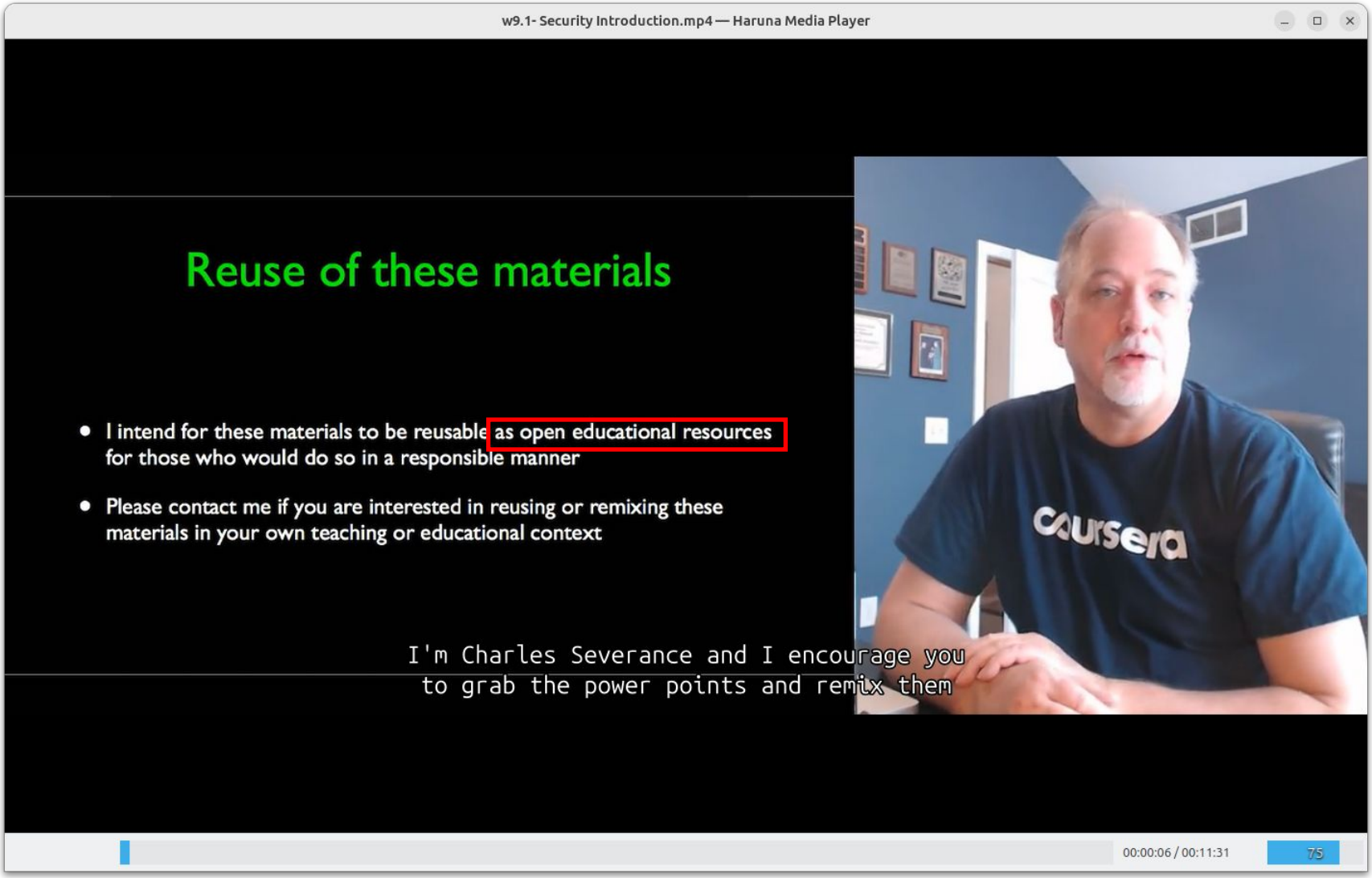
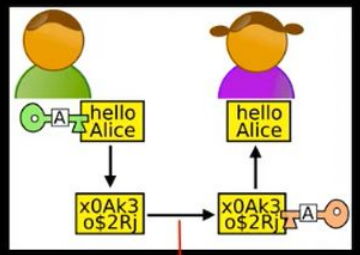
# w9.1- Security Introduction



