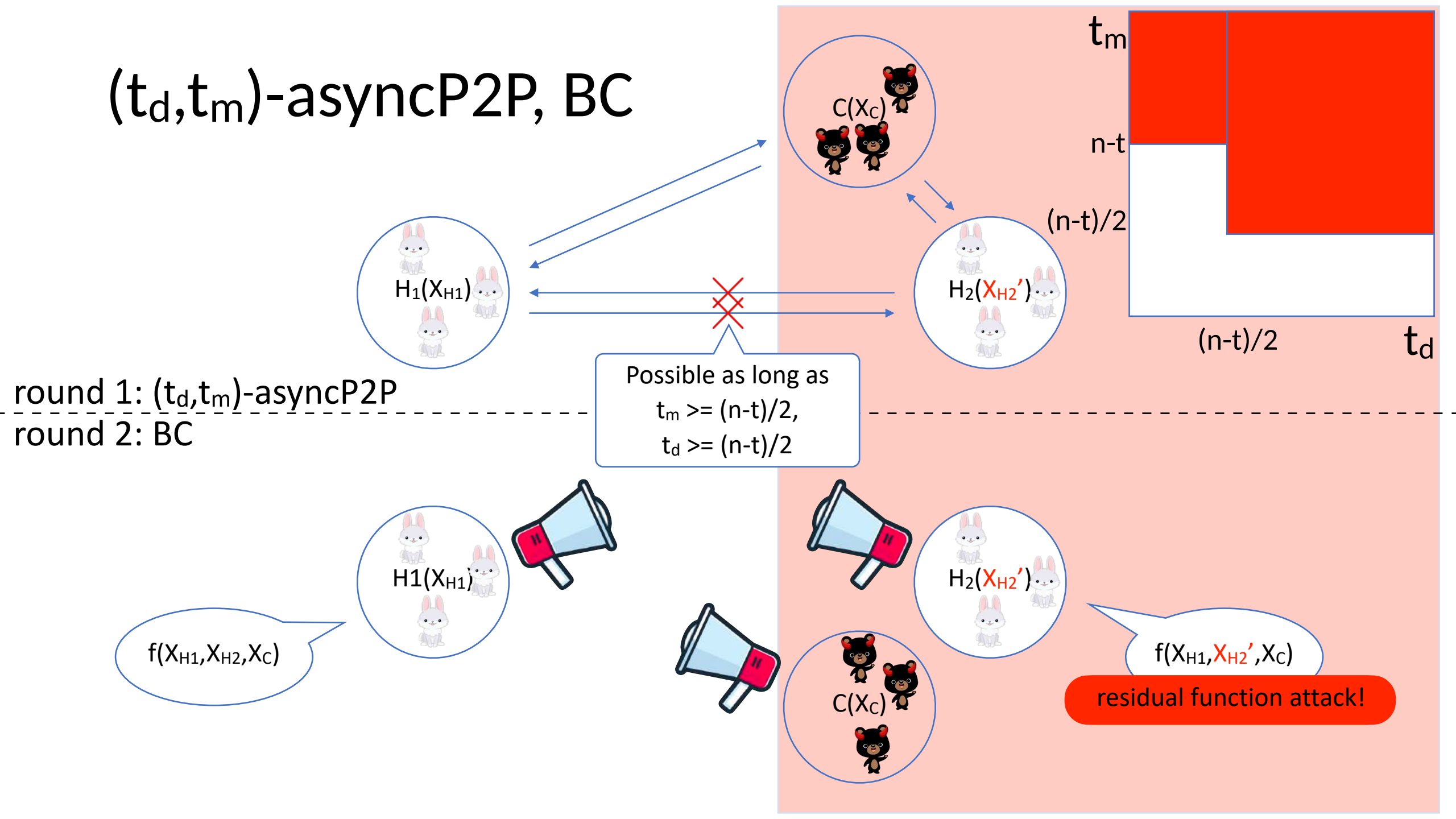


(t_d,t_m)-asyncP2P, BC

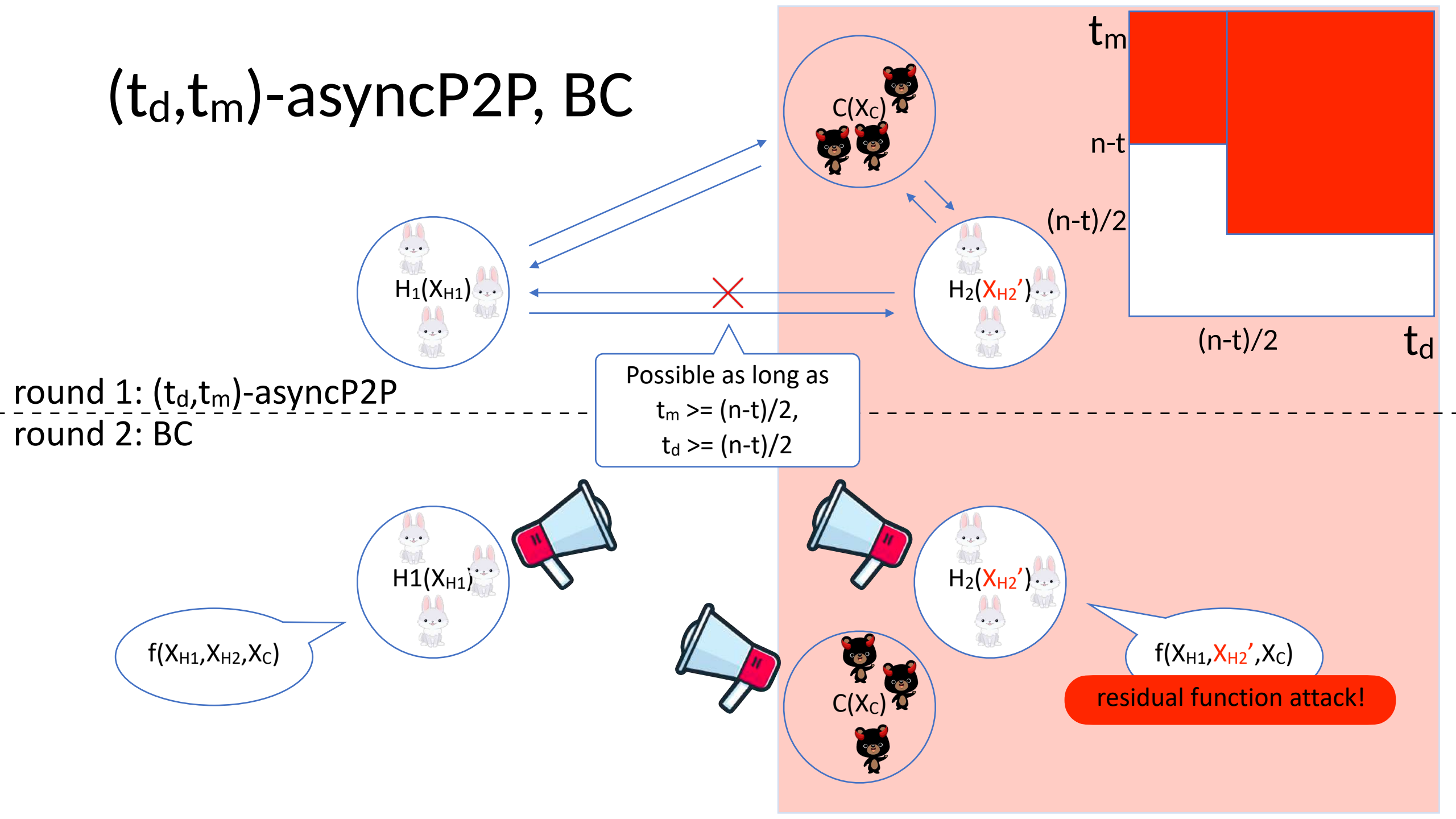
with private channels



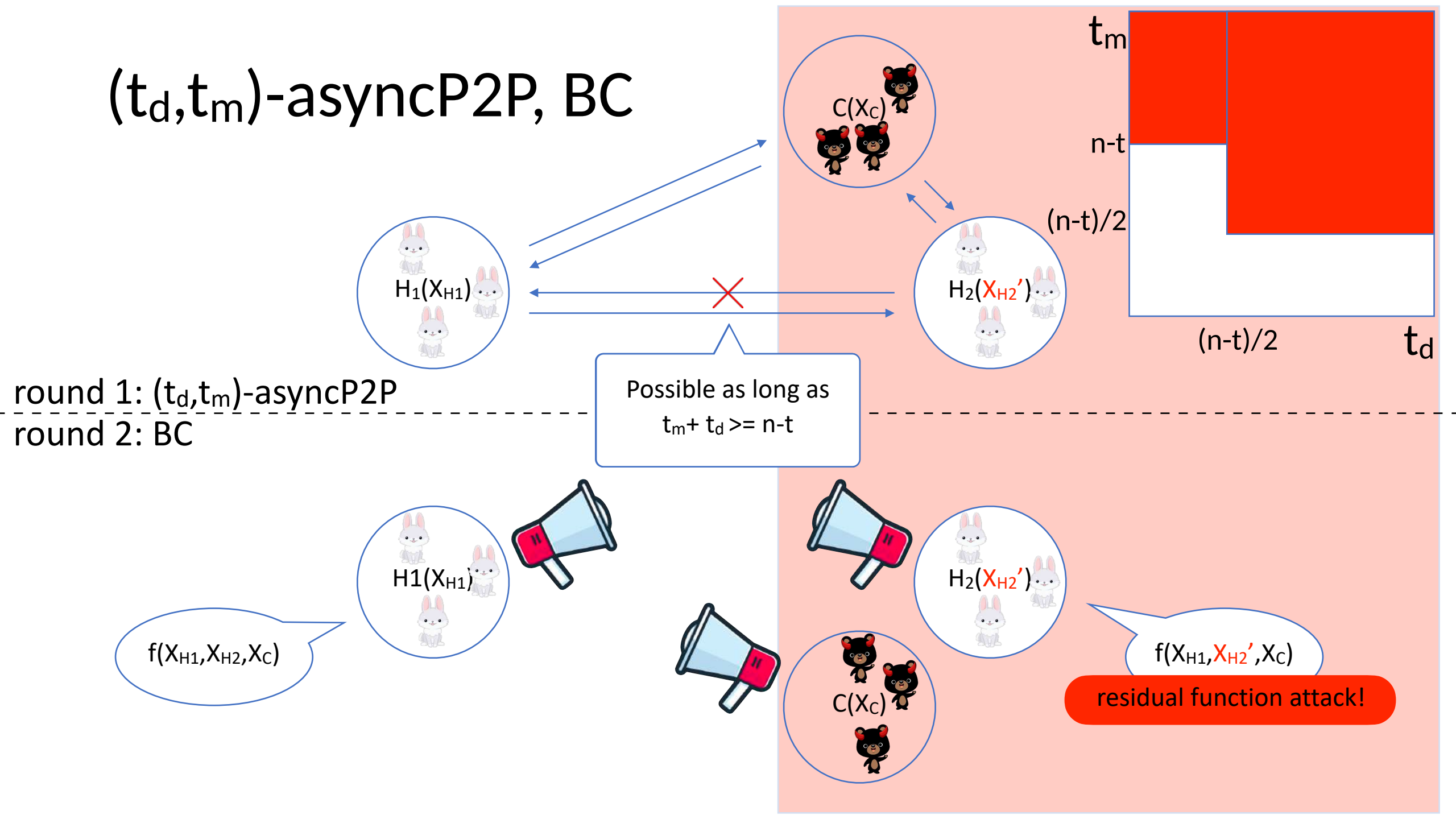
(t_d,t_m)-asyncP2P, BC



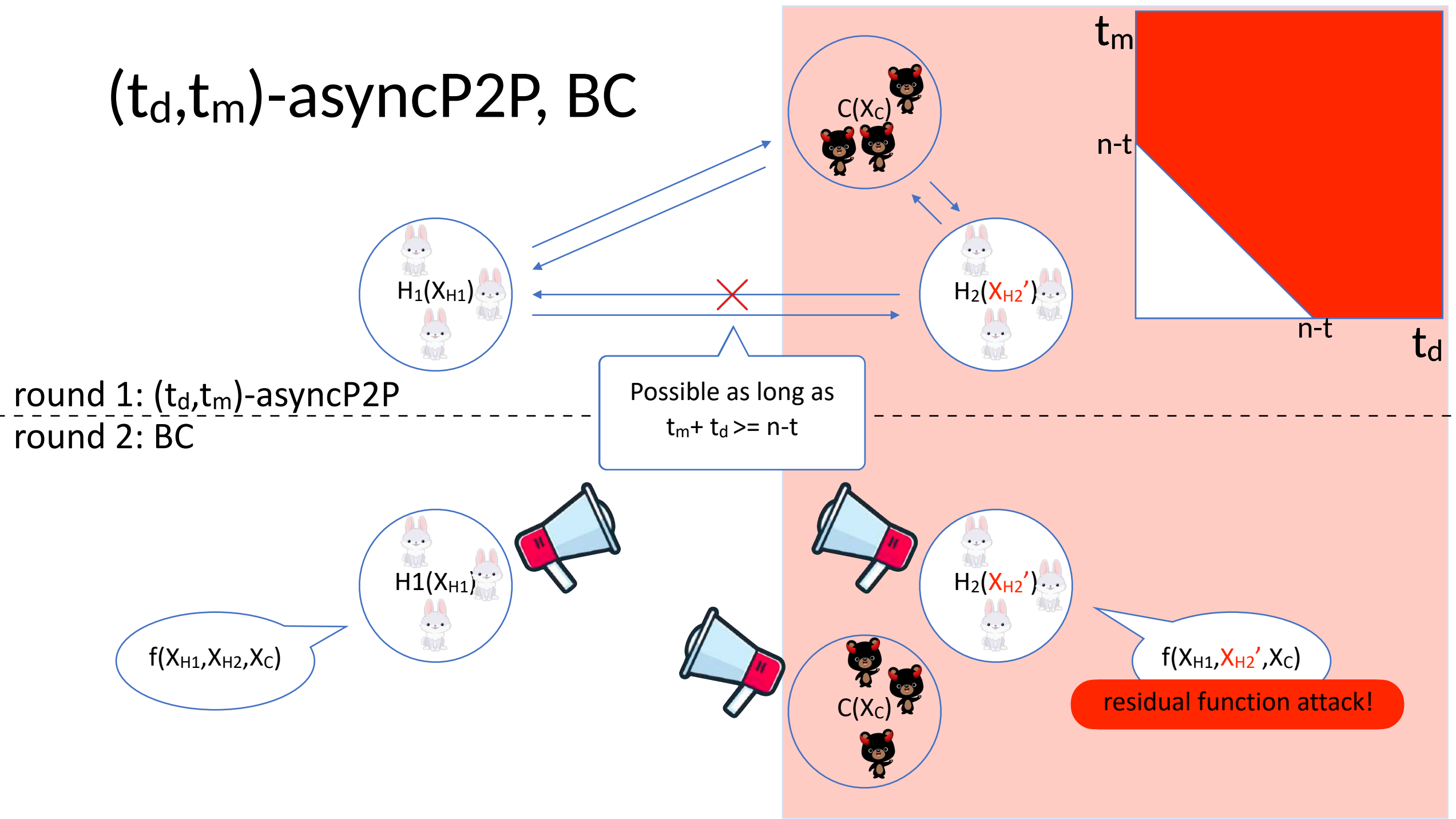
