Man-in-the-Middle attacks revisited

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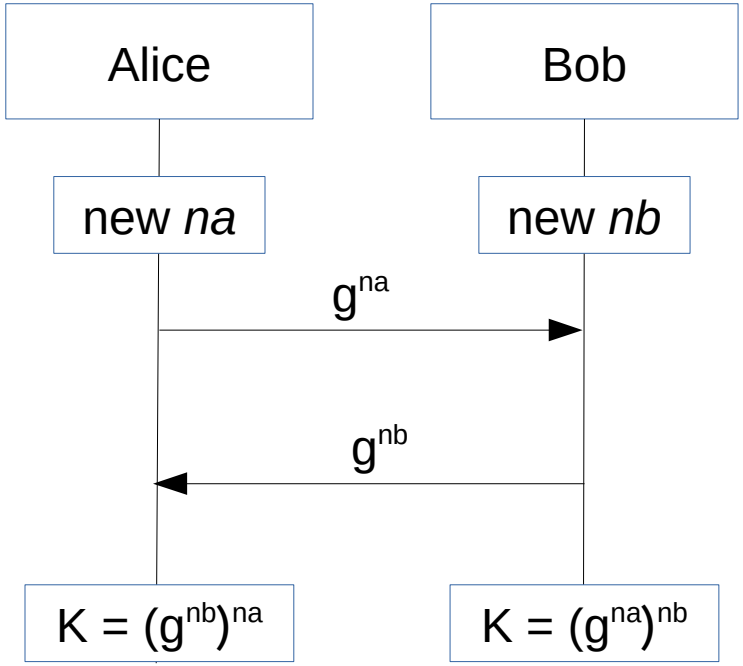
Man-in-the-middle attack

Diffie-Hellman



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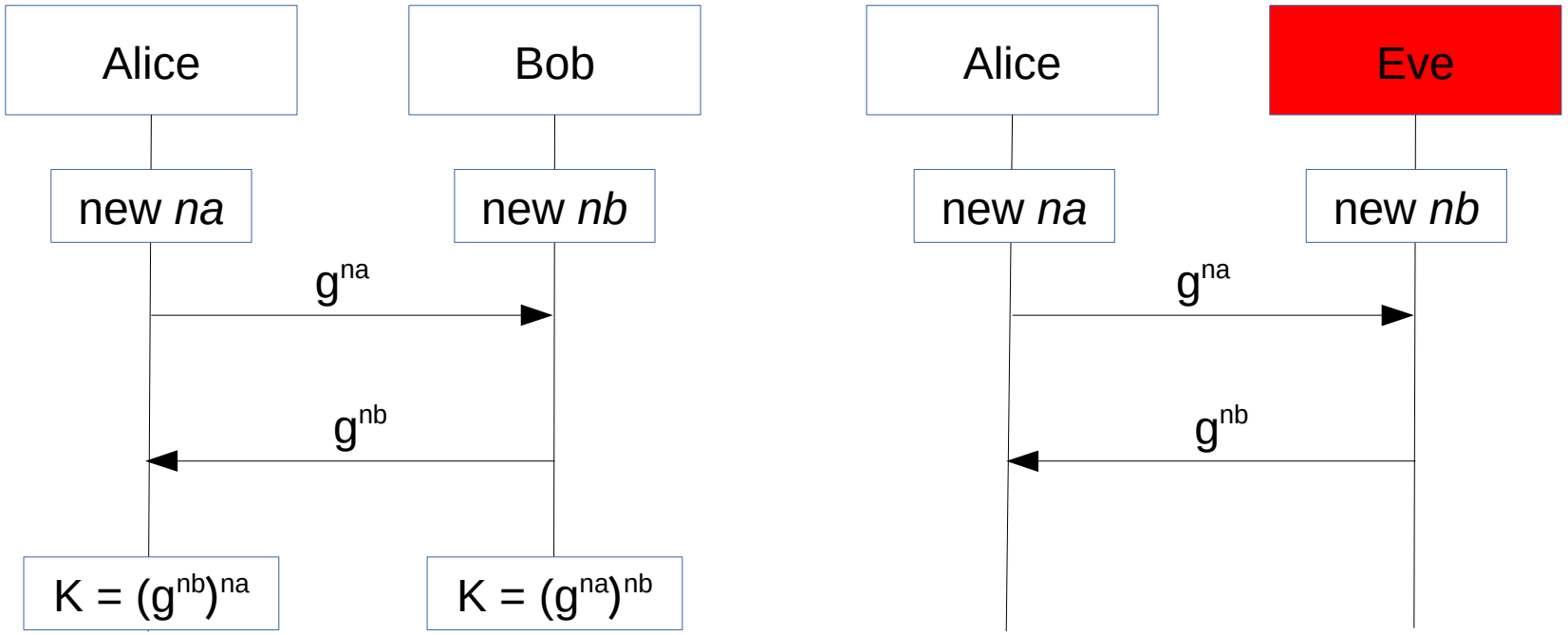

