NETWORK INFORMATION HIDING

CH. 4: INTRODUCTION TO NETWORK INFORMATION HIDING

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Definition

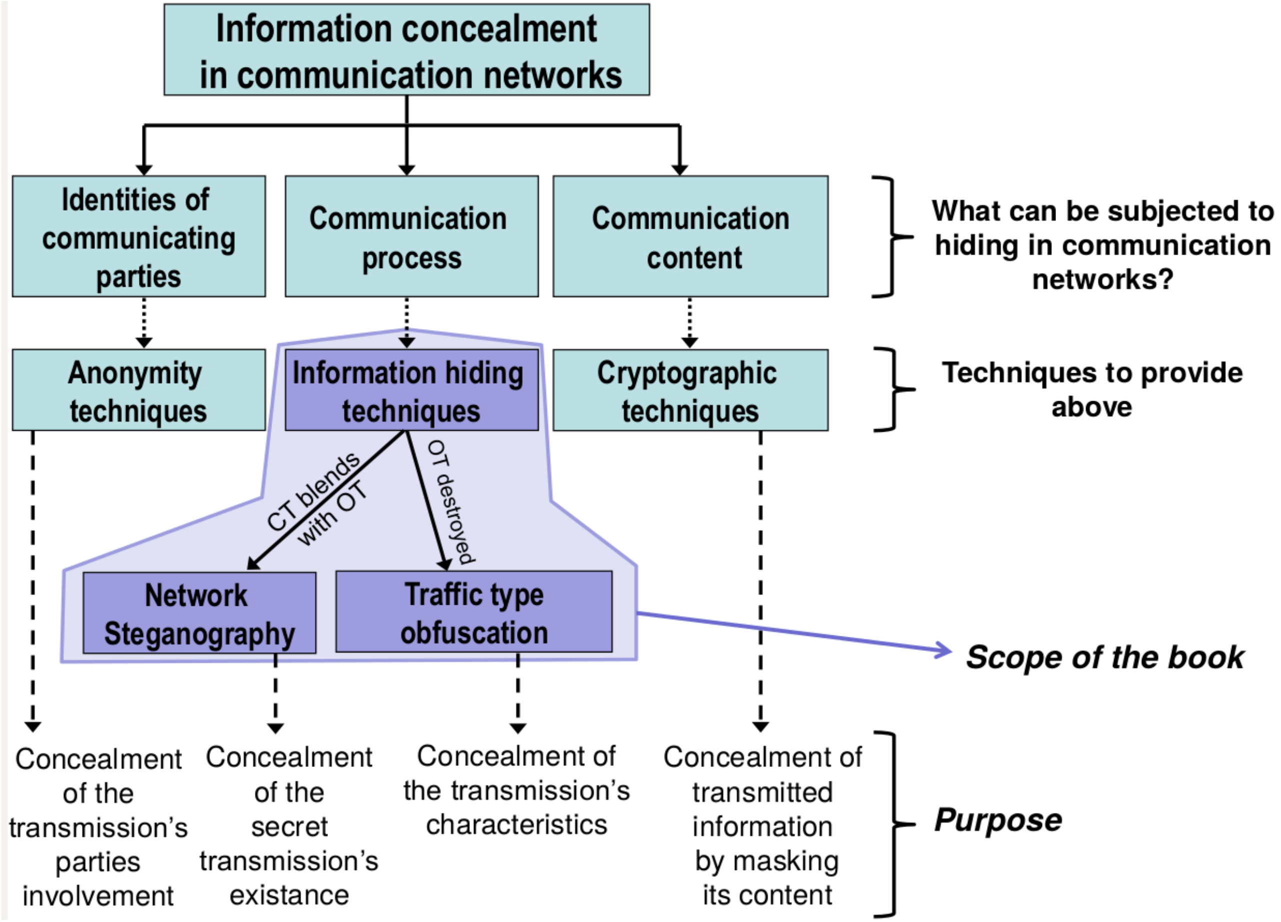


