

Robust Channels

Handling Unreliable Networks in the Record Layers of QUIC and DTLS 1.3

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QUIC/DTLS 1.3 within the Network Stack

Application (HTTPS, ...)

QUIC/DTLS

Handshake

Application data streams

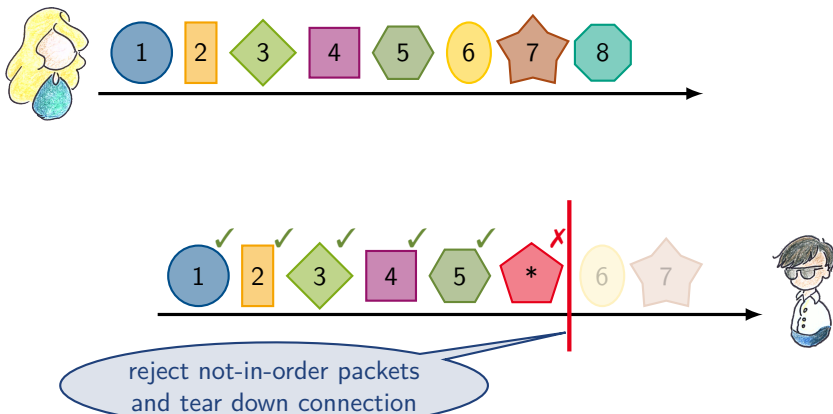
Record Layer

What **secure channel** guarantees do the QUIC/DTLS 1.3 record layers provide over UDP?

UDP

Recap: Secure Channels over TCP

... think: TLS

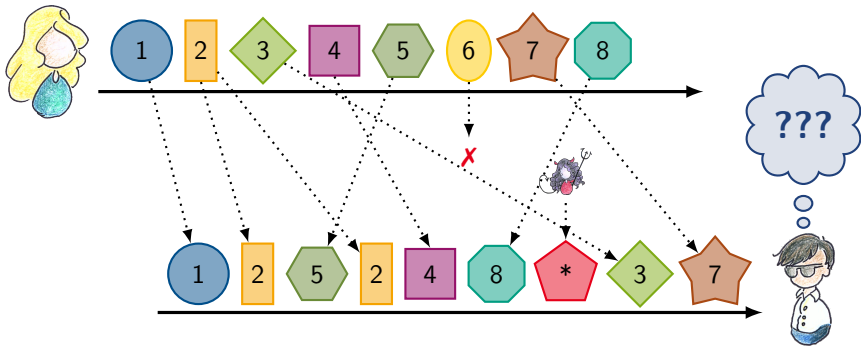


drawings by *Giorgia Azzurra Marson*

Handling Unreliable Transport

QUIC, DTLS, ... over UDP

ETH zürich



Handling Unreliable Transport

Many choices. . .

▶ Replays / Duplicates

- ▶ prevent them?
- ▶ check how far back?

QUIC

MUST prevent

e.g., anti-replay window (IPsec)

DTLS 1.3

optional

▶ Reordering

- ▶ permitted?
- ▶ by how far max.?

QUIC

dynamic 1–4B window

... well, yes—it's UDP ...

DTLS 1.3

dynamic 1–2B window

▶ Adversarial interaction

- ▶ Integrity: reject non-genuine packets

QUIC

DTLS 1.3

rely on AEAD

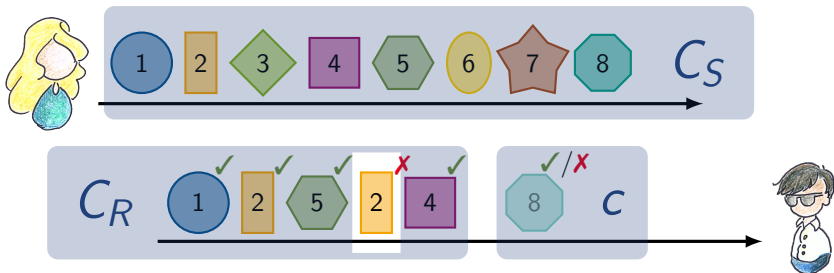
- ▶ But how do you (formally) guarantee that replayed / reordered / adversarial packets don't affect others?

new notion: **Robustness**

Generalizing Channel Correctness

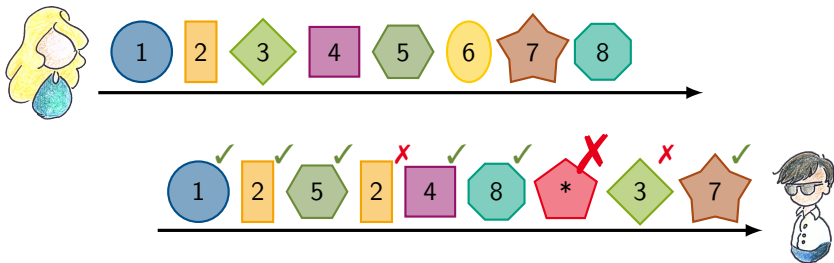
... beyond prior hierarchies [BKN02, KPB03, Boy+16, RZ18]

