WiFi security and physical layer stuff

CSE 548 Spring 2023
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Who cares about the local physical layer?

-Example 1: Poor transport-layer security

-Example 2: ARP cache poisoning

WiFi security

-WEP, WPA, WPA2, WPA3

Other applications of radio signals

- 3G, 4G, 5G, 900 Mhz, Bluetooth, ...

Who cares?

meituan.pcap

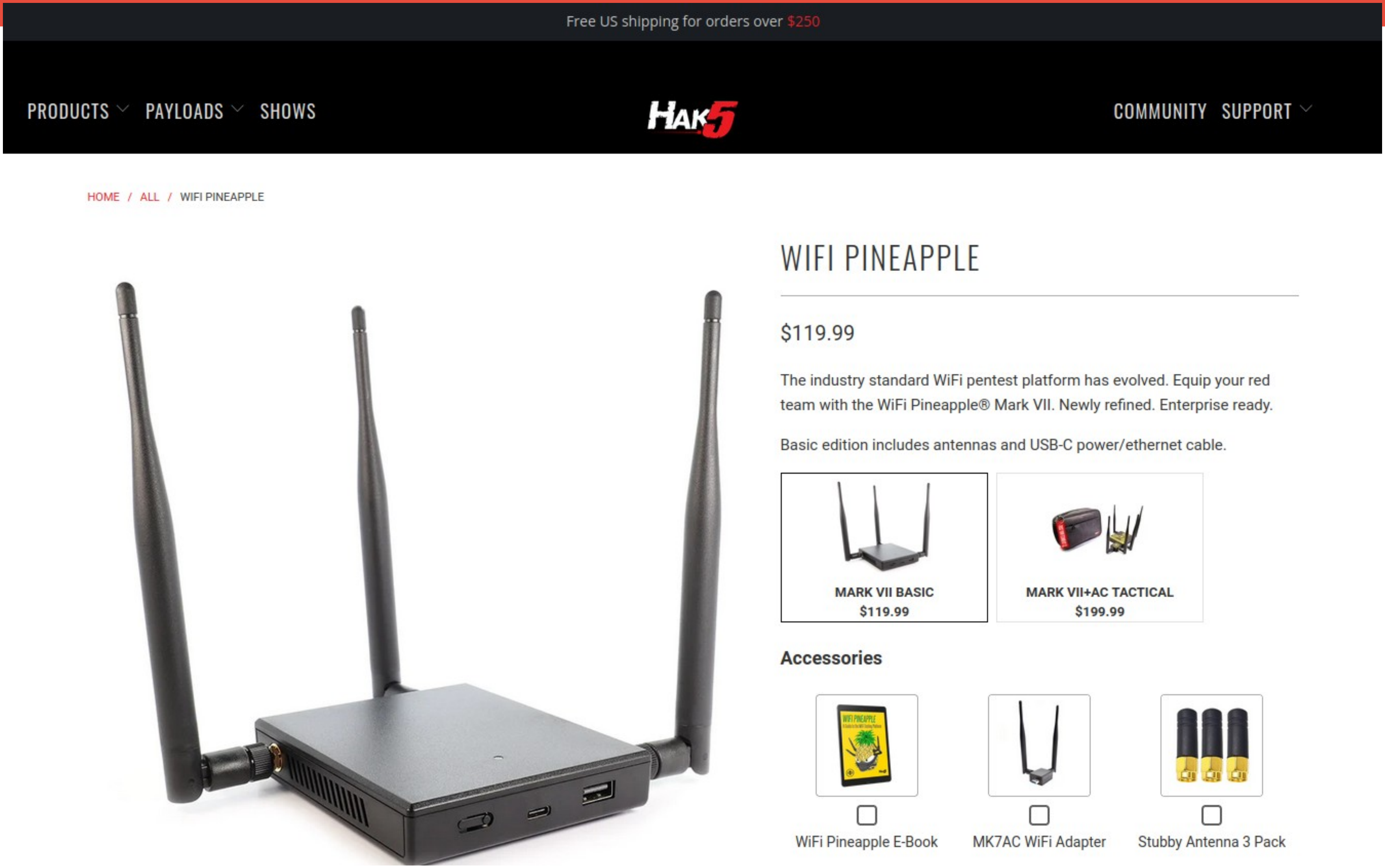
-Check out frame 36878

-Almost 700 million Annual Transacting Users

Who cares? (continued)

arpspoof.pcap

- -Downloaded from https://github.com/researcher111/ARP-pcap-files/blob/master/arpspoof.pcap
- -Real gateway is 08:00:27:5e:01:7c
- -Fake gateway is 08:00:27:2d:f8:5a
- -This is called ARP cache poisoning or ARP spoofing
  - -(Used to be a lot more complicated, these days switches and ARP caches mostly all act the same)