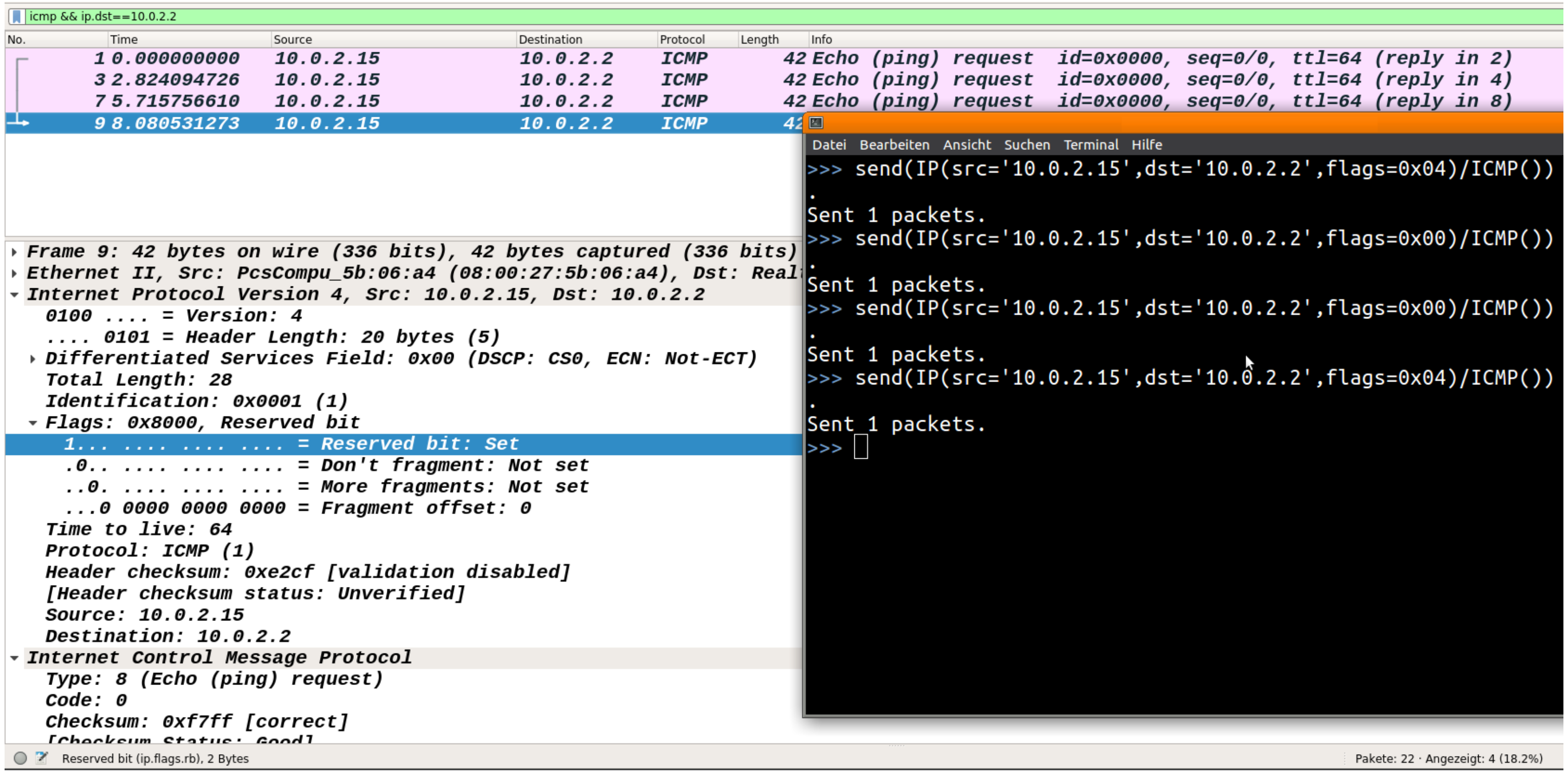
Fig.: W. Mazurczyk, S. Wendzel, S. Zander et al.: Information Hiding in Communication Networks, Wiley-IEEE, 2016