(t_d,t_m)-asyncP2P, BC



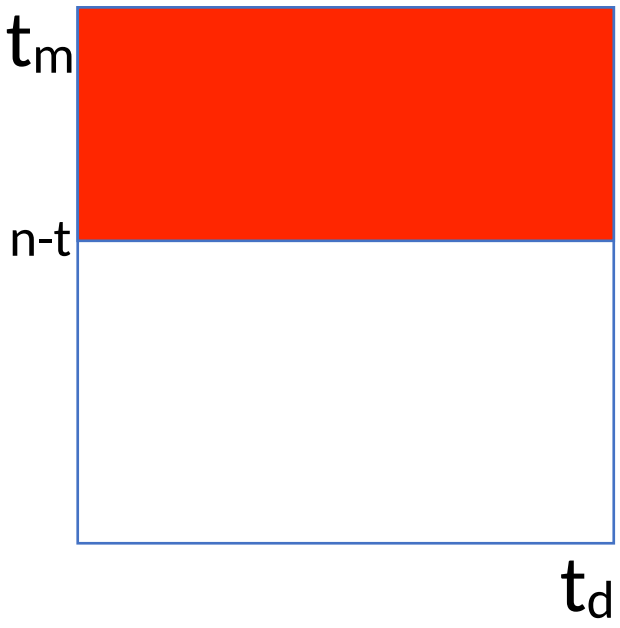
(t_d,t_m)-asyncP2P, BC



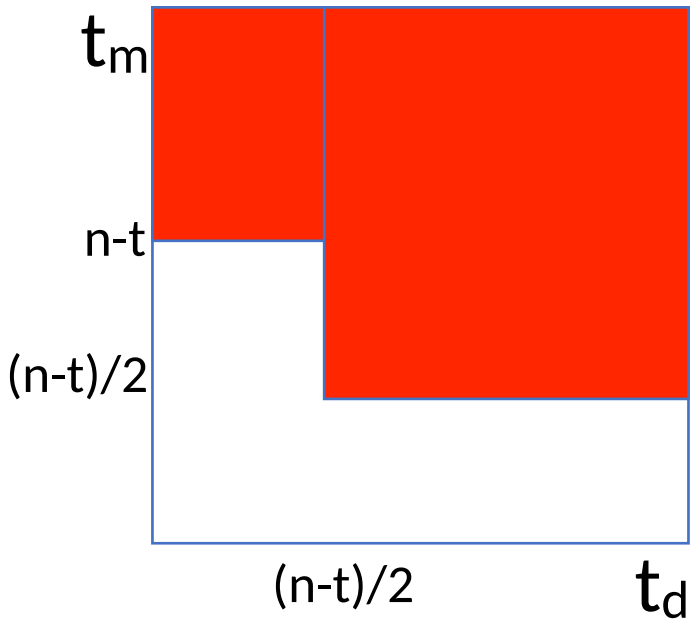
(t_d,t_m)-asyncP2P, BC



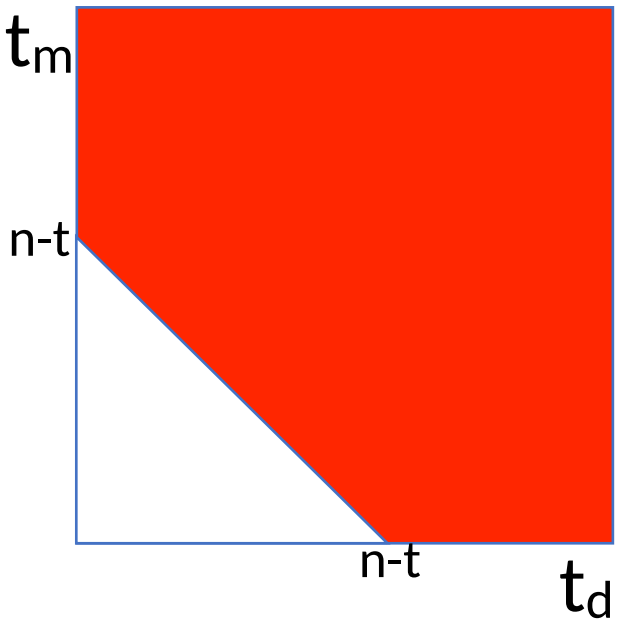
(t_d,t_m)-asyncP2P, BC