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Accessories

□ WiFi Pineapple E-Book

□ MK7AC WiFi Adapter

□ Stubby Antenna 3 Pack

WiFi security

Basically three use cases

- -Open
- -Personal (e.g., a passphrase)
- -Enterprise

https://securityuncorked.com/2022/07/wifi-security-the-3-types-of-wifi-networks/

WiFi security in a nutshell

WEP is very, very bad

WPA was only a stop gap

WPA2 is maybe okay for now if you do it right

WPA3 is better

WEP: the dawn of wireless

Open just meant unencrypted

Personal meant pre-shared key

No such thing as Enterprise

Top song in 1997: “Candle in the Wind 1997”

WEP encryption

“Wired Equivalent Privacy”

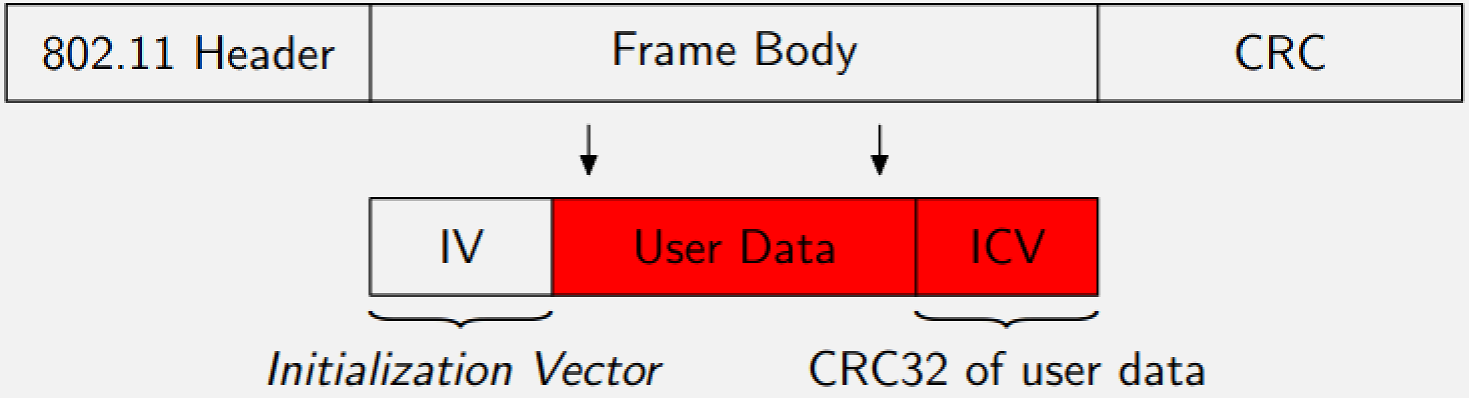
-Have to be physically in a building to plug in, have to know the passphrase to join WiFi (or do you?)

RC4, 40-bit key, 24-bit IV

Following are from:

https://jedcrandall.github.io/courses/cse468fall2022/wep/198fbe890b692e5296fcf7ad1b015e653ec9.pdf