Differences to traditional digital media steganography

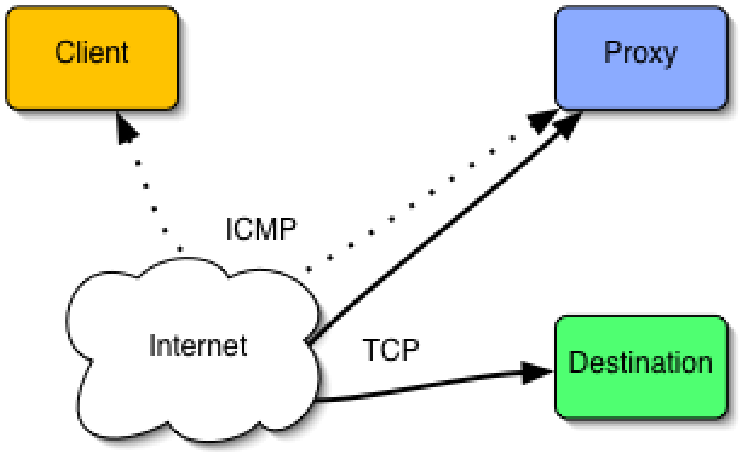
- **Inconsistent terminology**: no clear distinction between **steganography** and **covert channel**
  - See Ch. 1 for definitions of the terms steganography and covert channel and that both are considered as different research domains (covert channels in MLS context!).
  - Thus, in the network context: **network covert channel** or **network steganographic channel** handled **<u>separately</u>**
  - Unified: a steganographic **method** creates such a **covert channel** [1, Chapter 3]
- A bit more terminology:
  - Covert data is hidden in *overt* network transmissions
  - The „cover object“ is now called „carrier“ in the network context
  - Advantage of a constant transmission (e.g. permanent data leakage)
- Advantages:
  - Difficult to analyze **all** network data; smaller delay; with the growth of the Internet, the options for network IH grew and grow, too.

[1] W. Mazurczyk, S. Wendzel, S. Zander et al.: Information Hiding in Communication Networks, Wiley-IEEE, 2016

Example 1: Trivial Network Covert Channel via IPv4 Reserved Bit, sending message ``1001”



Example 2: Ping Tunnel



Analysis and improvements:
Jaspreet Kaur, Steffen Wendzel, Omar Eissa, Jernej Tonejc, Michael Meier: Covert Channel-internal Control Protocols: Attacks and Defense, *Security and Communication Networks (SCN)*, Vol. 9(15), Wiley, 2016.

Ethernet Frame
IP Header
ICMP Header
ICMP Echo Header
ICMP Echo Payload

Secret data is embedded into the ICMP echo payload.
In addition, a small protocol of the following format is used:

Figs.: http://www.cs.uit.no/%7Edaniels/PingTunnel/

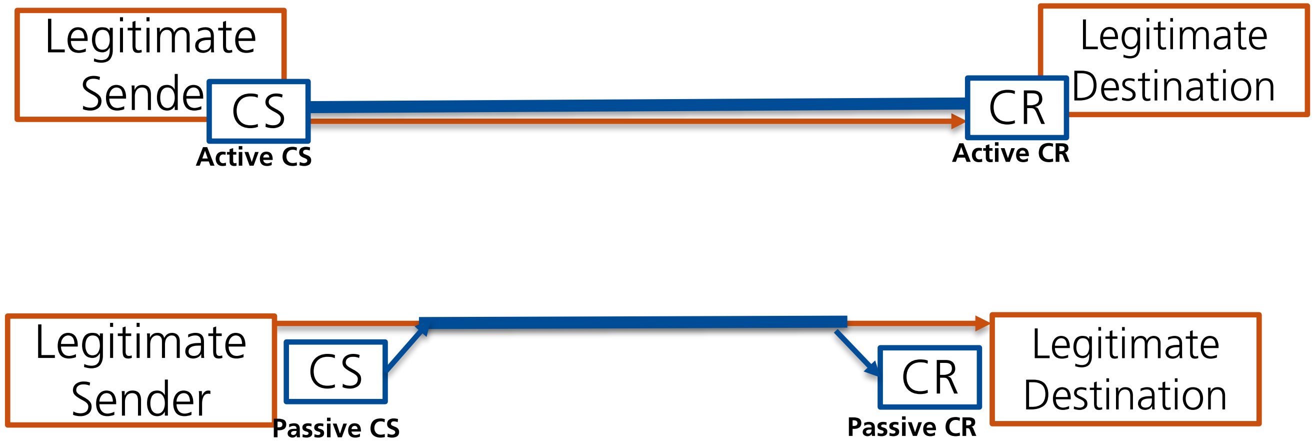
Types of (Network) Covert Channels

Fundamental:

- **Local** and **network** covert channels
- **Storage** and **timing** channels
- **Noisy** and **noise-free** covert channels

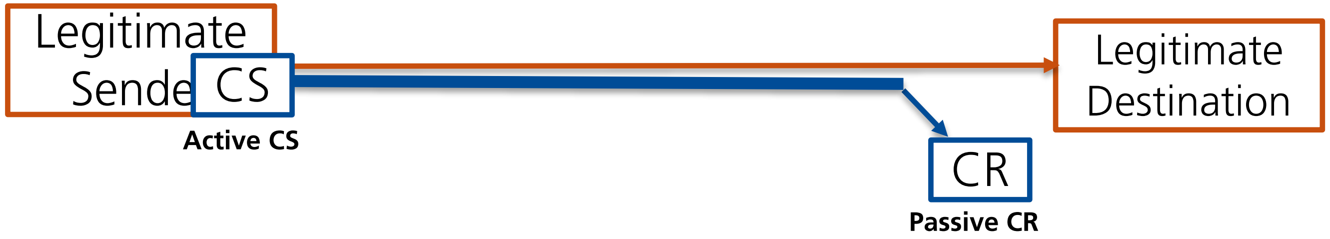
Types of (Network) Covert Channels: Active/Passive Cov. Channels

- **Active** and **passive** Covert Channels (passive elements have a different sender/receiver than the legitimate sender/receiver)

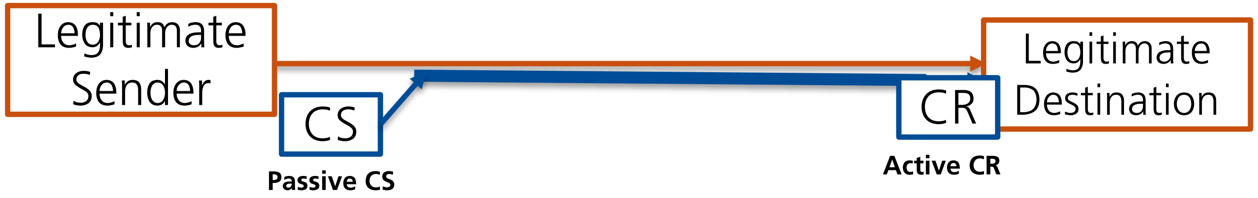


Types of (Network) Covert Channels: Semi-active/passive Cov. Channels

- **Semi-active** and **semi-passive** Covert Channels [1]
  - **Semi-active:**



  - **Semi-passive:**



[1] K. Lamshöft, J. Dittmann: *Assessment of Hidden Channel Attacks: Targetting Modbus/TCP*, IFAC-PapersOnLine, 53(2), 2020.

Types of (Network) Covert Channels: History Cov. Channels and Cov. Ch. Amplification

- Most covert channels focus on the **present**, e.g., packets might contain secret stego data in their **current** payload.
- **History** covert channels optimize transmission sizes by transferring **solely pointers to larger data chunks already seen somewhere**, e.g., in previous packets or online data [1]. These data chunks represent the actual secret information. First implementation called "**DYST**" (*Did You See That?*). Since the pointers are smaller than the actual secret data, one achieves an **amplification**.
- **Predictive** covert channels are a derivative of history channels but **anticipate upcoming** data they point to (e.g., anticipated regularly occurring network packets) [1].