# People With Bad Intent

- *Carol, Carlos or Charlie, as a third participant in communications.*
- *Chuck, as a third participant usually of malicious intent*
- *Dan or Dave, a fourth participant,*
- *Eve, an eavesdropper, is usually a passive attacker. While she can listen in on messages between Alice and Bob, she cannot modify them.*
- .....




http://en.wikipedia.org/wiki/Alice_and_Bob

Right, there's the bad guys and, and often they are called C, like, Carol or

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# Paranoia

- Who is out to get you?
- If you are interesting or influential people want to get into your personal info.
- If you are normal, folks want to use your resources or take your information to make money…
- Usually no one cares… But it is safest to assume some is always trying…


So it's always fun to talk about security
because the question is, you, and what

00:02:21 / 00:11:31

75

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# Alan Turing and Bletchley Park

- Top secret code breaking effort
- 10,000 people at the peak (team effort)
- BOMBE: Mechanical Computer
- Colossus: Electronic Computer

http://www.youtube.com/watch?v=5nK_ft0Lf1s


And, with your communications.
So who is out to get us?

00:03:42 / 00:11:31

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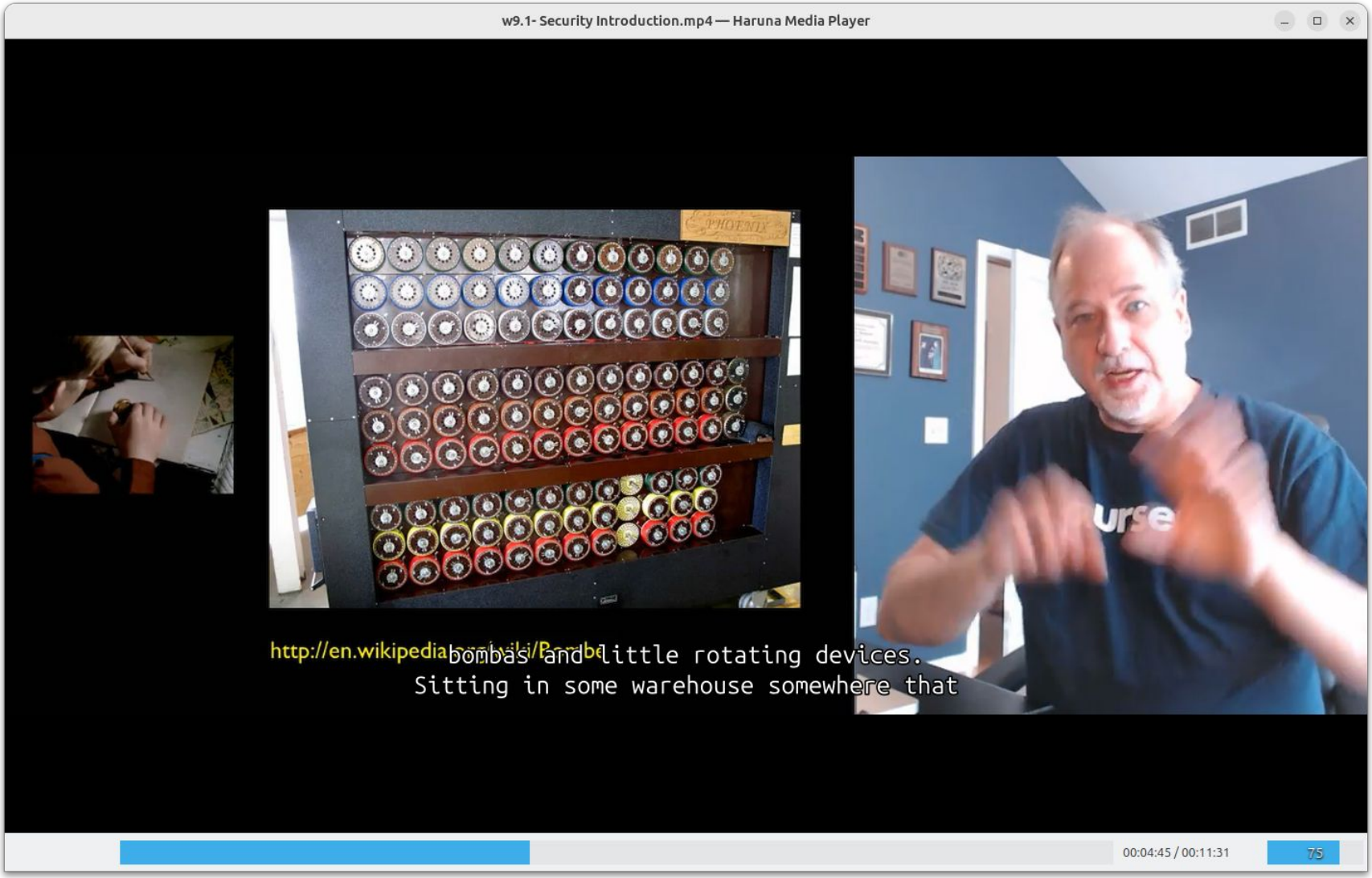
## Summary