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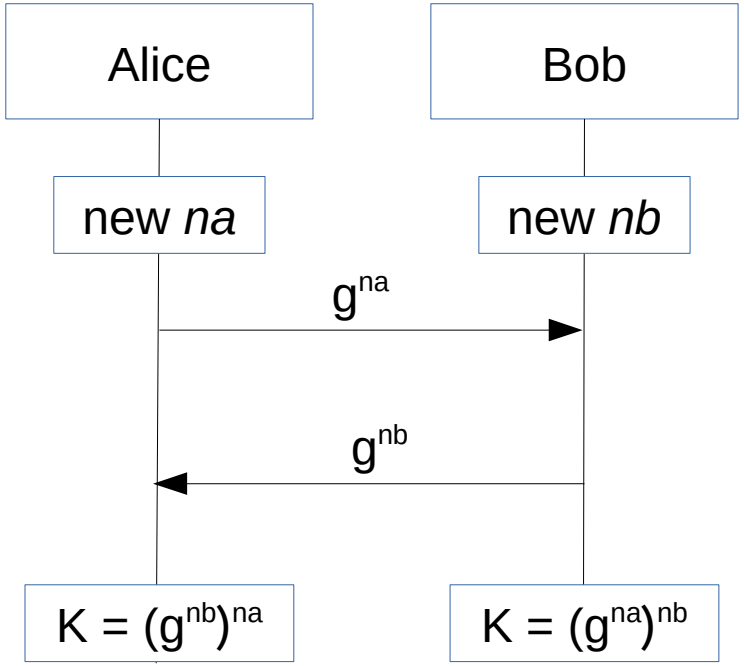
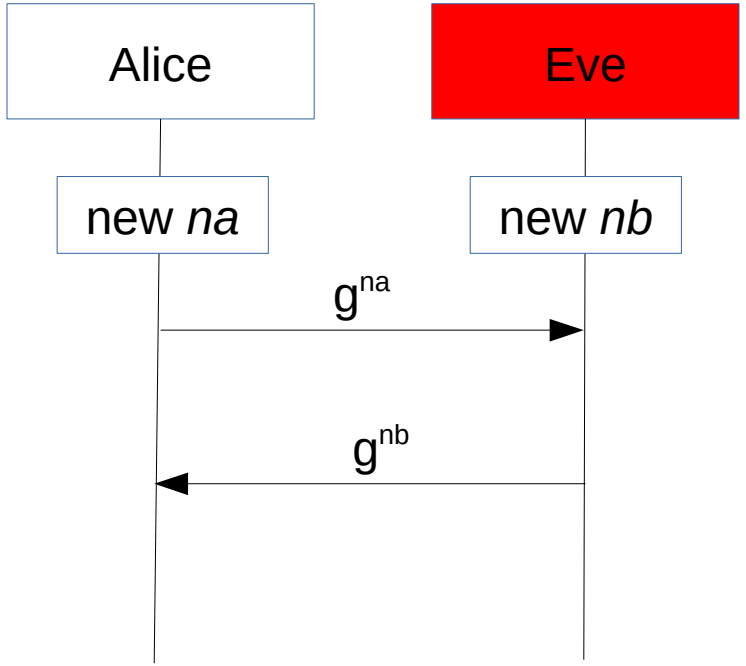
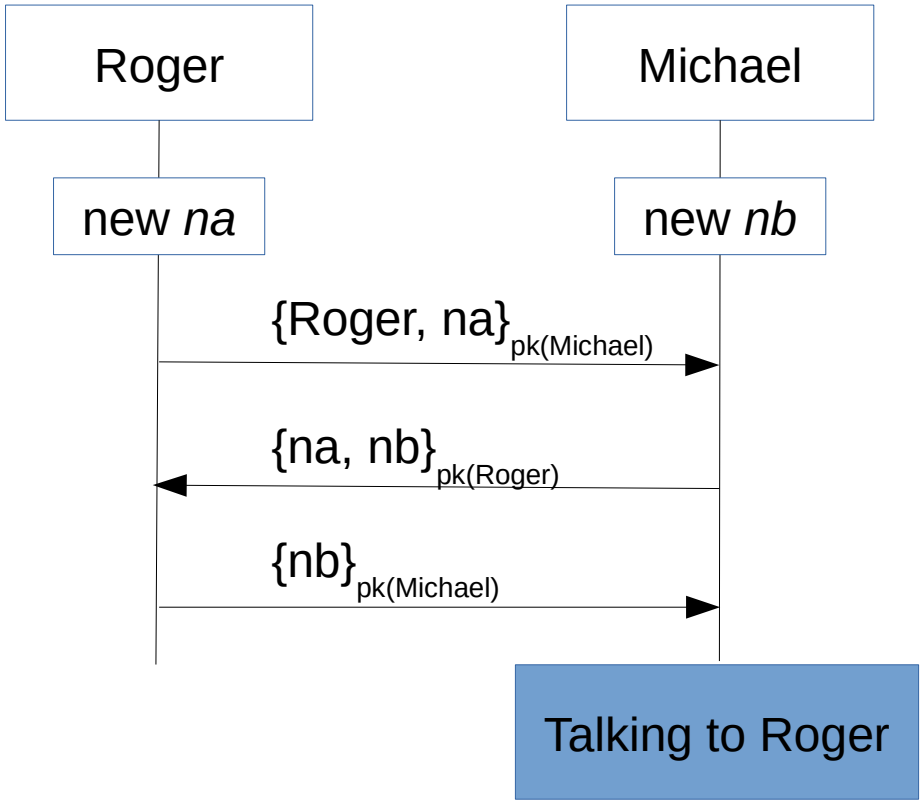