with PKI

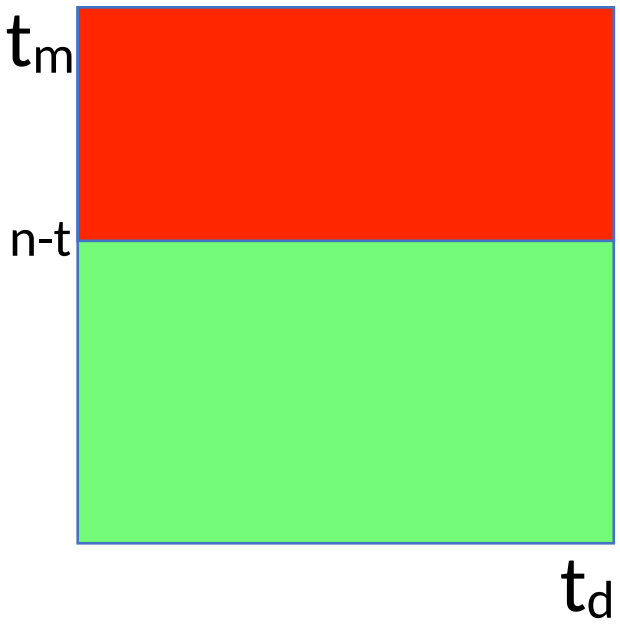


with private channels

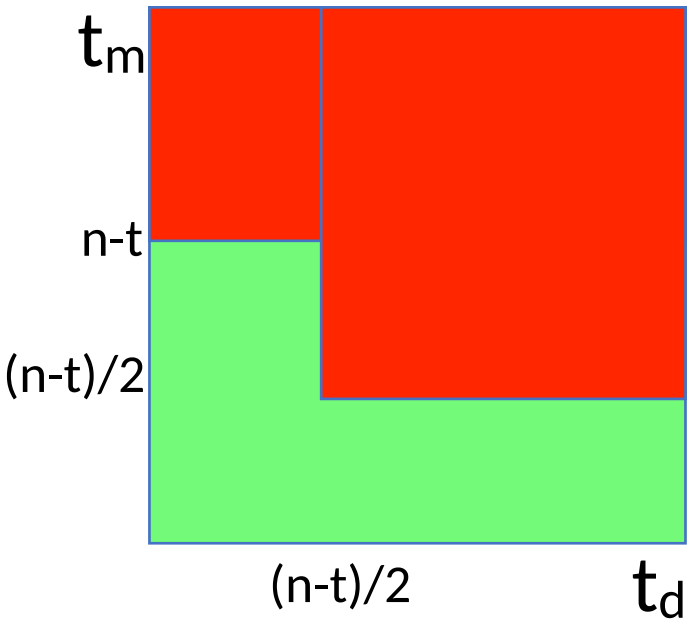


no PKI or private channels

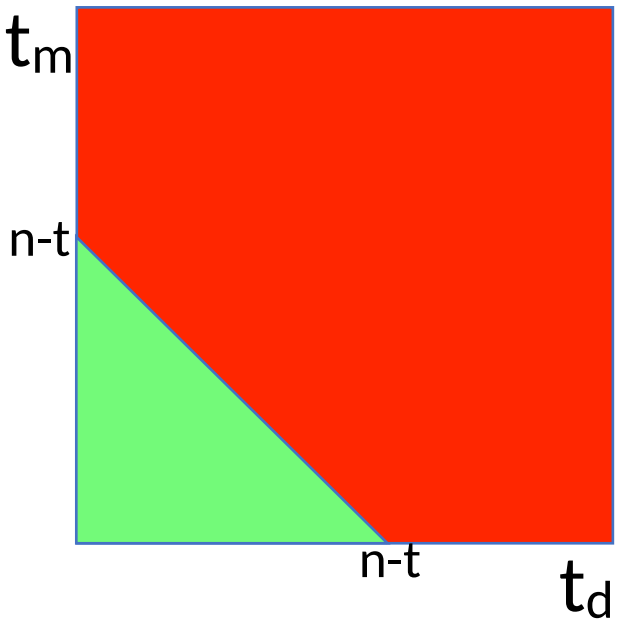
(t_d,t_m)-asyncP2P, BC