Alan Turing (1912–1954) was a pioneering mathematician and computer scientist who played a pivotal role in the Allied victory during World War II while working at Bletchley Park. Bletchley Park, located north of London, served as the top-secret headquarters for Britain's codebreaking efforts, often referred to as a "world's first Skunk Works" due to its innovative and collaborative environment.

**Key Contributions at Bletchley Park**

- **Breaking the Enigma:** Turing's primary focus was cracking the German Enigma machine, which used a complex system of encryption wheels to transmit operational orders.
- **The Bombe Machine:** Building on initial work by Polish mathematicians, Turing and a team of engineers designed the "Bombe". This electromechanical device allowed codebreakers to rapidly search for the correct Enigma settings.
- **Strategic Impact:** The intelligence gathered from these breakthroughs, known as Ultra, provided critical insights into German military movements, including confirming that deception tactics for the D-Day landings had successfully misled Hitler.



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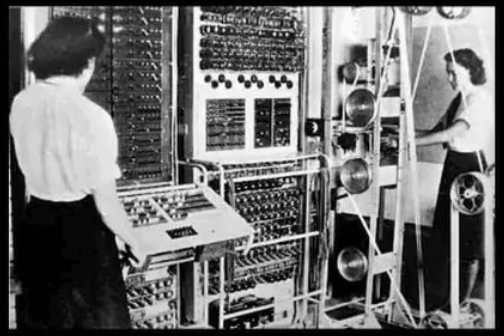
http://en.wikipedia.org/wiki/Colossus_computer



