Network Security: WLAN Security

Mohit Sethi
Ericsson, Finland
Aalto University, Finland

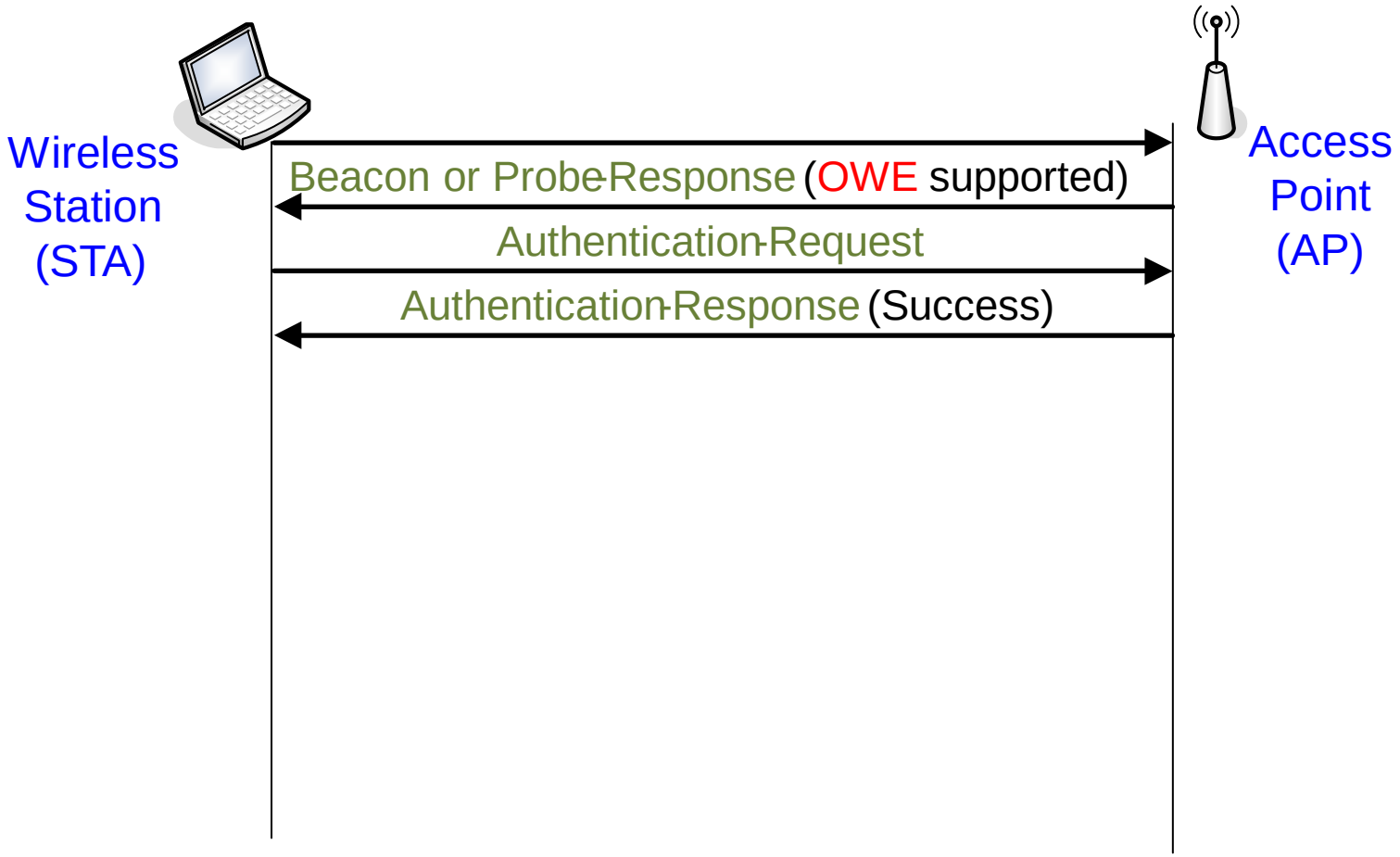
WLAN Security - Outline

- Part 1:
  - WLAN Standards and Components
  - Joining Open WLAN
  - WPA2-PSK and four-way handshake
- Part 2:
  - WPA 3: Opportunistic Wireless Encryption (Enhanced Open)
  - WPA 3: Password Authenticated Key Exchange (PAKE : Dragonfly)
- Part 3:
  - Enterprise security - EAP