with PKI

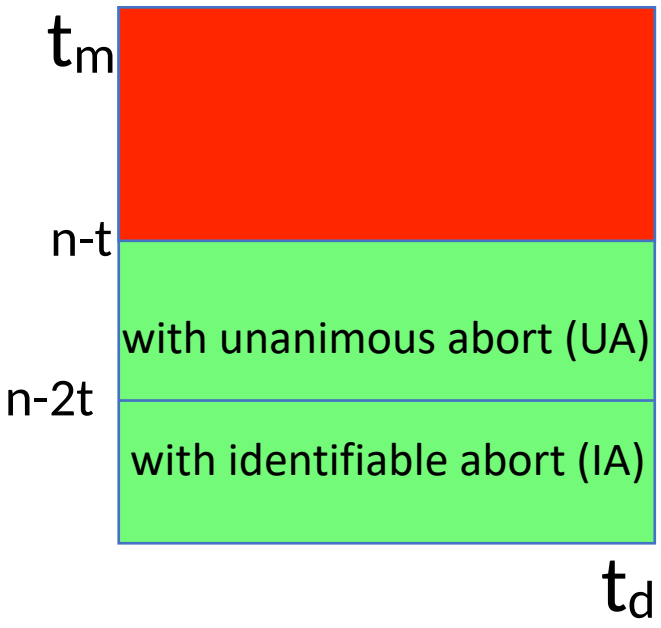


with private channels

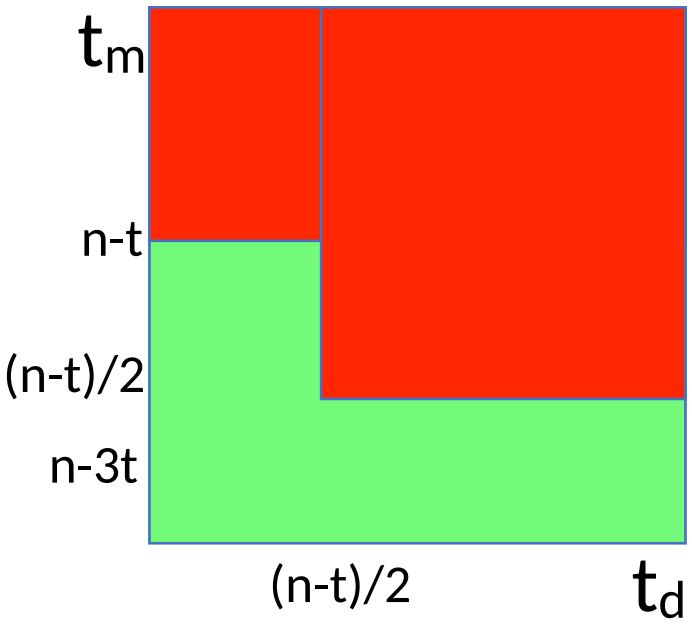


no PKI or private channels

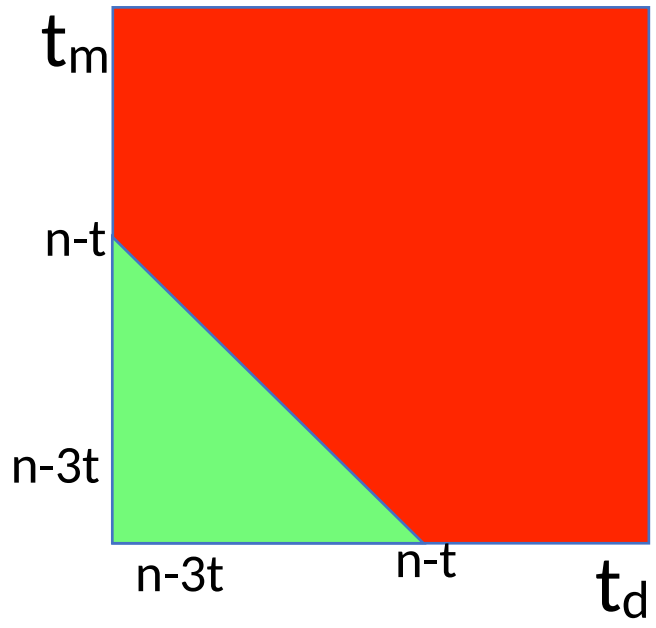
(t_d,t_m)-asyncP2P, BC



with PKI