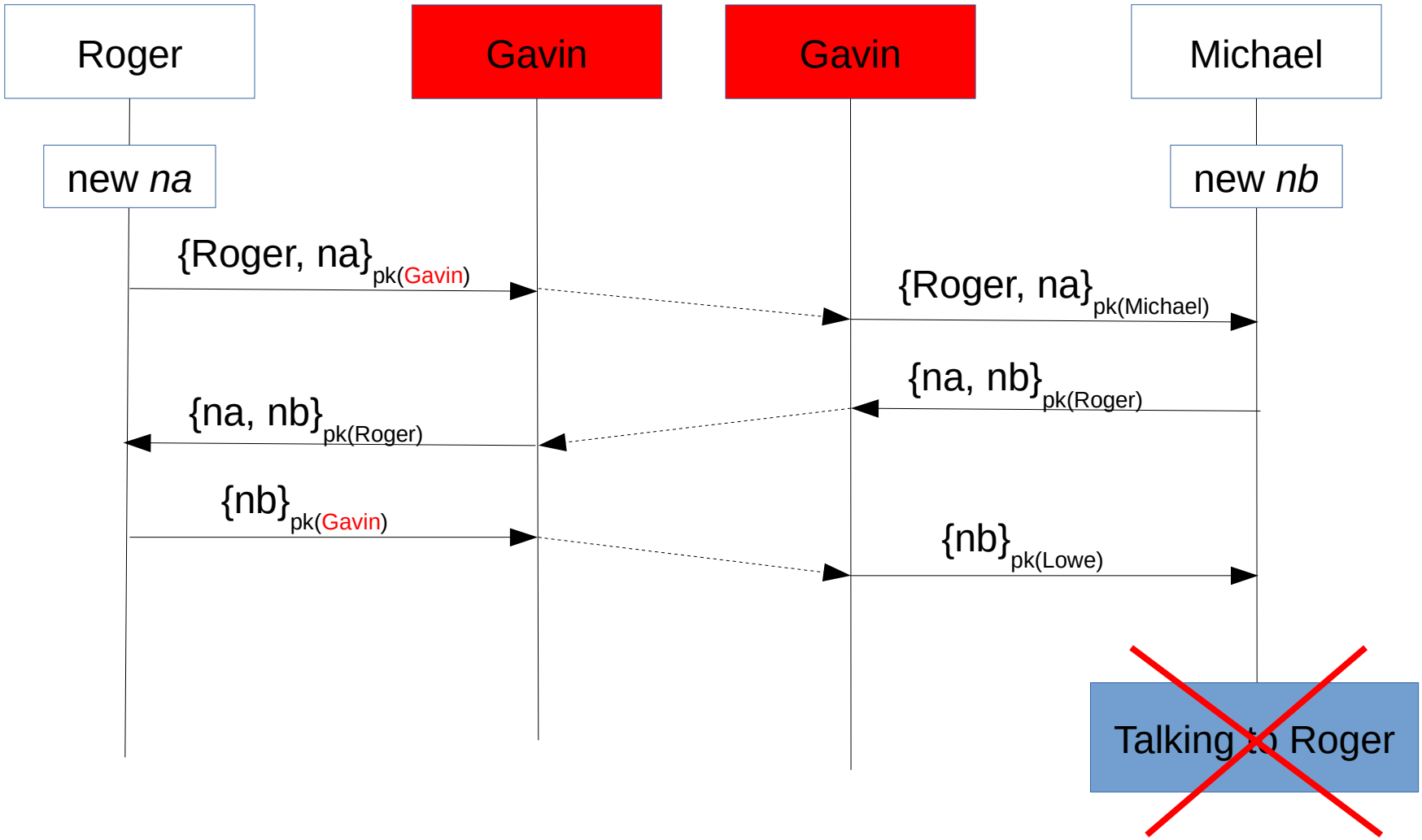
Diffie-Hell, man!