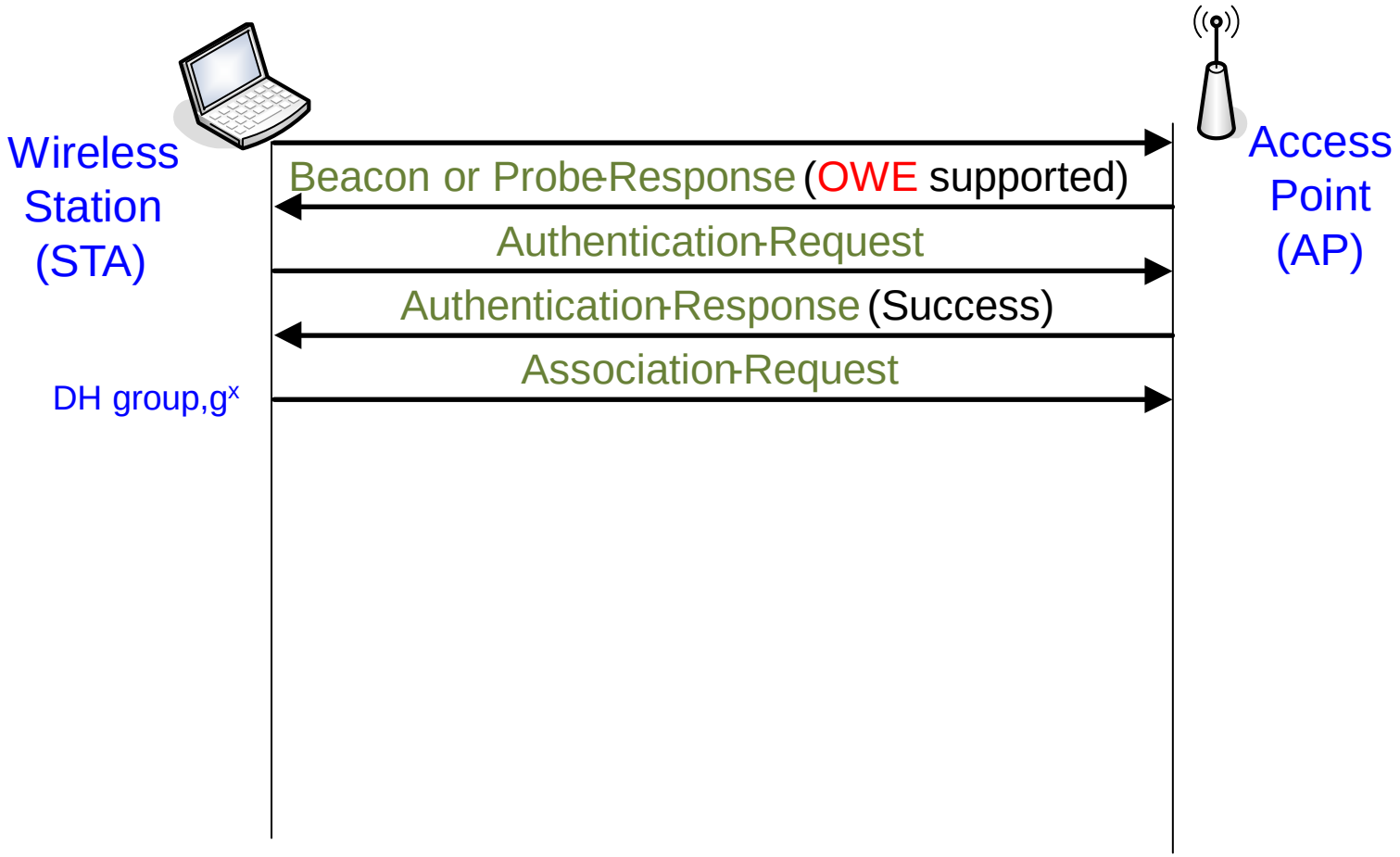
WPA3 Enhanced Open

- Open networks used in cafes and airports
  - Better user experience than asking for passphrase
- WPA3 Enhanced Open provides Opportunistic Wireless Encryption (OWE) for open networks – RFC 8110
- Station and AP perform Diffie-Hellman (DH) exchange during association
- A PMK is derived from DH shared secret
- PMK is used in 4 – way handshake as before