http://en.wikipedia.org/wiki/Tony_Sale


invent, like, electronic computers.
Because we have to have bigger computers,

00:05:05 / 00:11:31

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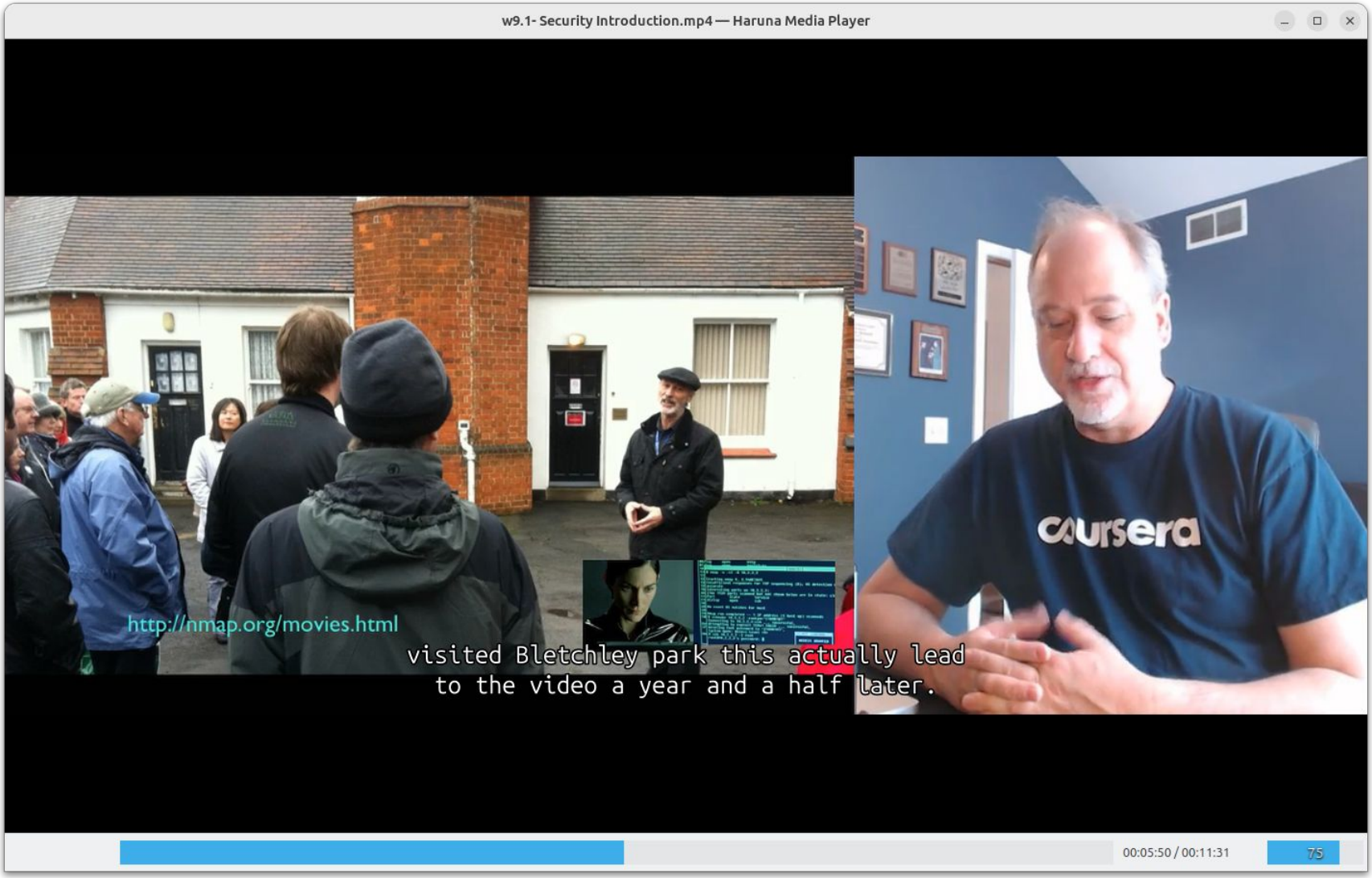