⇒ **<u>Reading Assignment:</u>** S. Wendzel, T. Schmidbauer, S. Zillien, J. Keller: DYST (Did You See That?): An Amplified Covert Channel That Points To Previously Seen Data. IEEE Transactions on Dependable and Secure Computing, DOI: 10.1109/TDSC.2024.3410679

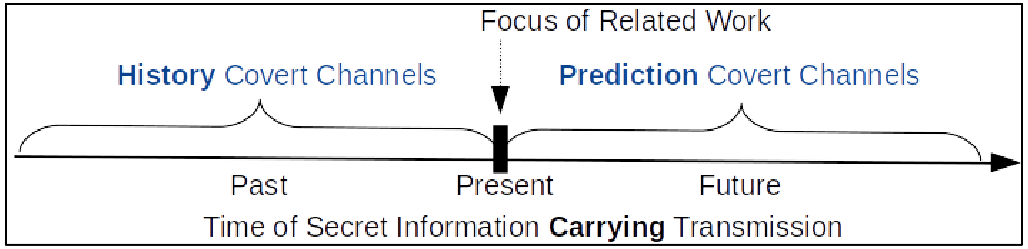


Fig.: [1]

[1] S. Wendzel, T. Schmidbauer, S. Zillien, J. Keller: DYST (Did You See That?): An Amplified Covert Channel That Points To Previously Seen Data. IEEE Transactions on Dependable and Secure Computing (TDSC), DOI: 10.1109/TDSC.2024.3410679

Types of (Network) Covert Channels: History Cov. Channels and Cov. Ch. Amplification

- History/prediction channels enable a new category of **fully-passive covert channels** (see **Fig.** below), where a stego data channel (in this case "**DYST**") can be represented through 100% legitimate traffic – solely the signaling channel (containing the pointer) needs to craft new/modify existing packets [1].

		Covert **Sender**		
		Active (generates own overt traffic in which it embeds covert data)	**Passive** (embeds covert data in overt traffic of third-party nodes)	**Fully-passive** (utilizes third-party traffic without modifying it)
Covert **Receiver**	**Active** (is the destination of the overt traffic)	**Active** Covert Channel	**Semi-passive** Covert Channel	**Fully-and-semi-passive** Covert Channel
	Passive (is not the direct destination of the overt traffic, e.g., a router)	**Semi-active** Covert Channel **DYST's Signal Channel**	**Passive** Covert Channel	**Fully-passive** Covert Channel **DYST's Data Channel**

Fig.: [1]

[1] S. Wendzel, T. Schmidbauer, S. Zillien, J. Keller: DYST (Did You See That?): An Amplified Covert Channel That Points To Previously Seen Data. IEEE Transactions on Dependable and Secure Computing (TDSC), DOI: 10.1109/TDSC.2024.3410679

Types of (Network) Covert Channels: History Cov. Channels: DYST (Basic Version)

- How do history covert channels work?
  - Different approaches feasible, also outside of networks.
- Together with the concept of history covert channels, we introduced a first implementation (before-mentioned **DYST**) in [1].