Data frame format



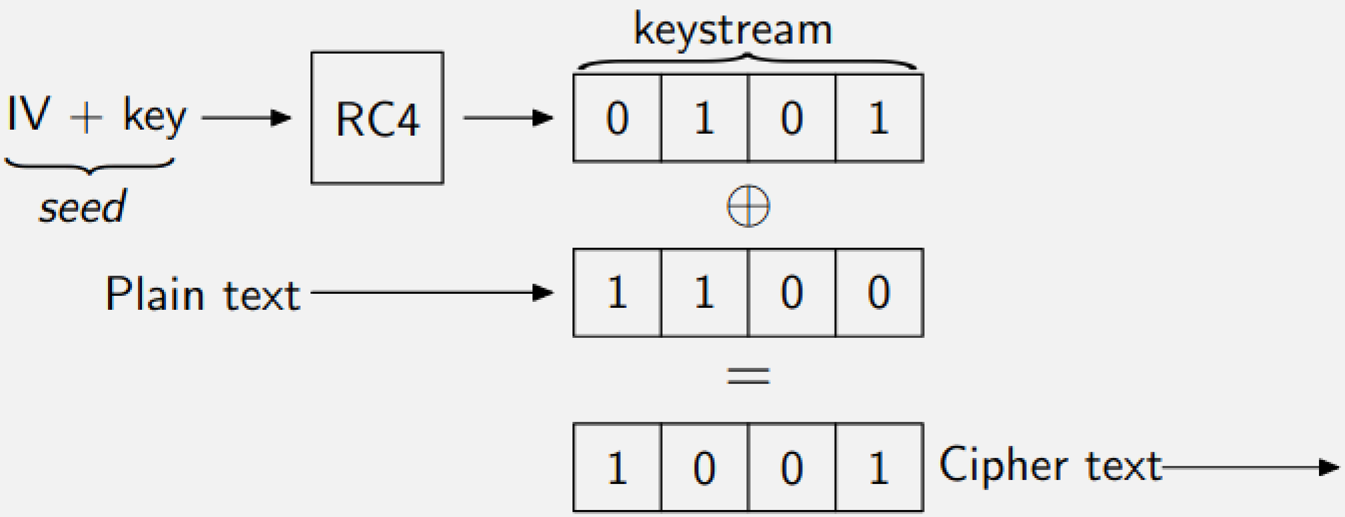
802.11 Header | Frame Body | CRC

IV | User Data | ICV

Initialization Vector

CRC32 of user data

Encryption



IV + key → RC4 → keystream

seed

0	1	0	1

⊕

Plain text →

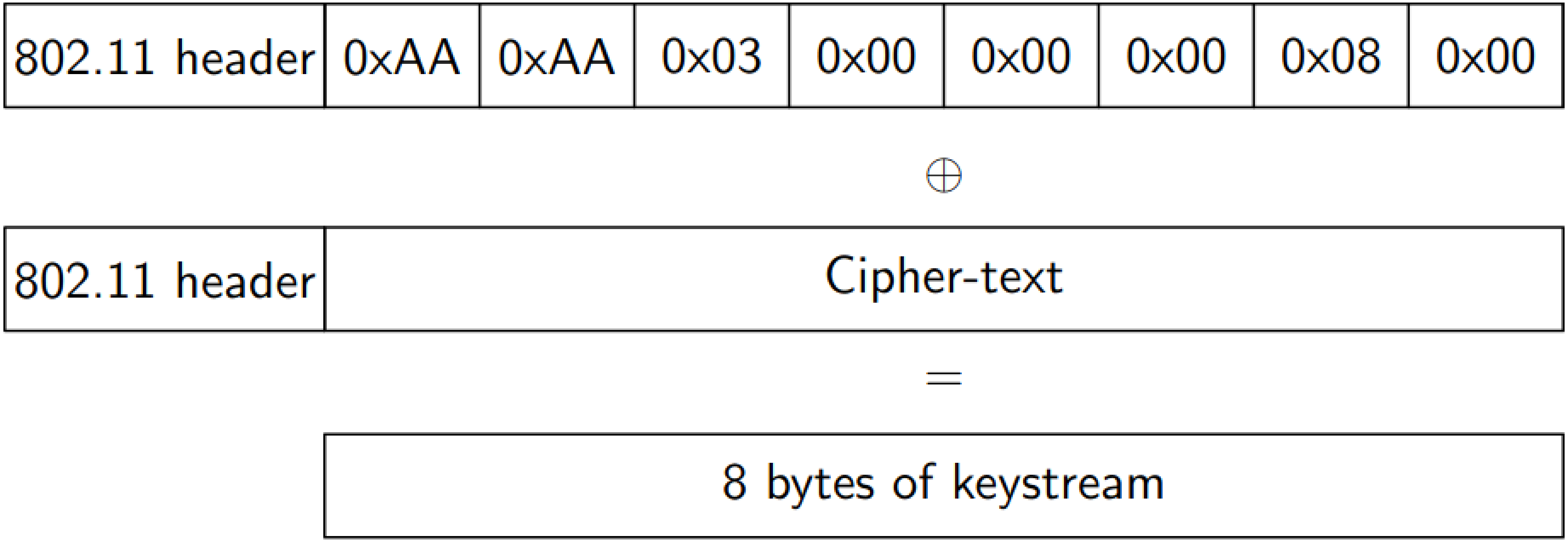
1	1	0	0

=

1	0	0	1

Cipher text →

If cipher-text & plain-text pair is known, their XOR is a keystream. Known plain-text (LLC/SNAP headers) in IP packets:



802.11 header	0xAA	0xAA	0x03	0x00	0x00	0x00	0x08	0x00

$\oplus$

802.11 header	Cipher-text

$=$

8 bytes of keystream

Can recover 8 bytes of keystream by eavesdropping a packet.