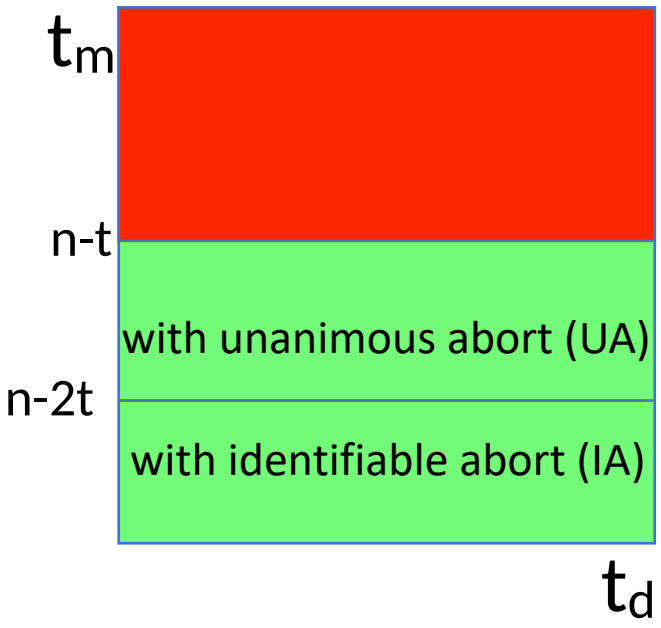


with private channels

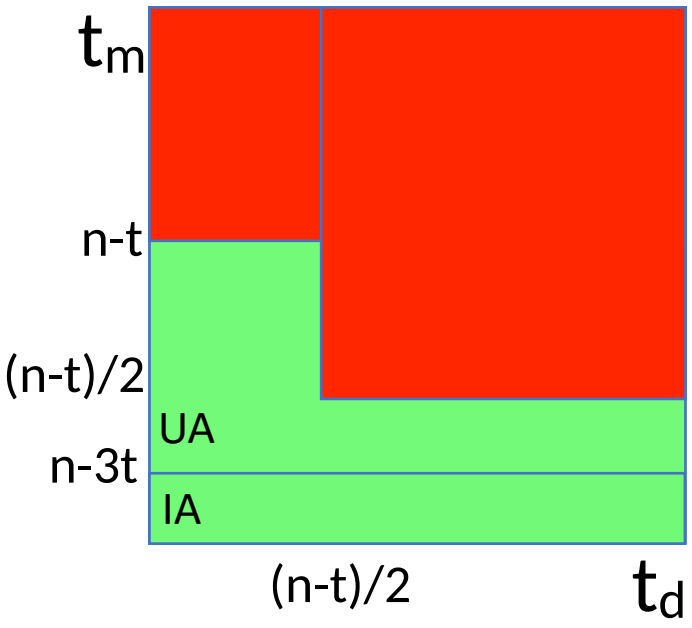


no PKI or private channels

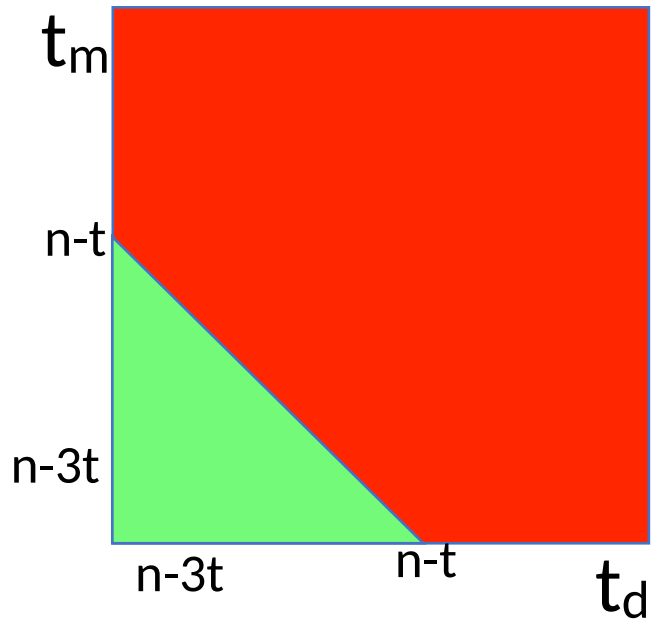
(t_d,t_m)-asyncP2P, BC



with PKI

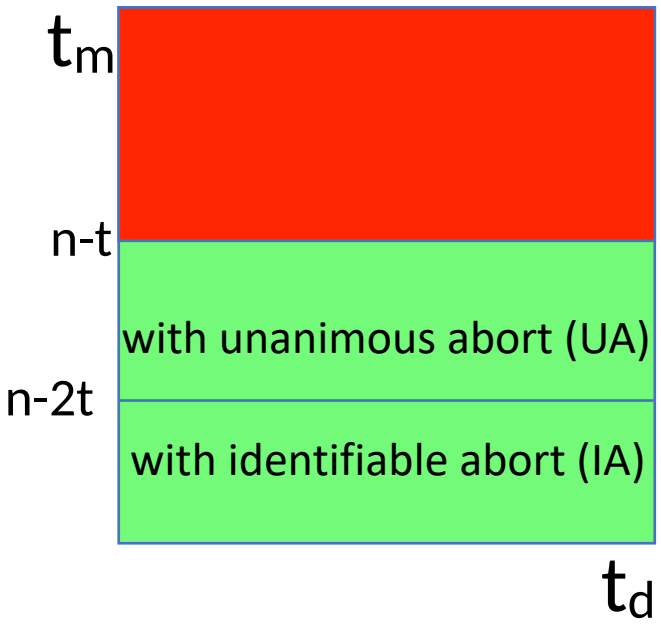