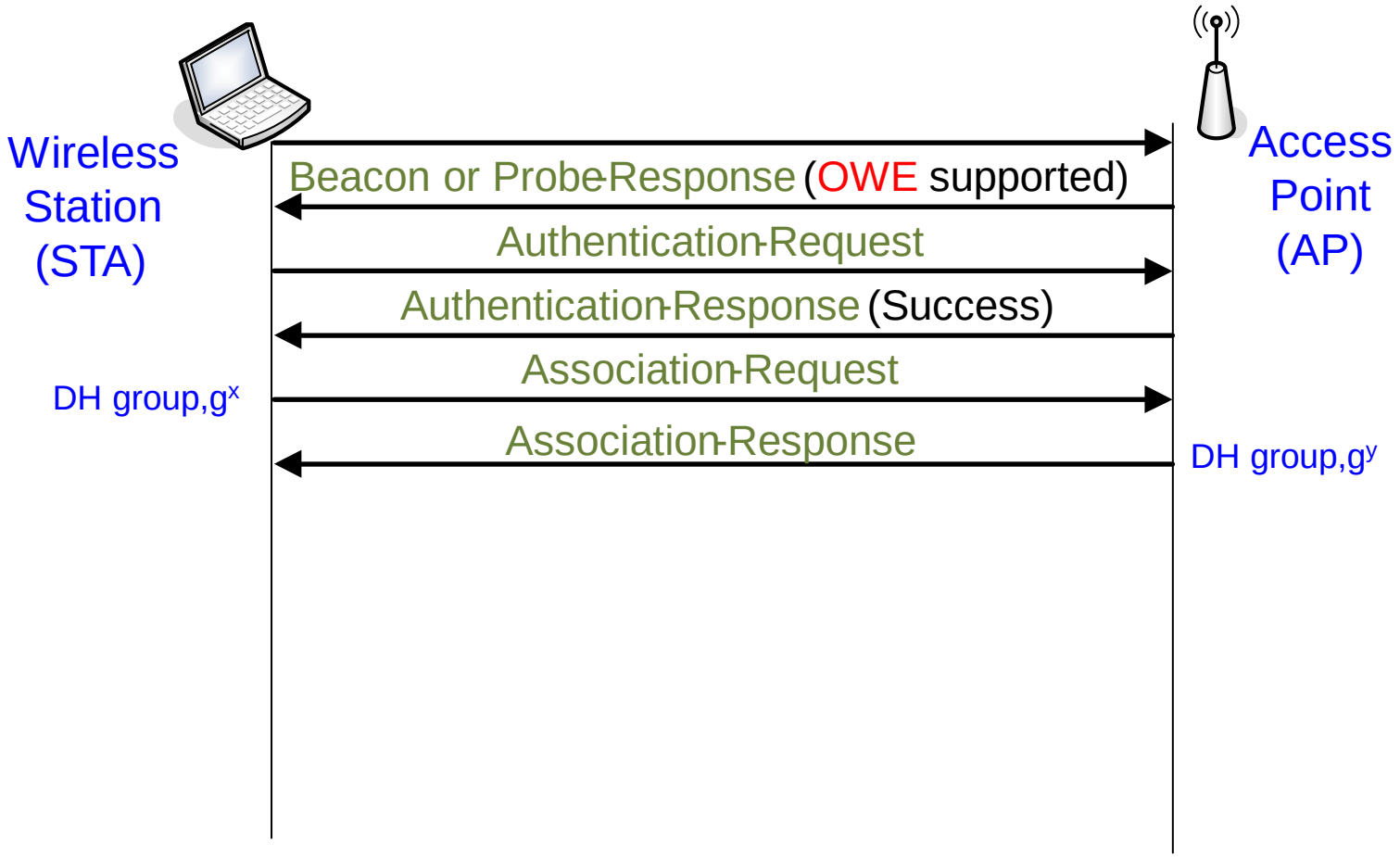
WPA3 Enhanced Open



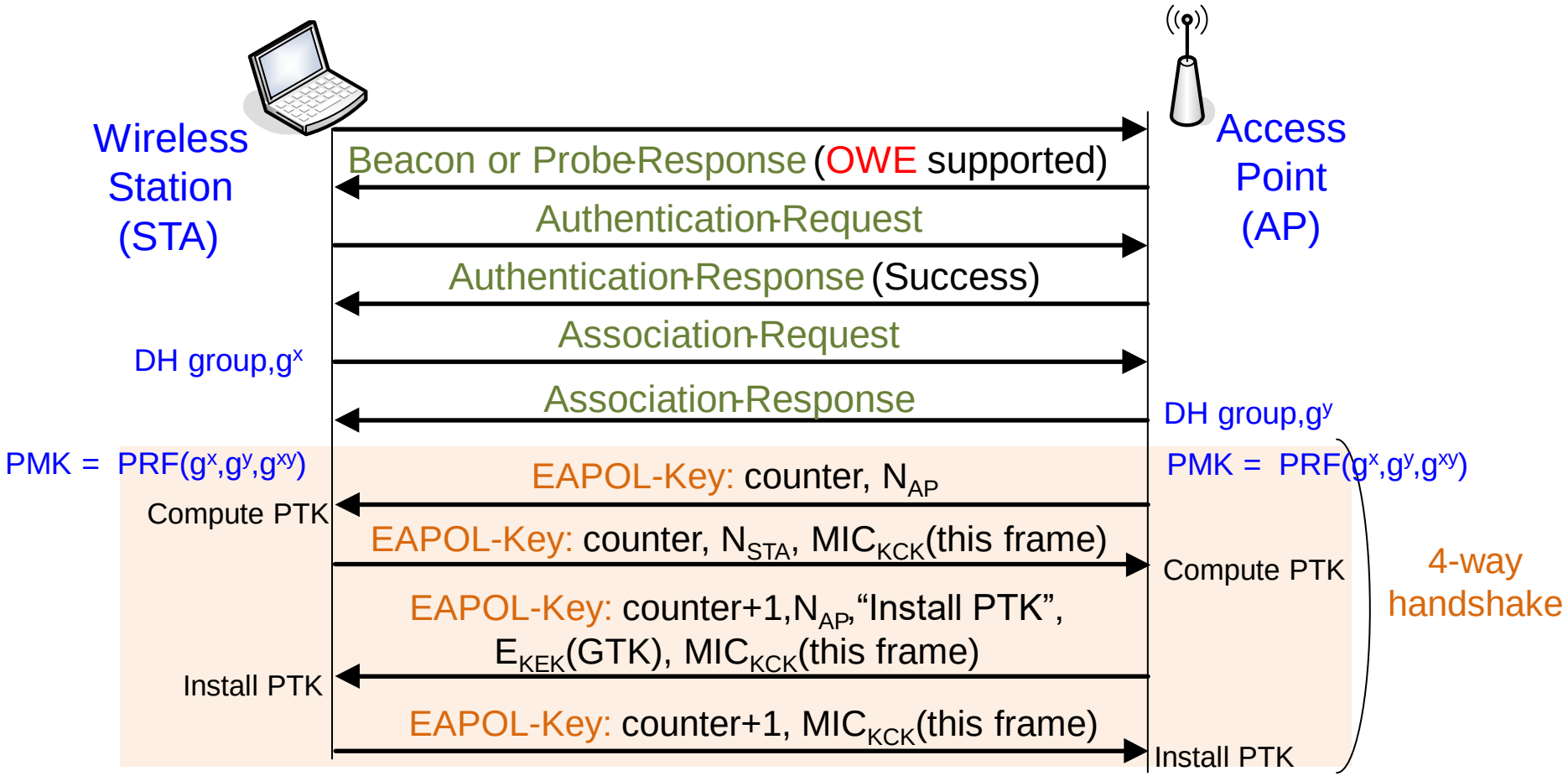
WPA3 Enhanced Open



WPA3 Enhanced Open



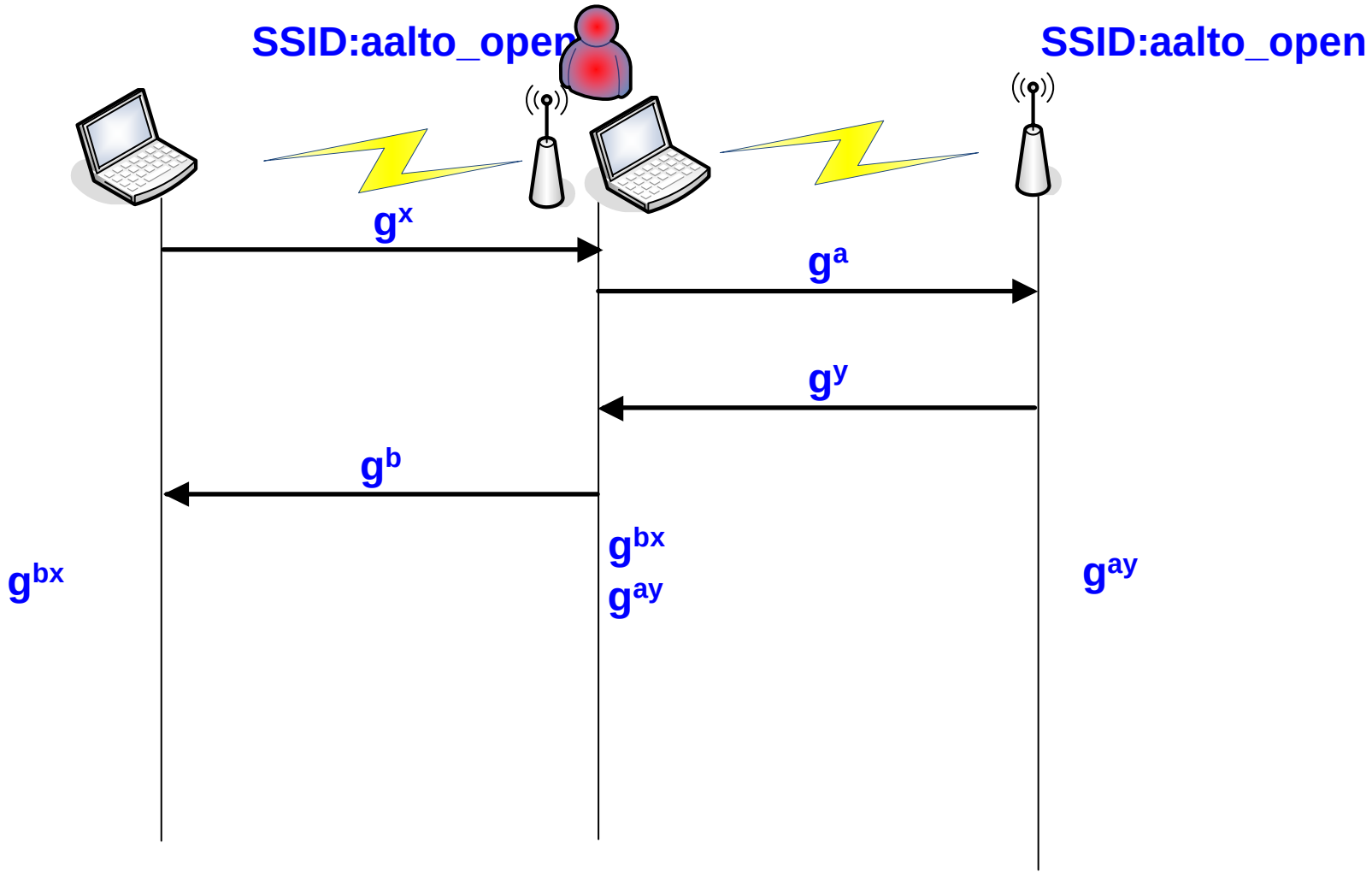
WPA3 Enhanced Open



WPA3 Enhanced Open

- OWE is encryption NOT authentication
  - Susceptible to active MiTM attack
  - Does NOT prevent evil twin APs