- Can encrypt (and transmit) 8 bytes of arbitrary data.

rc4-3.py

Possible to create statistical biases in the Key Scheduling Algorithm (KSA)

More info:

https://www.youtube.com/watch?v=2o3Hs-JDWLs

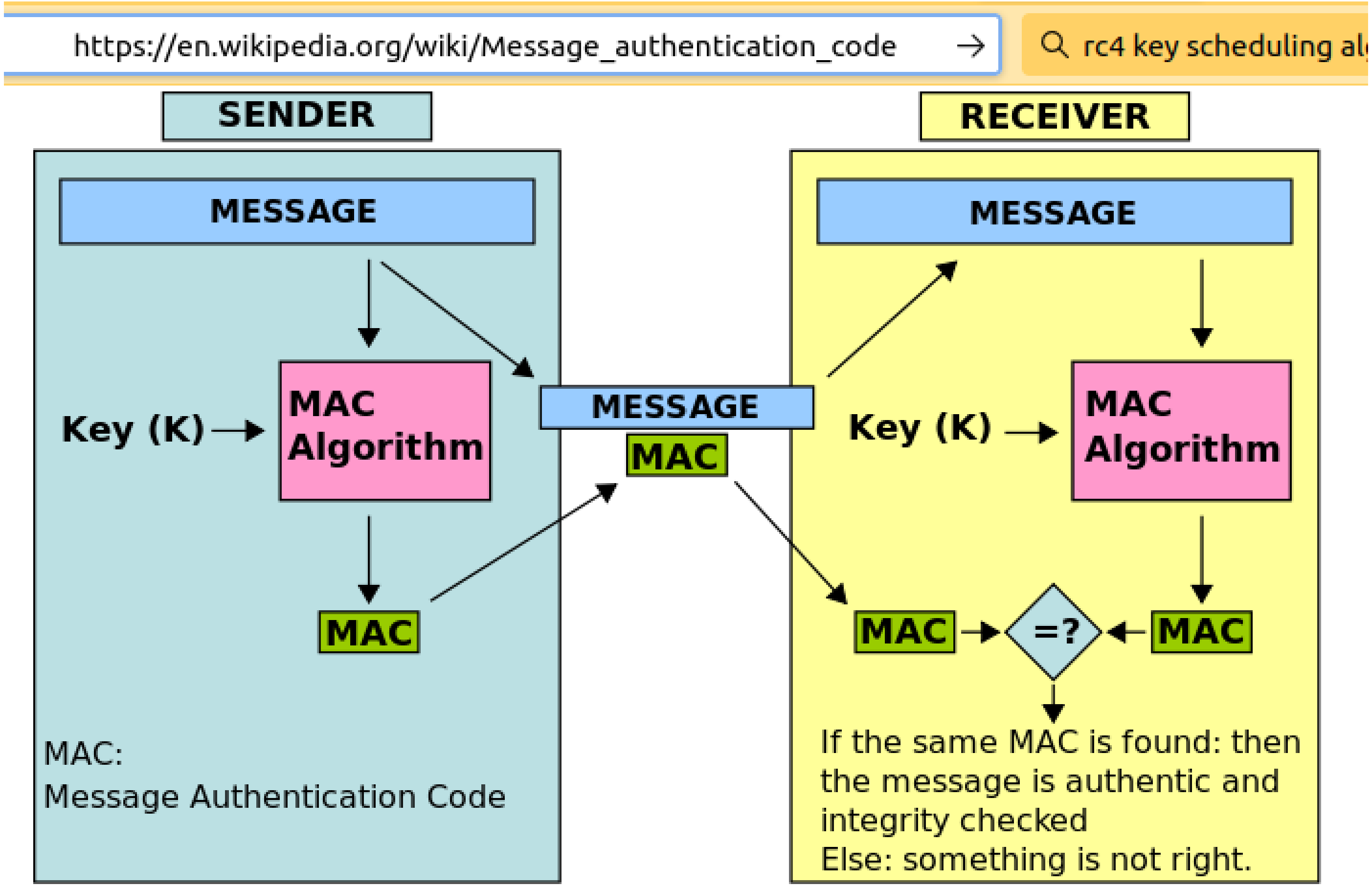
WPA

WiFi Protected Access

- -Stop gap because of WEP's failures
- -Encrypt like it's 1999

Temporal Key Integrity Protocol (TKIP)

- -Key mixing with IV and counter instead of concatenation
- -Out of order packets rejected by access point
- -64-bit Message Integrity Check (MIC)
  - -Same thing as a Message Authentication Code (MAC)



MAC:
Message Authentication Code

If the same MAC is found: then the message is authentic and integrity checked
Else: something is not right.