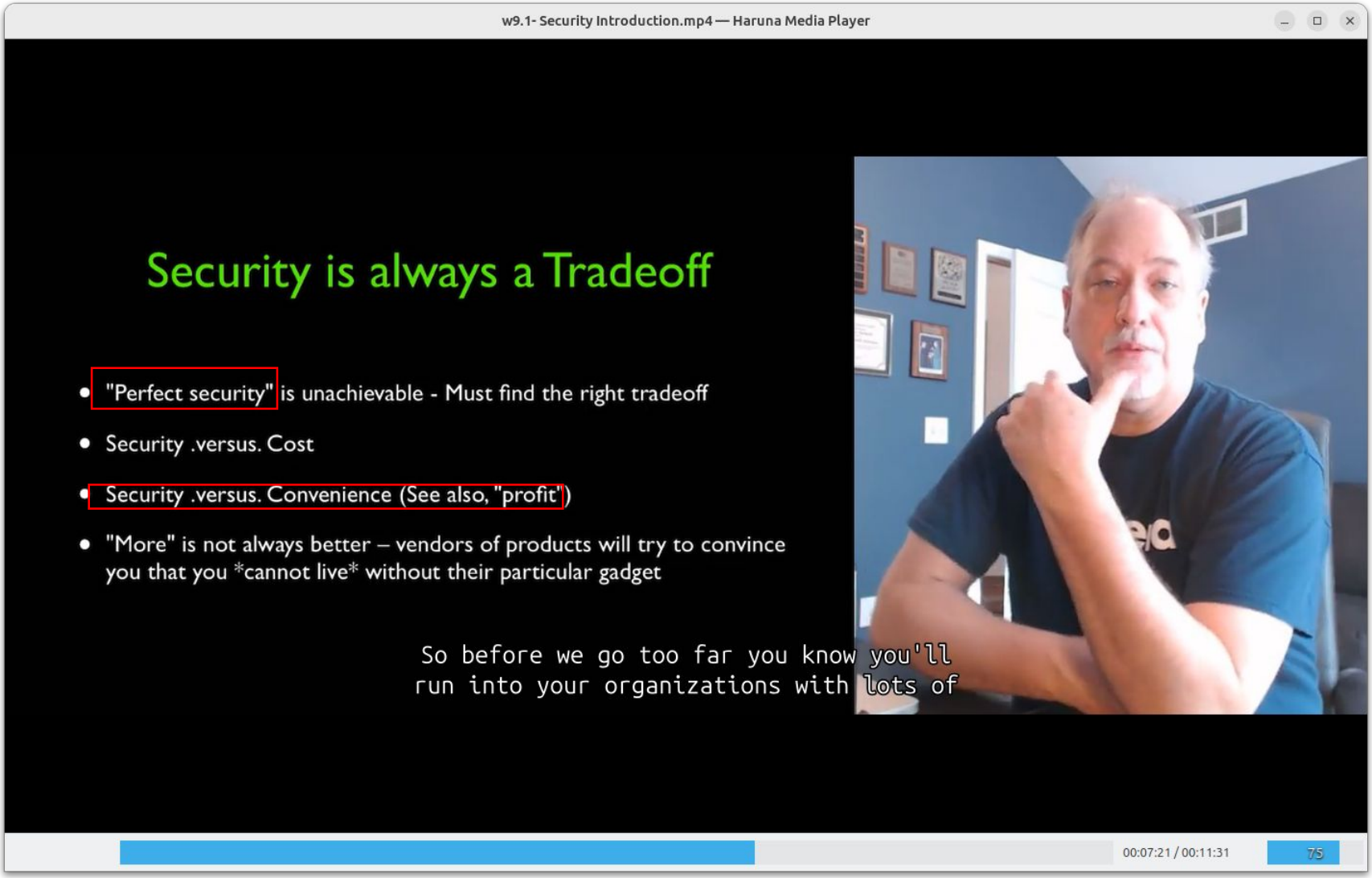
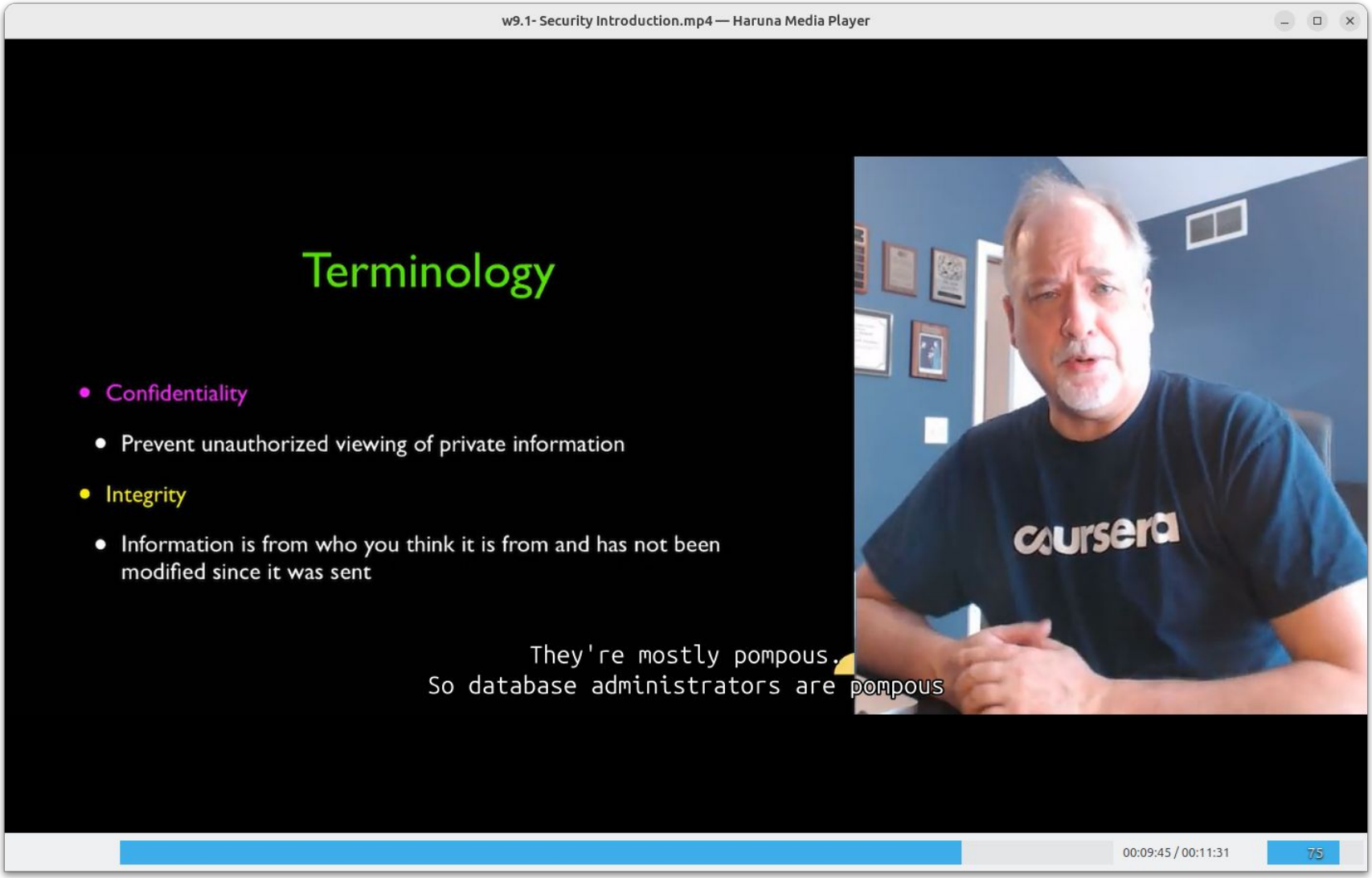