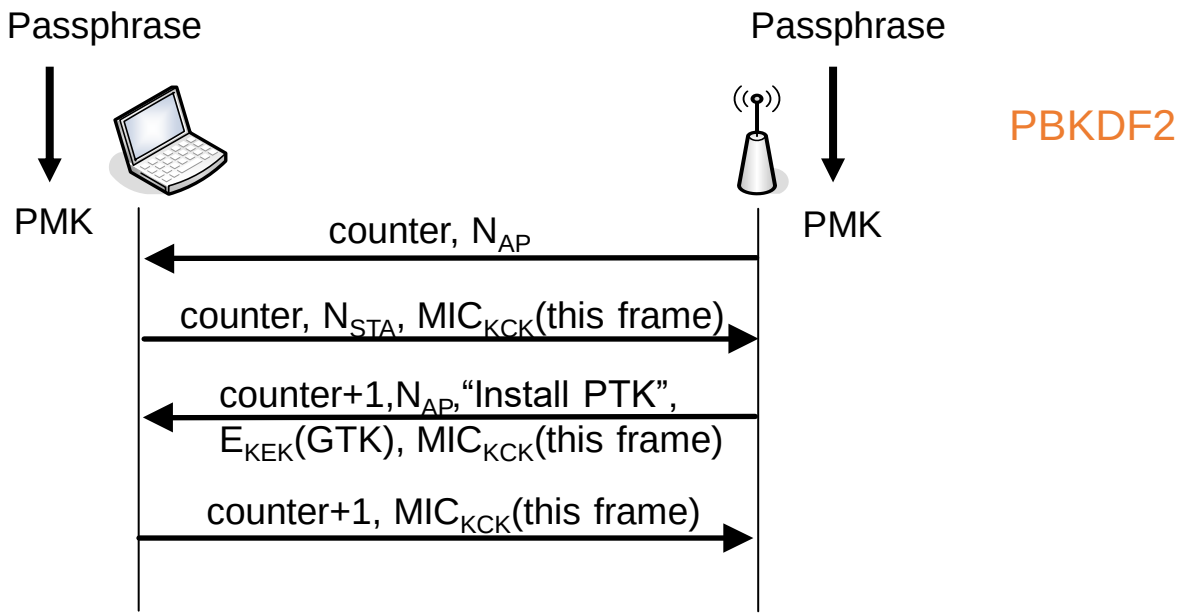
WPA3 Enhanced Open



WPA3 Enhanced Open

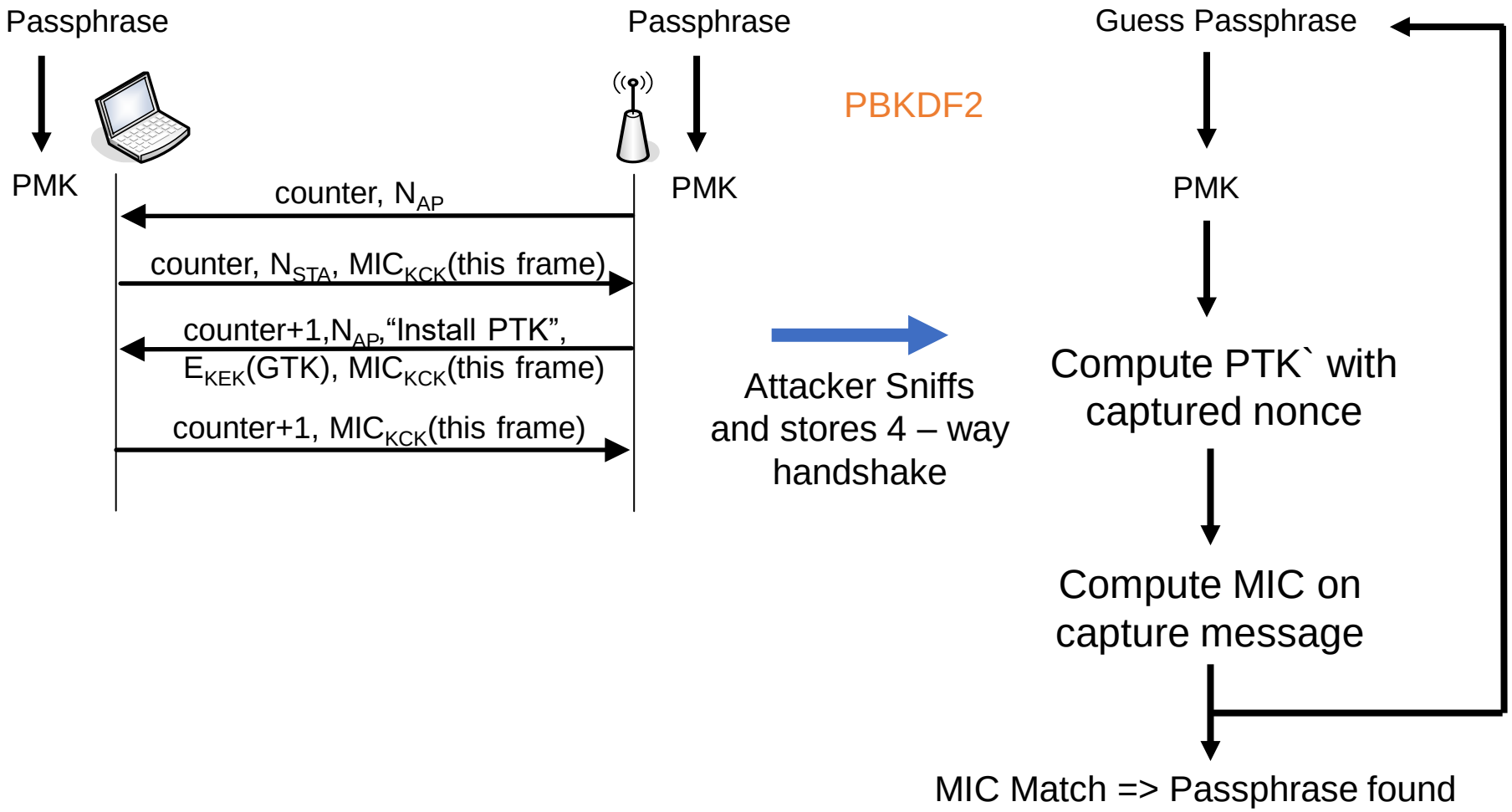
- Both ECC and FFC based Diffie-Hellman supported
- OWE is encryption NOT authentication
  - Susceptible to active MiTM attack
  - Does NOT prevent evil twin Aps
- No prior contact between Station and AP for PMK
- Better than open authentication:
  - Passive attacker now needs to be active
  - Attacker cannot inject packets without active MiTM first
  - Forward secrecy when private keys are deleted
- Can do client authentication later with captive portal