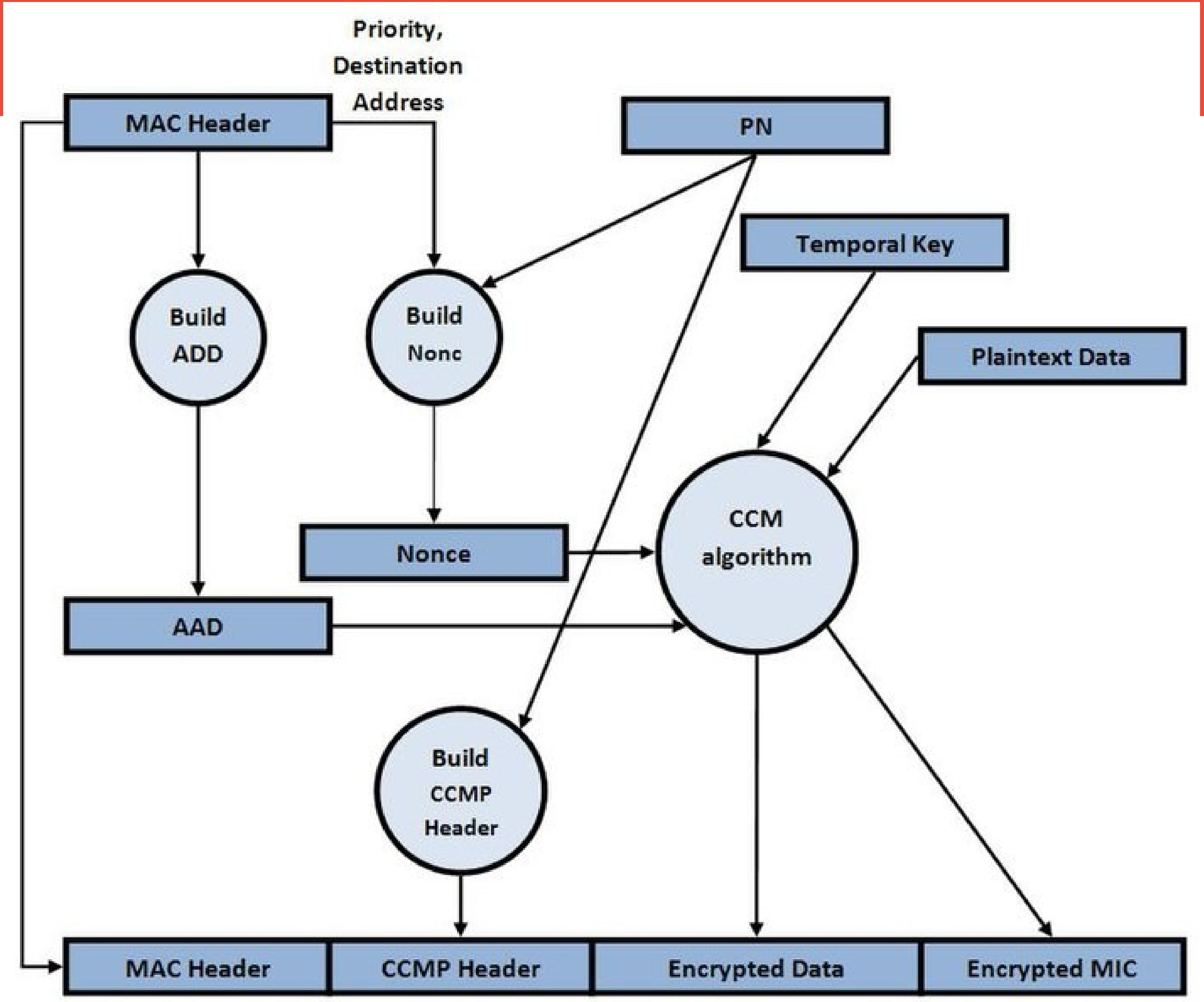
WPA2

Personal vs. Enterprise

Actual solution, not just new WPA version

- -Top 2004 pop song: Yeah! (feat. Lil Jon & Ludacris)Usher, Lil Jon, Ludacris

AES and CCMP (Counter Cipher Mode with Block Chaining Message Authentication Code Protocol)



https://en.wikipedia.org/wiki/File:CCMP_-_Encryption_and_Encapsulation.JPG

KRACK attacks

Let’s read the CCS 2007 paper next week

- -https://www.krackattacks.com/
- -https://blog.cryptographyengineering.com/2017/10/16/falling-through-the-kracks/