Needham-Schroeder



Needham, Schroeder & Lowe '95



Just a few of many examples

- Academic:
  - Diffie-Hellman: 1976?
  - Lowe on Needham-Schroeder: 1995
- Practice:
  - Moxie Marlinspike:
    - SSLsniff: 2002 attacks IE5.5
    - SSLstrip: 2009 (Black Hat 2009)

Conclusion: we're abundantly aware.

Stopping the MitM?

- Theory:
  - Modelchecking (~ 1995)
  - Tagging (~ 2003)
  - Tool support (mCRL, Scyther, Tamarin,...)
- Practice:
  - Certificate Authorities
  - DNSSec
  - Certificate Pinning
  - ...

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Conclusion: we've got this.

Meanwhile...

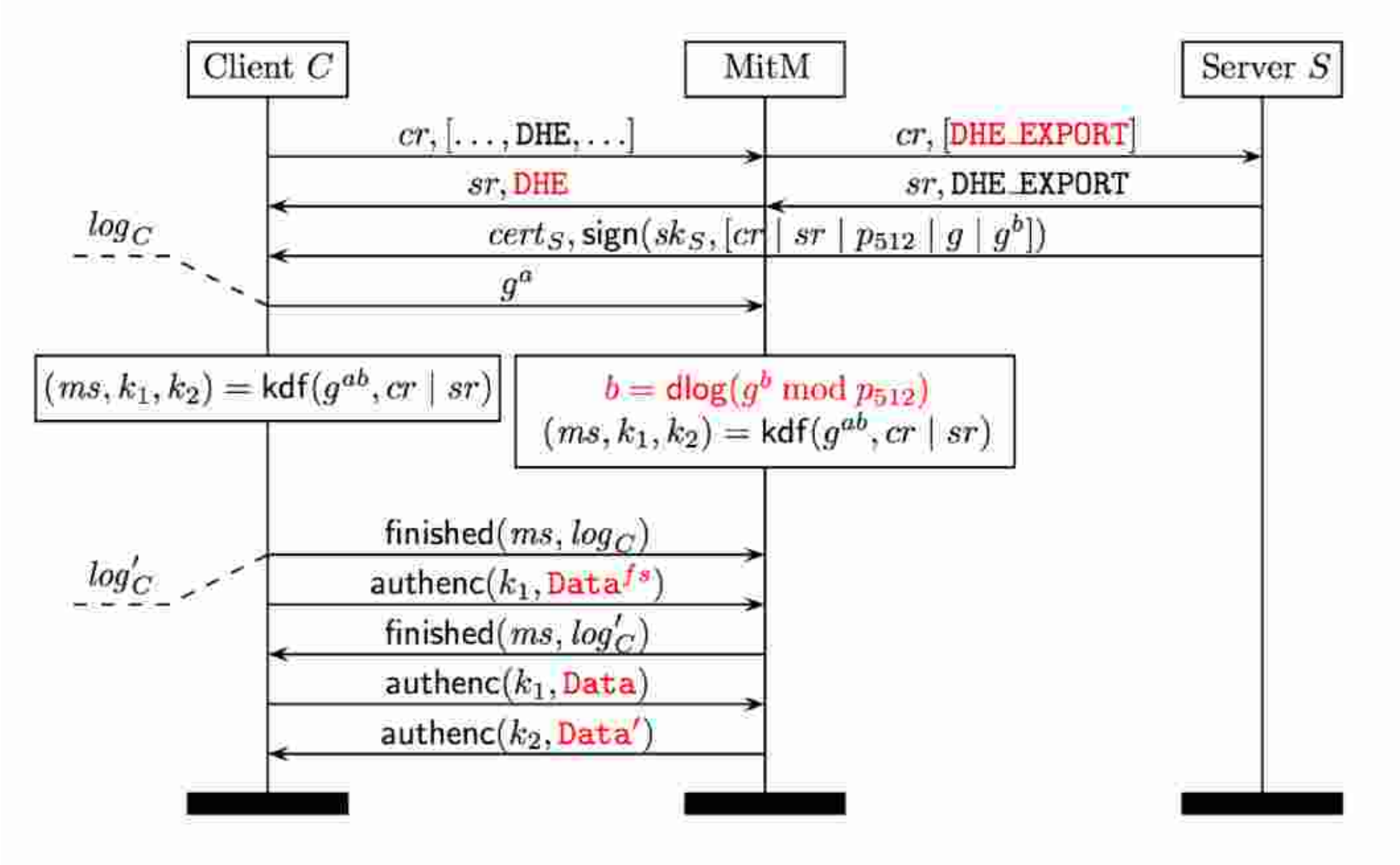
POODLE attack [MDK14]

- Force downgrade of TLS
- Attack SSLv3.0
  - RC4 is biased

FREAK attack [S&P15]

- US export restrictions mandated weak crypto (RSA < 512 bits)
- Still supported in some TLS implementations
- MitM changes cipher spec to “weak crypto”

LOGJAM attack [CCS15]



DROWN attack [ASS+16]

- Take client's encrypted TLS messages
- Use SSLv2.0 server as decryption oracle

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In general, the attacker must passively capture about 1,000 TLS sessions using RSA key exchange, make 40,000 SSLv2 connections to the victim server and perform 2^{50} symmetric encryption operations.

That's all theoretical, right?

MitM devices for cellphones:

- Stingray: $68,000
- Gossamer: $19,000
- Triggerfish: $90,000
- Hailstorm: $170,000

Conclusion:
We definitely do not “have” this.

Exploited flaws

- POODLE, Logjam, FREAK, DROWN: initialisation

- Cellphone MitM devices: new properties

Both cases: not accounted for by protocol.

Categorising attacks

- Protocol context
  - Initialisation
- User context
  - location

Solution directions

Embed context into formal security proofs

- With a trusted partner:
  context agreement

- Without a trusted partner:
  context verification

Context agreement

Definition 2 (Context agreement). *A party A achieves* context agreement *with another party B on B's context C_B if, whenever A completes a run of the protocol (apparently with B) then B has been previously running the protocol (apparently with A) and the observation of A on B's context is the same as B's observation of his context in that run, that is: $obs_A(C_B) = obs_B(C_B)$.*

Note: agreement on observed context, not on actual context.