WPA2 – Personal: Weakness

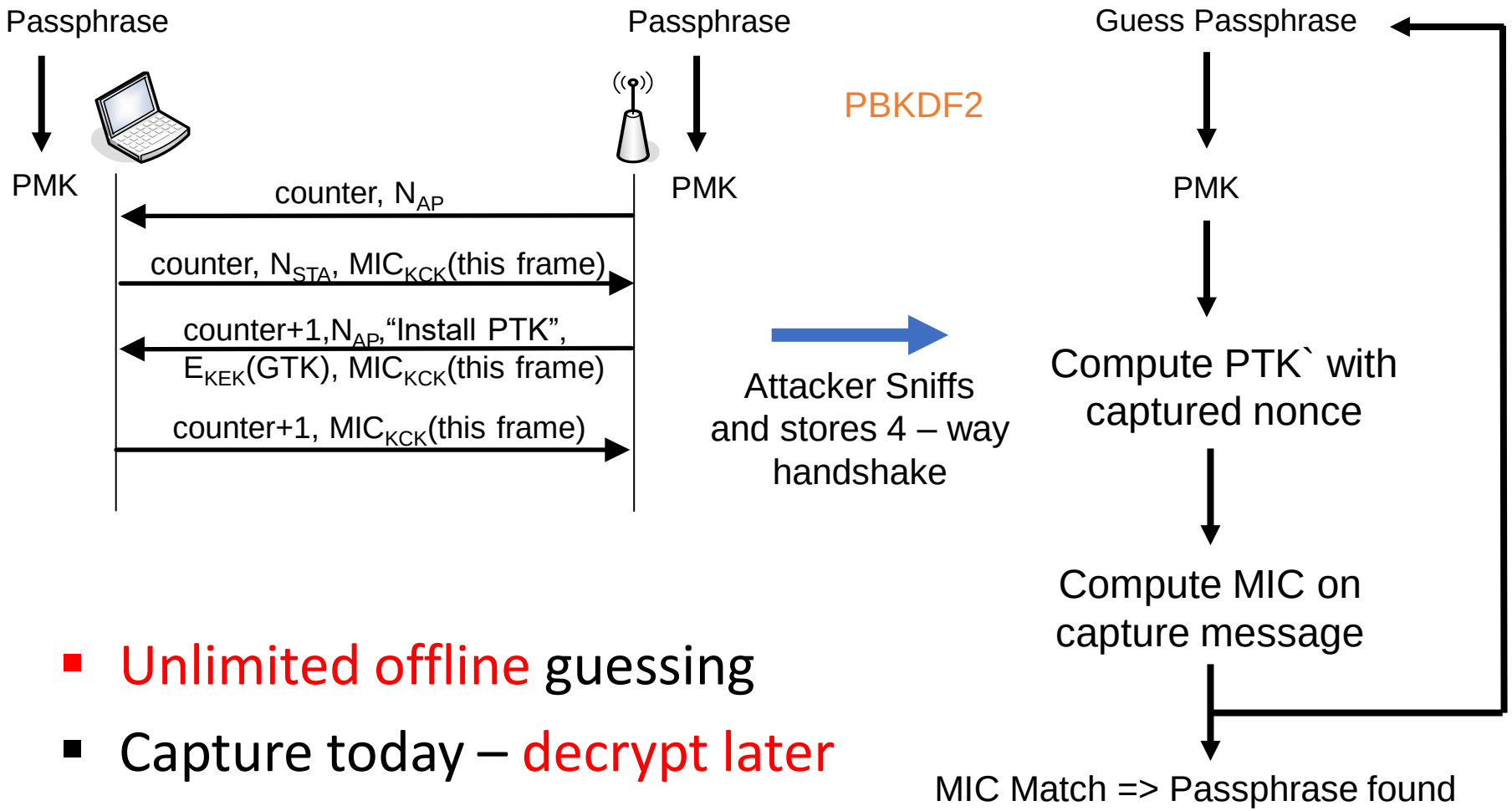


PBKDF2

WPA2 – Personal: Weakness



WPA2 – Personal: Weakness

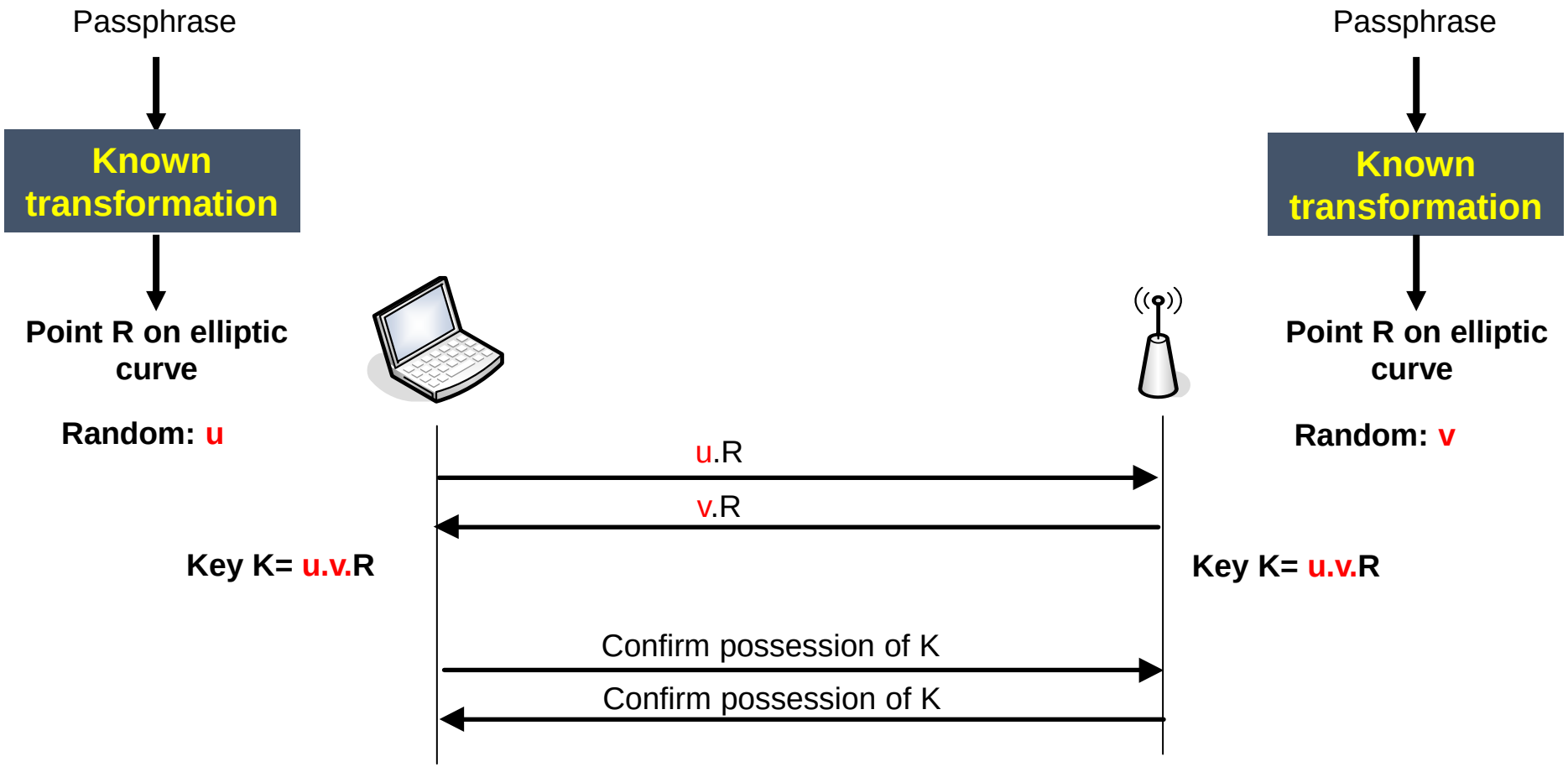


- Unlimited offline guessing
- Capture today – decrypt later

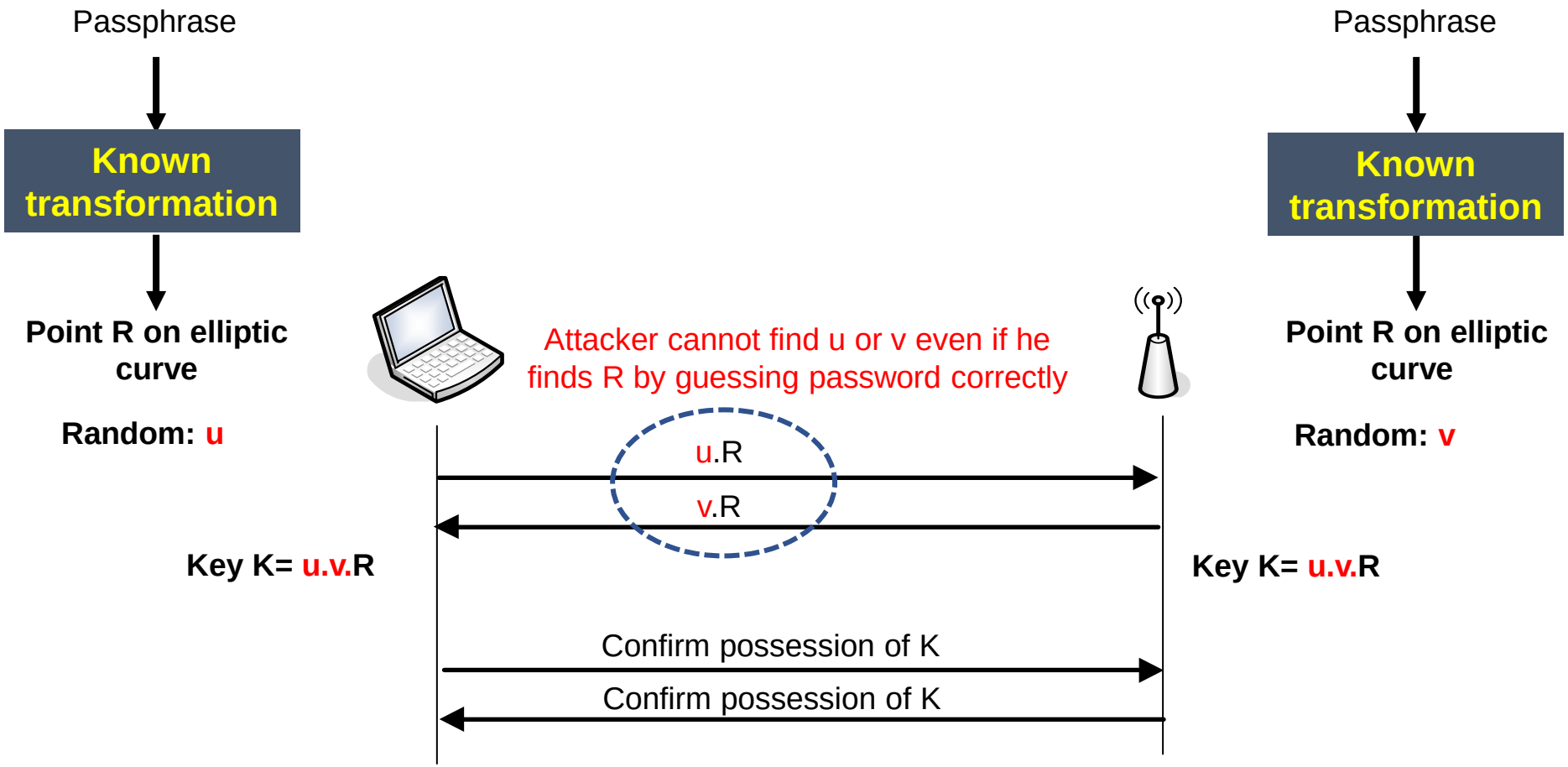
WPA3 PAKE : Dragonfly

- WPA3 uses Password Authenticated Key Exchange (PAKE) for preventing password guessing
  - WPA3 uses a variant of Dragonfly – RFC 7664 as PAKE
  - Original protocol called Simultaneous Authentication of Equals (SAE) defined in 802.11s in 2016
  - Standard for security in mesh networks
- Offline attacker cannot perform password guessing
- A live attacker physically present in the network can keep guessing but devices can setup protection against such repeated guessing - denial of service (DoS)