Crypto protocol and handshake

WPA2 Enterprise

RADIUS server, Extensible Authentication Protocol (EAP)

-First step of 4-way handshake is, e.g., username and password instead of pre-shared password

-Still vulnerable to KRACK

WPA3

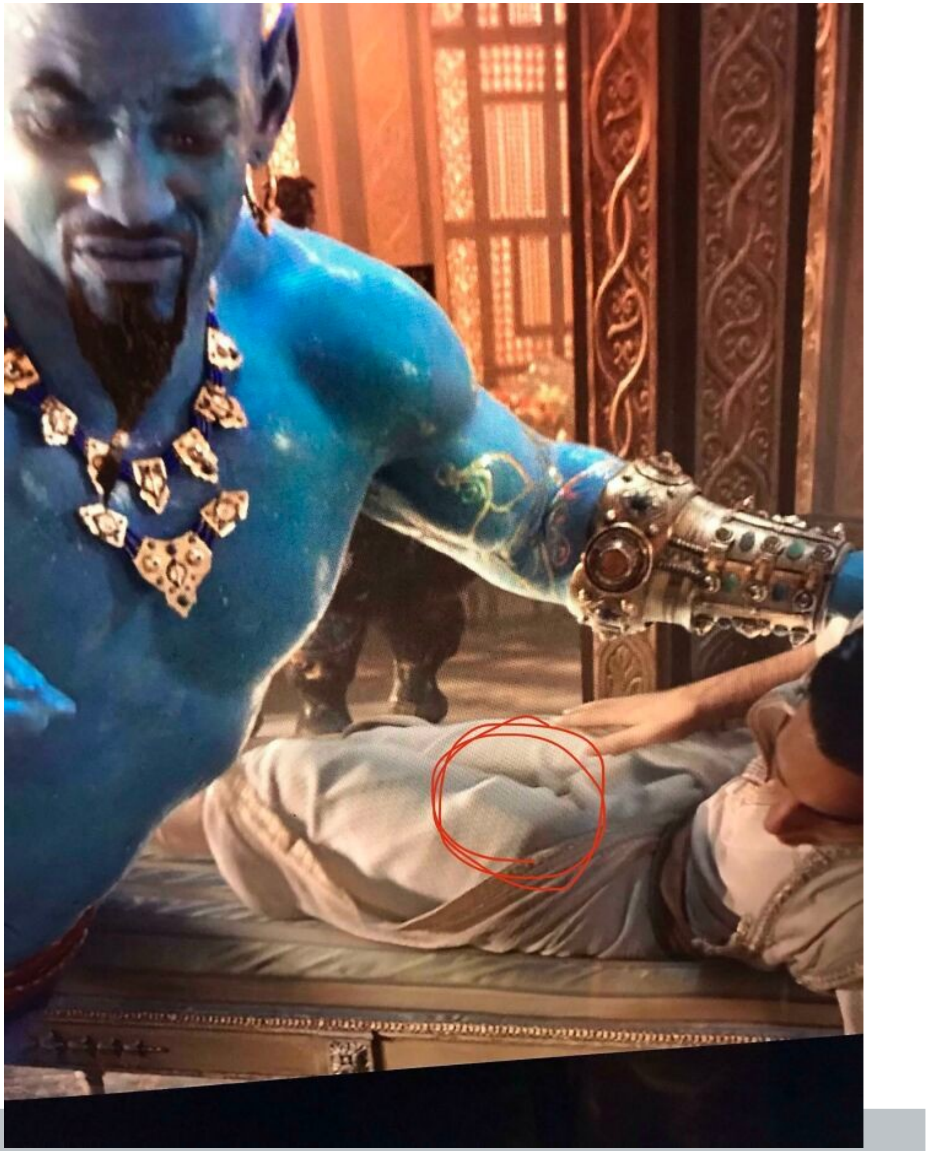
Lots of improvements over WPA2

- -Top pop song in 2018: “God’s Plan” by Drake
- -Bigger keys possible: 192-bit equivalent AES-256 GCM and SHA-384 HMAC
- -Simultaneous Authentication of Equals (SAE), Diffie-Hellman and forward secrecy
- -Open network improvements a.k.a. Enhanced Open (https://securityuncorked.com/2022/08/wifi-security-wpa2-vs-wpa3/)