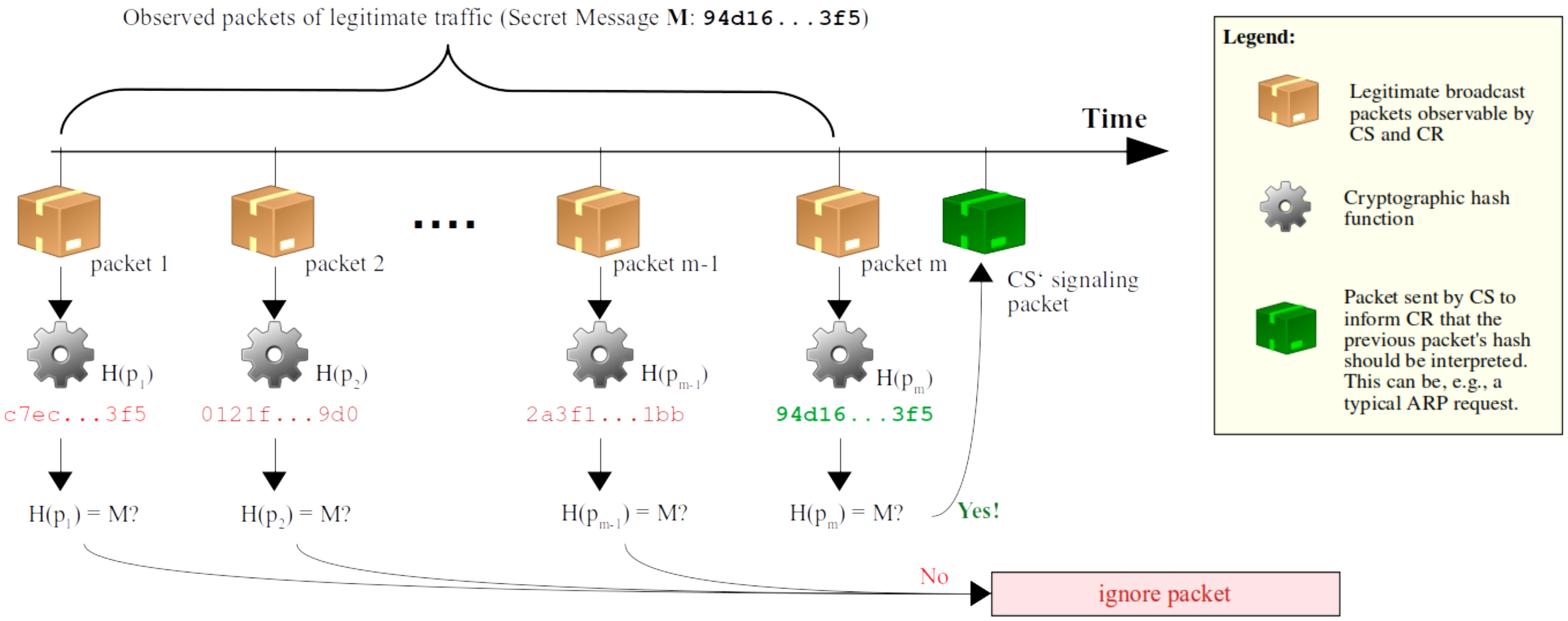
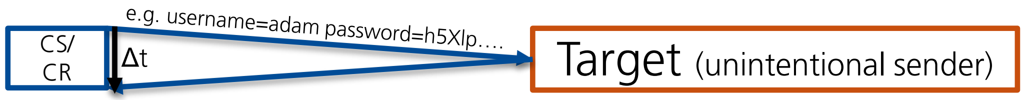


Fig.: [1]

[1] S. Wendzel, T. Schmidbauer, S. Zillien, J. Keller: DYST (Did You See That?): An Amplified Covert Channel That Points To Previously Seen Data. IEEE Transactions on Dependable and Secure Computing (TDSC), DOI: 10.1109/TDSC.2024.3410679

Types of (Network) Covert Channels: (Un)Intentional Cov. Channels

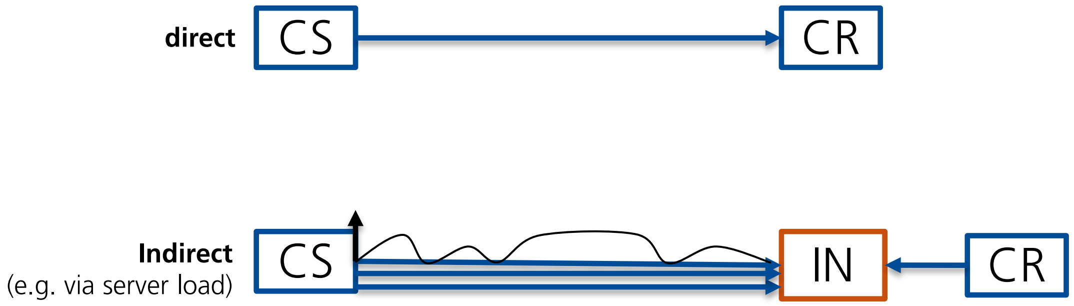
- **Intentional** (**covert**) and **unintentional** (**side**) channels
  - e.g. side channels in web applications, see [talk by S. Schinzel]()
  - Example:



* Traffic must be sent many times and measured exactly to gain any useful information out of this.