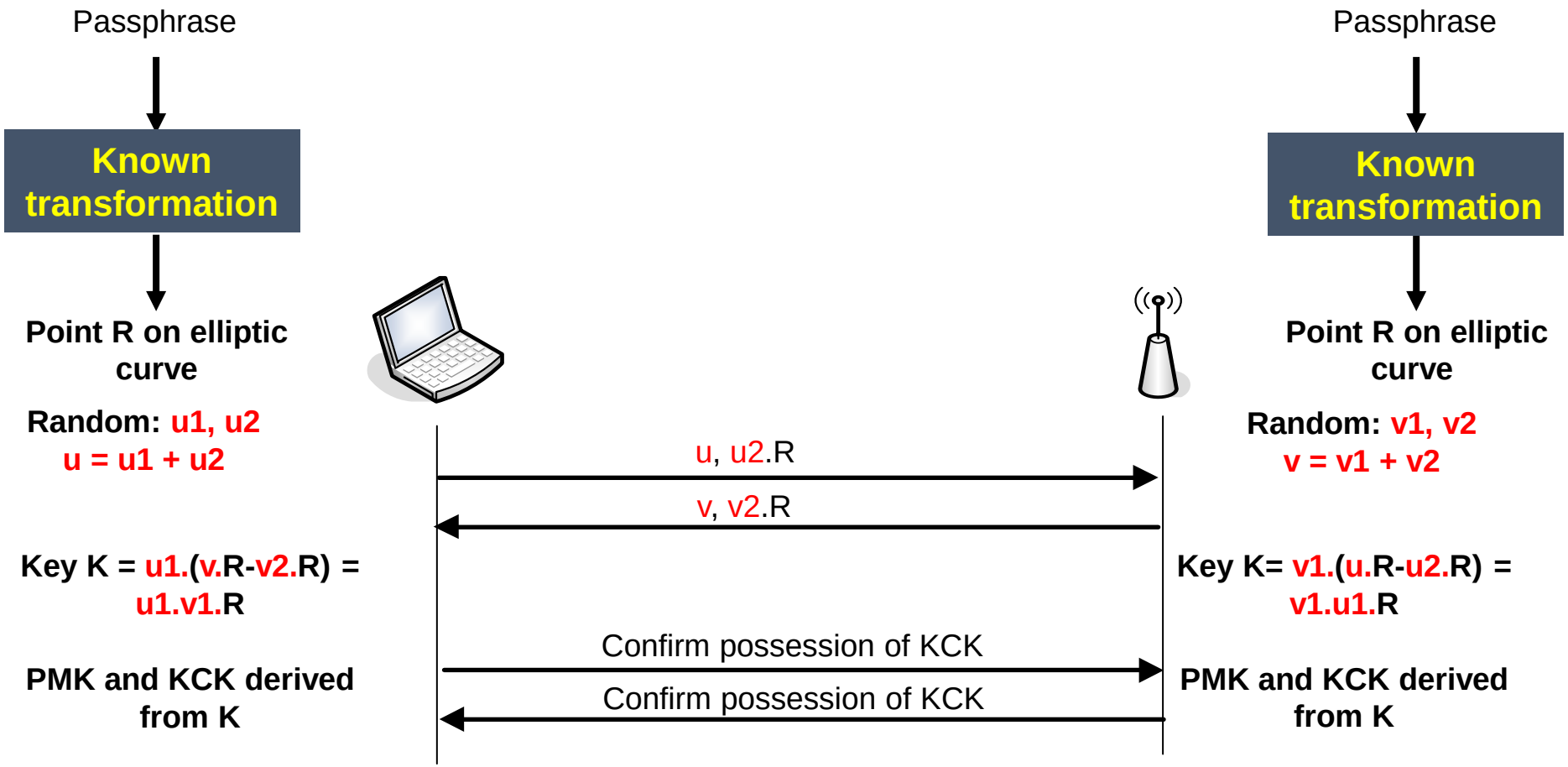
PAKE example



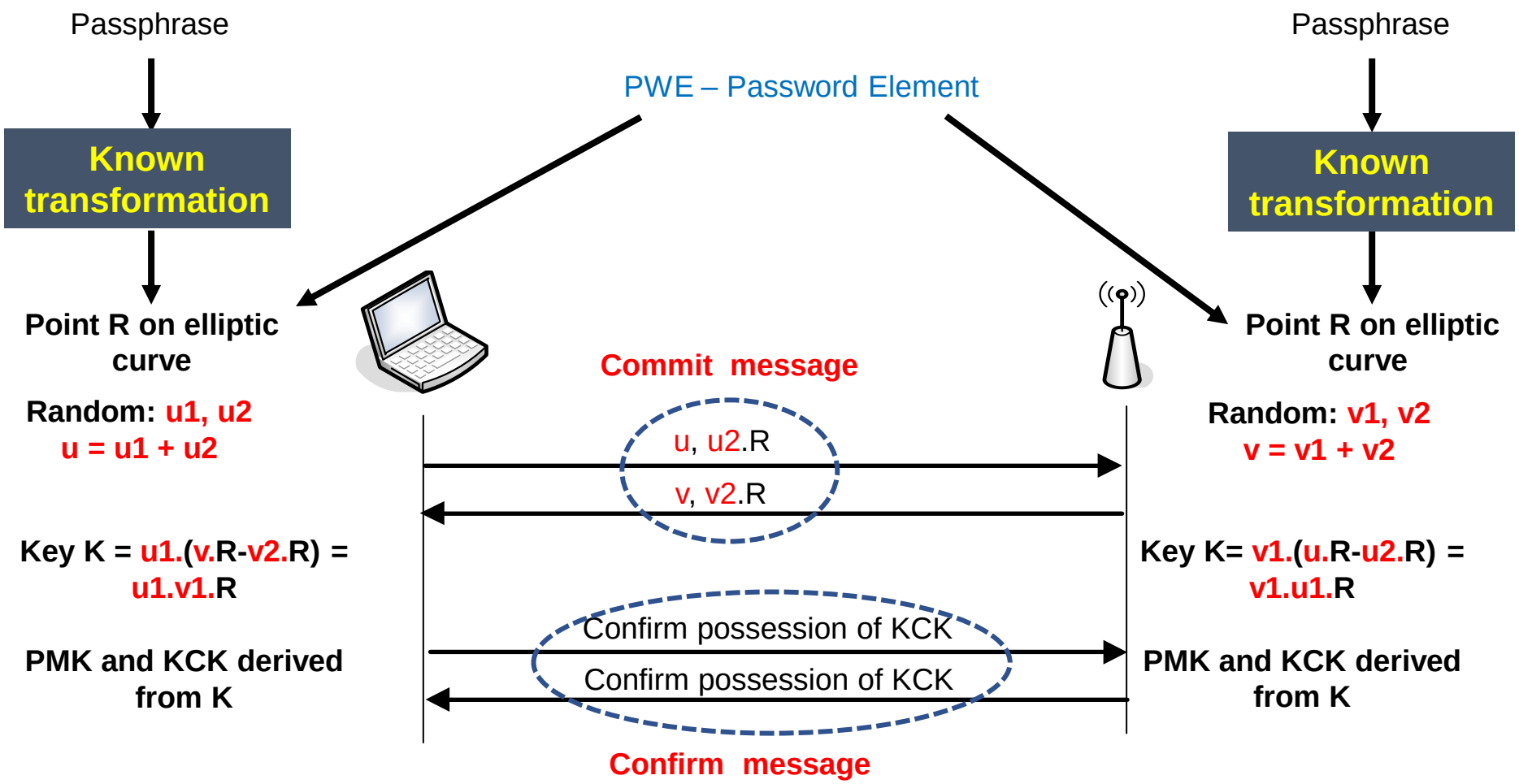
PAKE example



Dragonfly


Passphrase
Known transformation
Point R on elliptic curve
Random: u1, u2
u = u1 + u2
Key K = u1.(v.R-v2.R) = u1.v1.R
PMK and KCK derived from K
Passphrase
Known transformation
Point R on elliptic curve
Random: v1, v2
v = v1 + v2
Key K= v1.(u.R-u2.R) = v1.u1.R
PMK and KCK derived from K
u, u2.R
v, v2.R
Confirm possession of KCK
Confirm possession of KCK