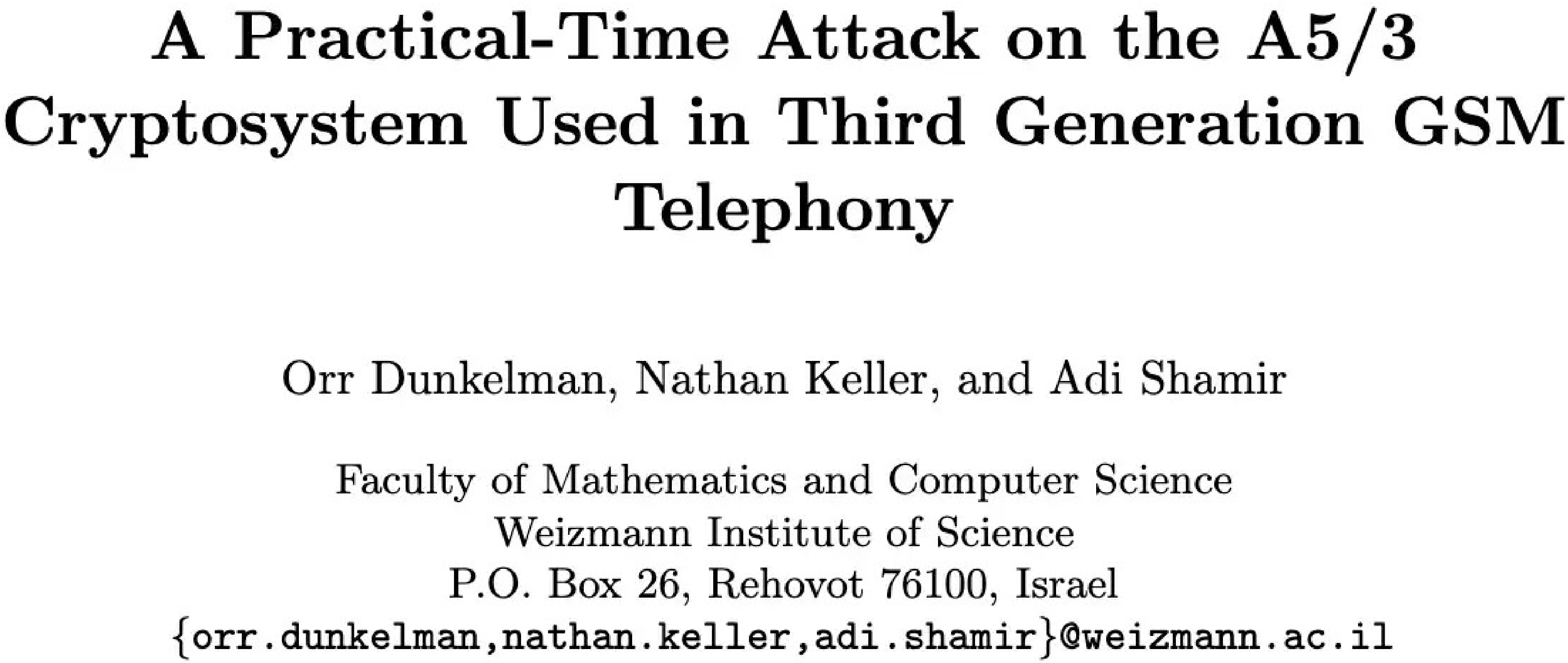
Dragonblood attacks (2019)

- -Side channels and downgrade attacks
- -https://wpa3.mathyvanhoef.com/

Other applications of radio



3G (cracked?)



A Practical-Time Attack on the A5/3 Cryptosystem Used in Third Generation GSM Telephony

Orr Dunkelman, Nathan Keller, and Adi Shamir

Faculty of Mathematics and Computer Science
Weizmann Institute of Science
P.O. Box 26, Rehovot 76100, Israel
{orr.dunkelman,nathan.keller,adi.shamir}@weizmann.ac.il