with private channels

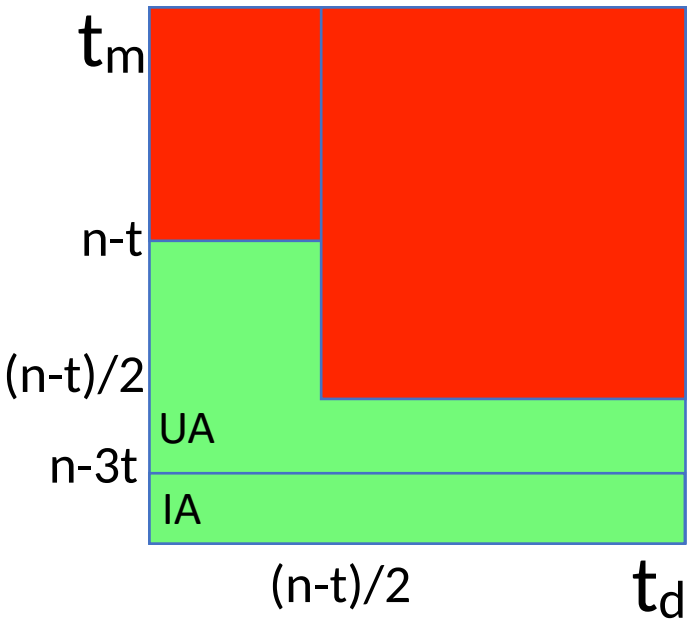


no PKI or private channels

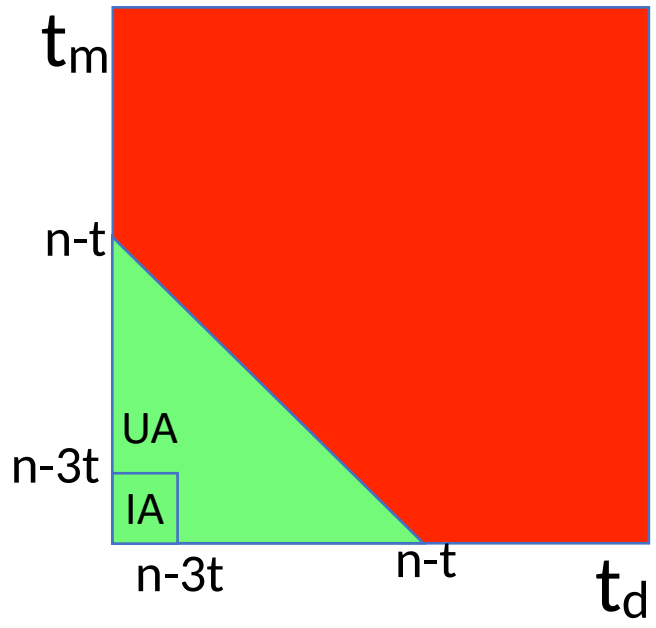
(t_d,t_m)-asyncP2P, BC



with PKI



with private channels



no PKI or private channels

(t_d,t_m)-asyncP2P, BC: Constructions

- Using tools from previous papers
  - Variants of one-or-nothing secret sharing
  - Do not support all values of t_d,t_m
- New constructions from indistinguishability obfuscation
  - New primitive: puncturable sender-public key encryption
  - Inefficient / unrealistic building blocks

Summary

- Our contributions:
  - New notion of (t_d,t_m)-asynchrony
  - Impossibility results
  - Constructions