Summary

## Security Lecture: The Arms Race Summary

### 1. The Players: Alice, Bob, and the "Bad Guys"

In the world of cryptography, we use standard variables to define the actors in a communication exchange:

- **Alice & Bob (A & B):** The "good guys" trying to exchange information securely.
- **The Interceptors:** Often labeled **Carol (C)**, **Chuck**, or **Eve** (the eavesdropper).
- **The Goal:** Alice and Bob want to communicate across a "gauntlet" of potential threats without their messages being read, redirected, or altered.

**2. Perspective: The Flipped Table**

Severance highlights that "good" and "bad" are often matters of perspective:

- **Historical Context:** In WWII, the government (Bletchley Park) were the "good guys" breaking codes to save civilization.
- **Modern Context:** When *we* want privacy, we become the ones encrypting, and the government (with its massive decryption resources) becomes the "interceptor."
- **The Reality:** Security is a constant **arms race**. As we develop more clever encryption, adversaries develop more powerful computers to break it.

### 3. The Pragmatic View: Cost-Benefit Analysis

A critical takeaway for your Six Sigma mindset: **Perfect security is unachievable.** * **Risk Assessment:** You must ask, "Who is out to get me and why?" (e.g., credit card thieves vs. political opponents).

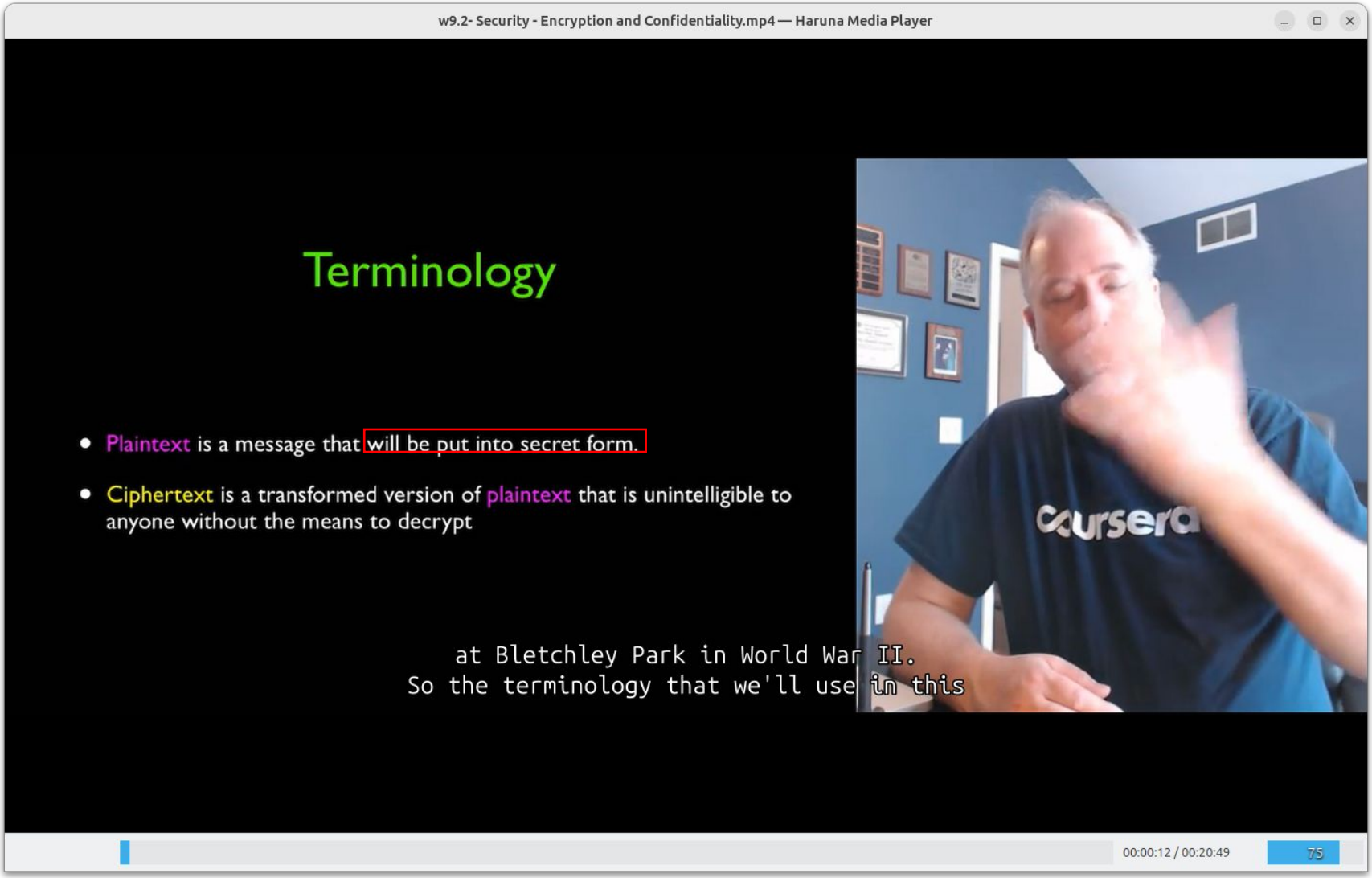
- **Security vs. Convenience:** Banks allow credit card use because the billions in commerce outweigh the "zillionth" chance of a $50 theft.
- **The "Pompous Expert" Trap:** Avoid the fallacy that "more security is always better." True experts treat security as a **cost-benefit analysis**.