4G LTE

Authentication in the clear

-User's identity and location are vulnerable, IMSI catchers

-Calls and messages, etc., after are not

Purely symmetric crypto

-No perfect forward secrecy

Not end-to-end

-Only protects between user and base station

-If you've ever visited a network, they have the key

5G

Curve25519 (asymmetric), end-to-end, and other improvements

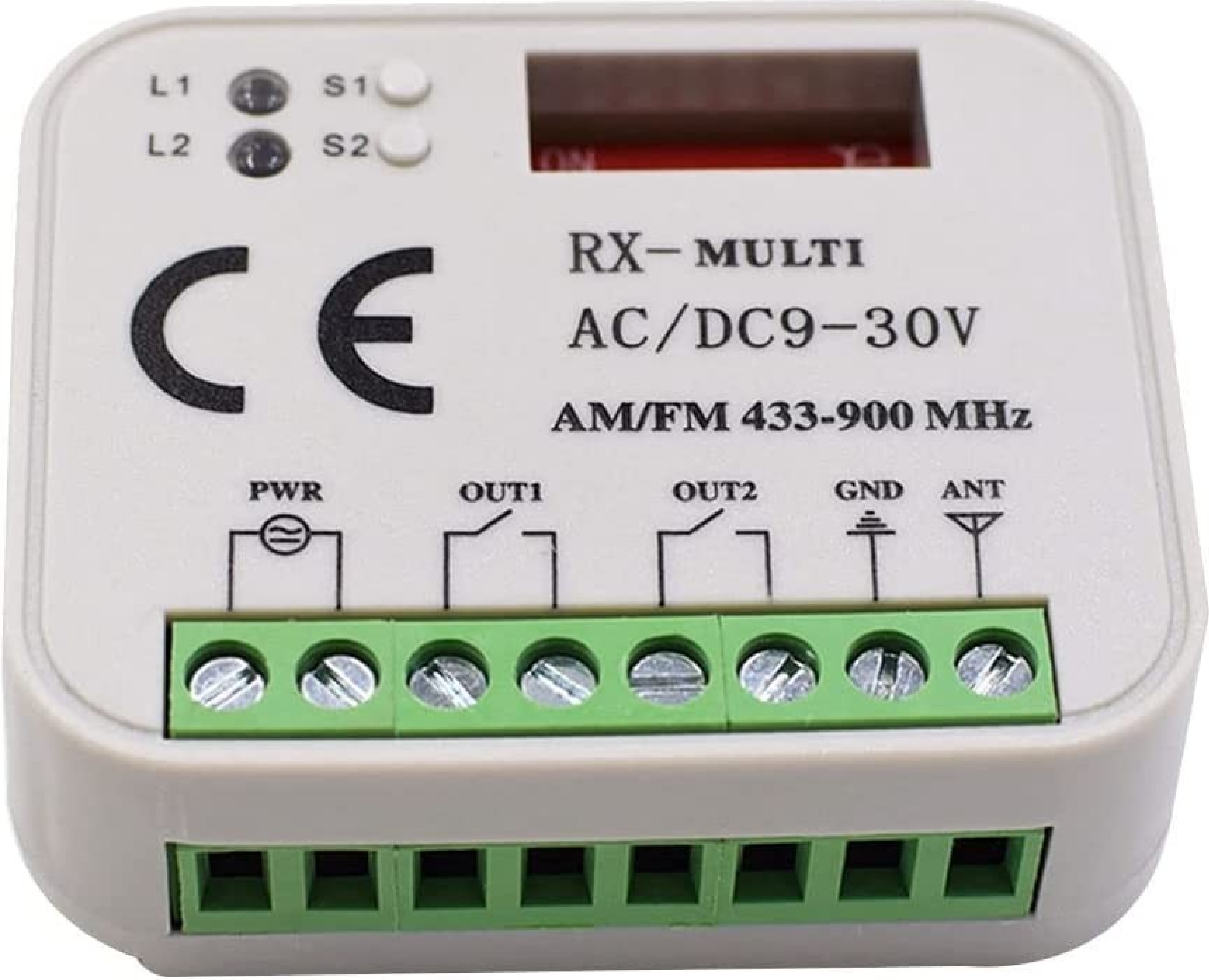
-https://datatracker.ietf.org/meeting/113/materials/slides-113-hrpc-5g-security-privacy-and-surveillance-2022-update-00

No perfect forward secrecy

IMSI catchers still an issue because of downgrade attacks and implementation issues?

-https://i.blackhat.com/USA21/Wednesday-Handouts/us-21-5G-IMSI-Catchers-Mirage.pdf

UHF


L1
L2
S1
S2
CE
RX- MULTI
AC/DC9-30V
AM/FM 433-900 MHz
PWR
OUT1
OUT2
GND
ANT

Others

Bluetooth

Zigbee

-Physical frame injection

ANT+

-Garmin products

Zwave

-Smart homes

-Replay attacks, etc. (https://github.com/CNK2100/VFuzz-public)

https://wigle.net/

Wired networks

Ethernet

CAN bus

FPD-Link

SONET

ATM

PPP, tunnels, etc.