Types of (Network) Covert Channels: (In)Direct Cov. Channels

- **Direct** and **indirect** covert channels: direct channels do not rely on intermediate nodes (IN).
  - Example: via web page + server load
  - General illustration:



Further differentiation into two major patterns for the intermediate node (IN): **redirector** and **broker**.

- A broker can be a **proxy** or a **dead drop**.

⇒ **Reading Assignment:** T. Schmidbauer, S. Wendzel: *SoK A Survey of indirect network-level covert channels*, in Proc. 17th AsiaCCS, ACM, 2022. **Section 3**. https://doi.org/10.1145/3488932.3517418 (PDF available through Moodle).

How to „measure“ covert channels?

Only in brief as this **will be covered in more detail in the course 01730 „Introduction to Information Hiding“ by J. Keller**.

- Capacity, Bitrate and Bandwidth (how much information or data can be transferred per time?)
- Undetectability / covertness (how detectable is the covert channel?)
- Robustness (for noisy channels: how fragile is the covert channel?)

How to „measure" covert channels?

– Introduction of **Covertness** by Giani et al. [1]:

Covertness $\propto$ (Capacity if the medium – Transmission Rate)

If the whole capacity of a transmission medium (e.g. network packets or an audio CD) is used, the covertness is zero, leading to a trivial detection. However, if only a tiny fraction of the capacity is used, the covertness can remain close to one.

[1] A. Giani, V. H. Berk, G. V. Cybenko: Data Exfiltration and Covert Channels, Sensors, and Command, Control, Communications, and Intelligence (C3I) Technologies for Homeland Security and Homeland Defense V. Vol. 6201. International Society for Optics and Photonics, 2006.

How to „measure" covert channels?

- **Steganographic Cost (SC)** by Mazurczyk et al. [1]:
  - Measure of degradation or distortion of a carrier caused by the application of a steganographic method.
  - Calculation depends on context. For instance, for *LACK* steganography, which exploits packet loss, the **SC** can be calculated using the *Mean Opinion Score* (MOS) as a difference in quality of the voice signal (**RQ**) without and with LACK applied (**LQ**):

$$SC_{T-LACK}(t) = \Delta MOS(t) = RQ(t) - LQ(t)$$

  - For *Retransmission Steganography* (RSTEG), one can calculate the retransmission difference R_D instead:

$$SC_{T-RSTEG} = R_D = R_{N-RSTEG} - R_N$$

    - $R_{N-RSTEG}$ denotes retransmissions in the network with RSTEG and R_N the network's retransmissions without applying RSTEG.

[1] W. Mazurczyk, S. Wendzel, I. Azagra Villares, K. Szczypiorski: On importance of steganographic cost for network steganography, SCN, 9(8), 781-790, Wiley, 2016.

How to „measure" covert channels?

- **Steganographic Cost** by Mazurczyk et al. [1]:
  - If multiple steganographic methods exploit the same subcarrier **S1** of the carrier **C1**, the **total steganographic cost of the carrier $\boldsymbol{SC_{T(C1)}}$** can be expressed as:

$$SC_{T(C1)}(n) = \sum_{n=1}^{n} SC_{S1-n}$$

  - $\boldsymbol{SC_{S1-n}}$ is the steganographic cost of the **n'**th method applied to subcarrier **S1**.

[1] W. Mazurczyk, S. Wendzel, I. Azagra Villares, K. Szczypiorski: On importance of steganographic cost for network steganography, Security and Communication Networks (SCN), Vol. 9(8), 781-790, Wiley, 2016.