- ▶ parameterize what packet (ciphertext) reordering a channel **supports**
- ▶ predicate $\text{supp}(C_S, C_R, c) = \checkmark / \times$
 - ▶ C_S : sequence of sent ciphertexts
 - ▶ C_R : sequence of *supported* ciphertexts received prior
 - ▶ c : next ciphertext to receive
- ▶ correctness (only) requires genuine, supported ctexts be correctly decrypted



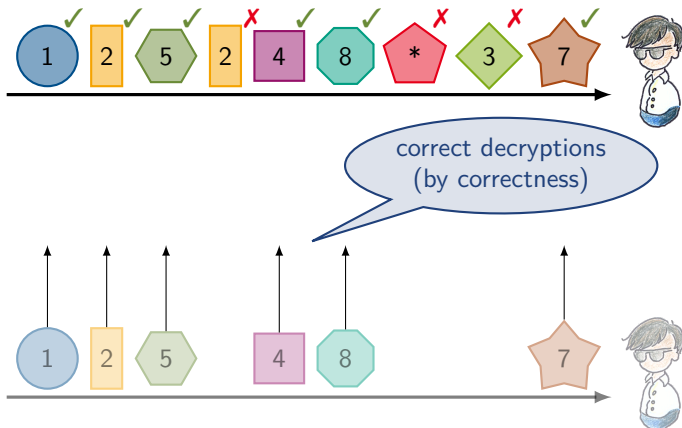
Defining Robustness (ROB)

“malicious packets cannot disturb expected channel behavior”



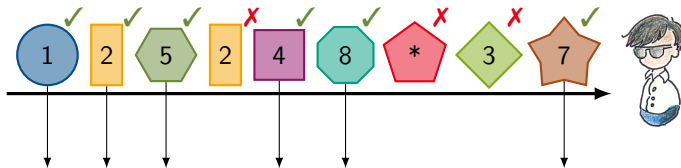
Defining Robustness (ROB)

Idea: Compare with the supported, correct sub-trace

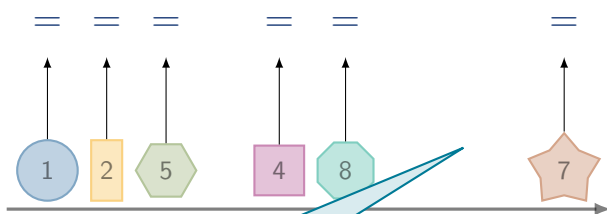


Defining Robustness (ROB)

Idea: Compare with the supported, correct sub-trace



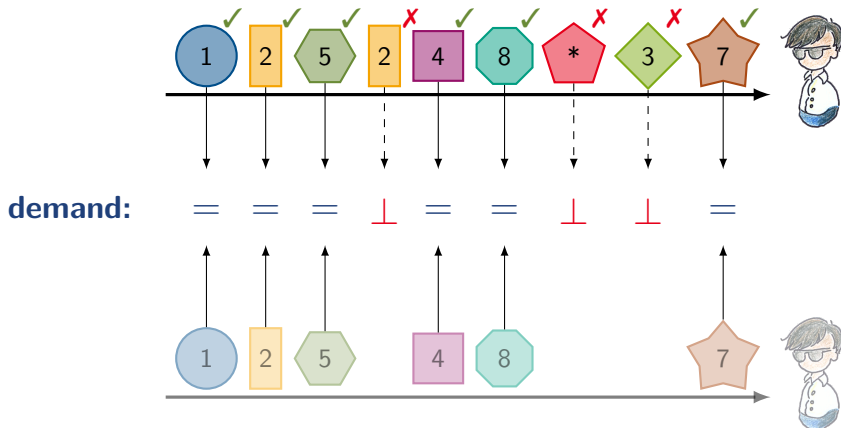
demand:

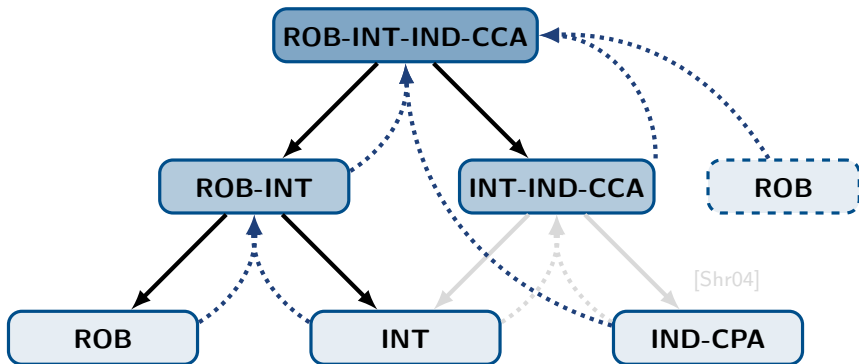


What about the (non-supported) gaps?