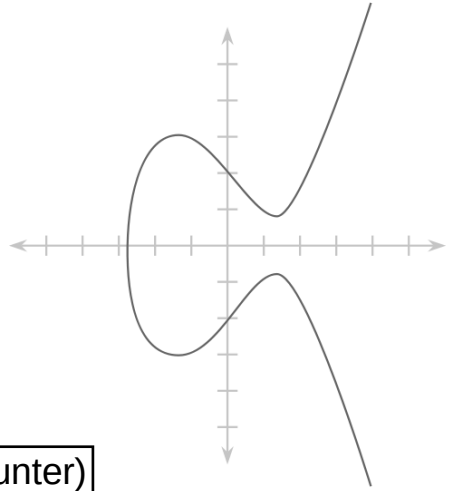
Dragonfly

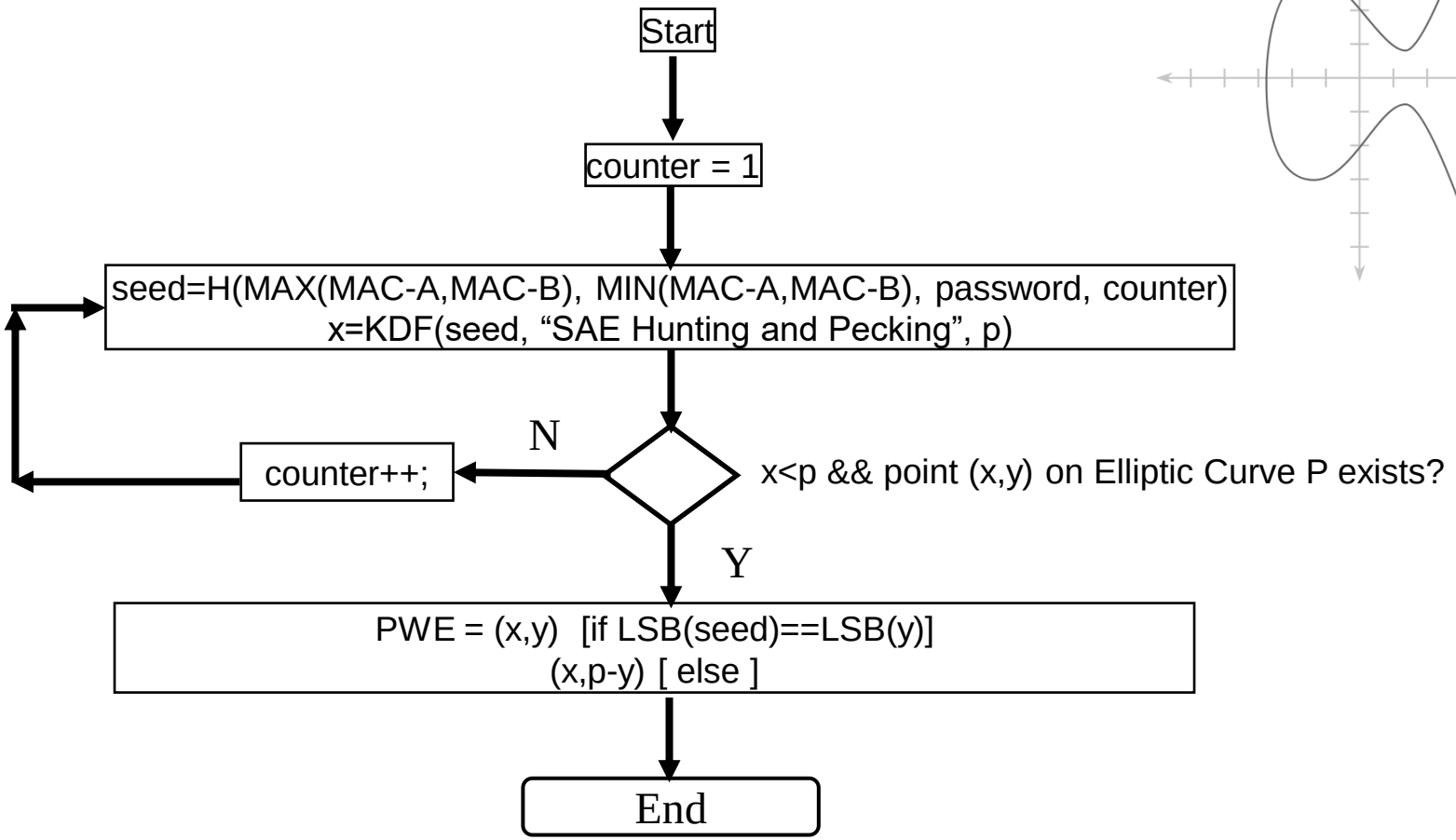

Passphrase
Known transformation
Point R on elliptic curve
Random: u1, u2
u = u1 + u2
Key K = u1.(v.R-v2.R) = u1.v1.R
PMK and KCK derived from K
PWE – Password Element
Commit message
u, u2.R
v, v2.R
Confirm possession of KCK
Confirm possession of KCK
Confirm message
Passphrase
Known transformation
Point R on elliptic curve
Random: v1, v2
v = v1 + v2
Key K= v1.(u.R-u2.R) = v1.u1.R
PMK and KCK derived from K

WPA3 PAKE : Dragonfly

- Dragonfly supports ECC and FFC group
- If not carefully implemented, side channel attacks are very possible
- Designed as a balanced PAKE – both sides know passphrase in plain
- Fresh PMK negotiated each time. This PMK is used in 4 – way handshake as before.
- PMK cannot be recovered even if passphrase is revealed later => forward secrecy after deleting u and v.

Example of PWE selection





WPA3 PAKE : Dragonfly

- Lot of controversy in IETF/IRTF when publishing
  - Trevor Perrin (well-known and respected cryptographer):
  - Questioned CFRG process: https://mailarchive.ietf.org/arch/msg/cfrg/0mnqMOmLy2N2H2K_F93MdUN_G28
  - Provided a critical review of Dragonfly: https://mailarchive.ietf.org/arch/msg/cfrg/YE4eKgOE9LTGbYd_hzN-nGDN-No
  - Asked for removal of CFRG chair: https://mailarchive.ietf.org/arch/msg/cfrg/scLoq7DvtXzo9Jl9AG9fQOcSGsM
- Many new attacks in published in April 2019
  - https://papers.mathyvanhoef.com/dragonblood.pdf

Next Video

- Part 3:
  - Enterprise security - EAP