Context verification

Definition 1 (Context verification). *A party A achieves* context verification *of her observation $obs_A(C_B)$ of the context C_B of party B if, whenever A completes a run of the protocol (apparently with B) then $obs_A(C_B)$ is correct with respect to C_B.*

Example application: GSM

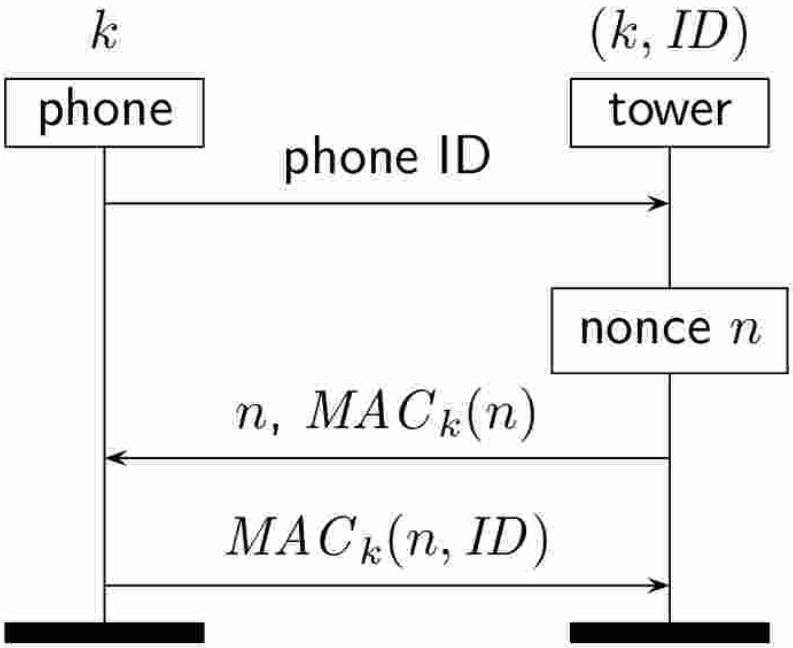

Fig. 1. Simplified UMTS protocol.

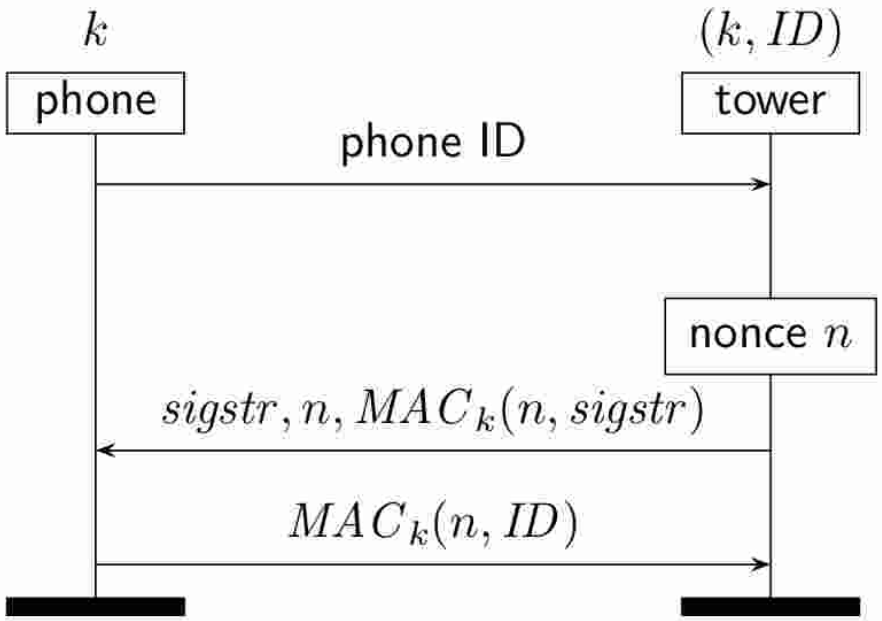

Fig. 2. Inclusion of context.

Conclusion

- Man-in-the-middle attacks still exist
- They are preventable
- Prevention:
  - Account for context
    - Protocol context (initialisation)
    - User context (location)
  - With or without trusted partner

Thank you for your attention!