Robust Integrity (ROB-INT)

- ▶ join **robustness** and **integrity** for desired property over unreliable transport

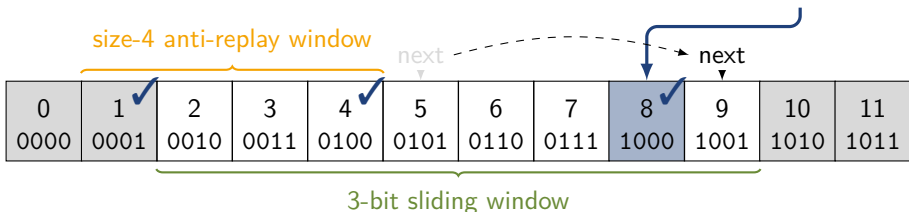
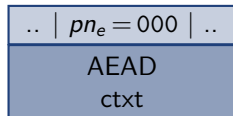




QUIC Channel

Correctness for Dynamic Sliding Windows

- ▶ header (w/ partial packet no. pn_e) + AEAD ciphertext
- ▶ pn_e defines $|pn_e|$ -bit **dynamic sliding window**
- ▶ check for **replays** in w_r -sized **window**



$$\text{supp}_{dw-r[w_r]}(C_S, C_R, c) :=$$

$$\left[c \in C_S \wedge c \notin C_R \wedge \text{index}(c, C_S) \in [n - \min(w_b^c, w_r + 1), n + w_f^c] \right]$$

(simplified)

supported if in sliding window (dynamic for c) and replay window


QUIC Channel

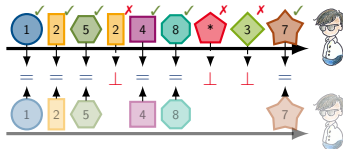
Robust Confidentiality and Integrity (ROB-INT-IND-CCA)

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- ▶ use hierarchy: **IND-CPA + ROB-INT = ROB-INT-IND-CCA**

$$\text{Adv}_{\text{QUIC}}^{\text{ROB-INT-IND-CCA}} \leq \text{Adv}_{\text{AEAD}}^{\text{priv}} + q_R \cdot \text{Adv}_{\text{AEAD}}^{\text{auth}}$$

- ▶ important:  can make **multiple forgery attempts**
- ▶ factor q_R (#received ciphertexts) loss in security reduction



- ▶ IETF WGs updated QUIC / DTLS 1.3 drafts to mandate **concrete forgery limits** (beyond confidentiality limits [LP17])

The integrity protections ... depend on limiting the number of attempts to forge packets. ... QUIC ignores any packet that cannot be authenticated, allowing multiple forgery attempts.

- ▶ **Usage Limits on AEAD Algorithms** `draft-irtf-cfrg-aead-limits`
 - ▶ new CFRG document draft (w/ Chris Wood, Martin Thomson)
 - ▶ aims to provide user guidance on AEAD usage limits
 - ▶ confidentiality/integrity, single-/multi-key, AES-GCM/AES-CCM/ChaCha20Poly1305

Network Working Group Internet-Draft Intended status: Informational Expires: 24 March 2021	F. Günther ETH Zurich M. Thomson Mozilla C.A. Wood Cloudflare 20 September 2020
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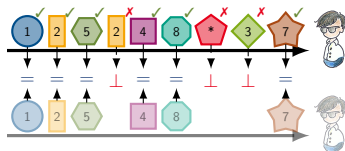
Usage Limits on AEAD Algorithms
draft-irtf-cfrg-aead-limits-01

Abstract

An Authenticated Encryption with Associated Data (AEAD) algorithm provides confidentiality and integrity. Excessive use of the same key can give an attacker advantages in breaking these properties. This document provides simple guidance for users of common AEAD functions about how to limit the use of keys in order to bound the advantage given to an attacker. It considers limits in both single- and multi-user settings.

- ▶ We introduce **robustness** as first-class security property
“malicious packets cannot disturb expected channel behavior”
- ▶ We analyze **QUIC and DTLS 1.3**
 - ▶ capturing dynamic sliding window & replay-checking
 - ▶ confirm both achieve intended **robust confidentiality and integrity**
 - ▶ ... but q_R loss has to be taken into account
- ▶ Led to **updated QUIC and DTLS 1.3 drafts**, mandating forgery limits

full version @ IACR ePrint: <https://ia.cr/2020/718>



Thank You!
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