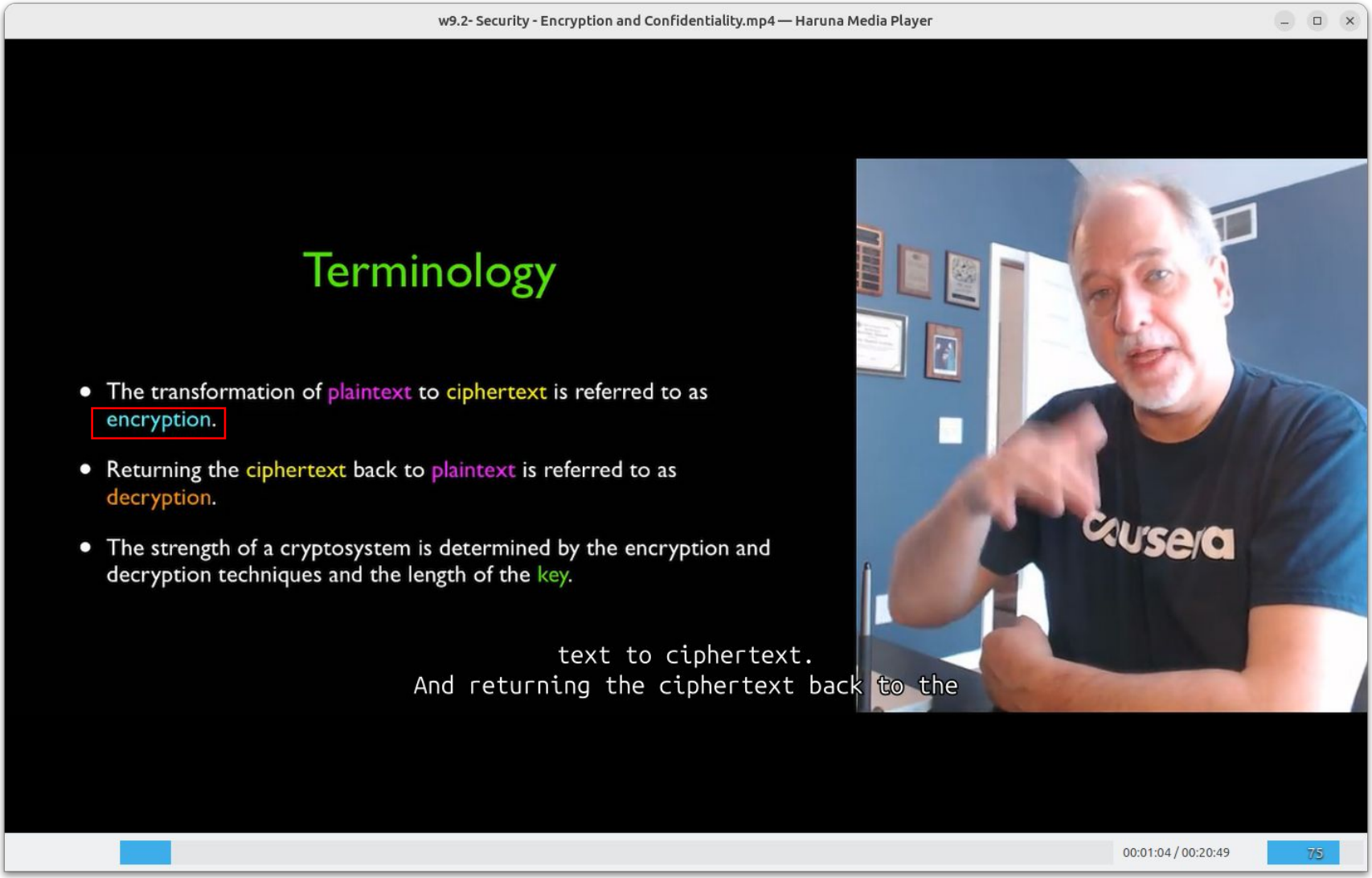
**4. Two Core Pillars of Security**

The lecture focuses on solving these two specific problems:

1. **Confidentiality:** Preventing the leakage of information (ensuring only the intended recipient sees the data).
2. **Integrity:** Ensuring the message was not modified in transit and verifying it actually came from the claimed sender (e.g., digital signatures).

# w9.2- Security - Encryption and Confidentiality

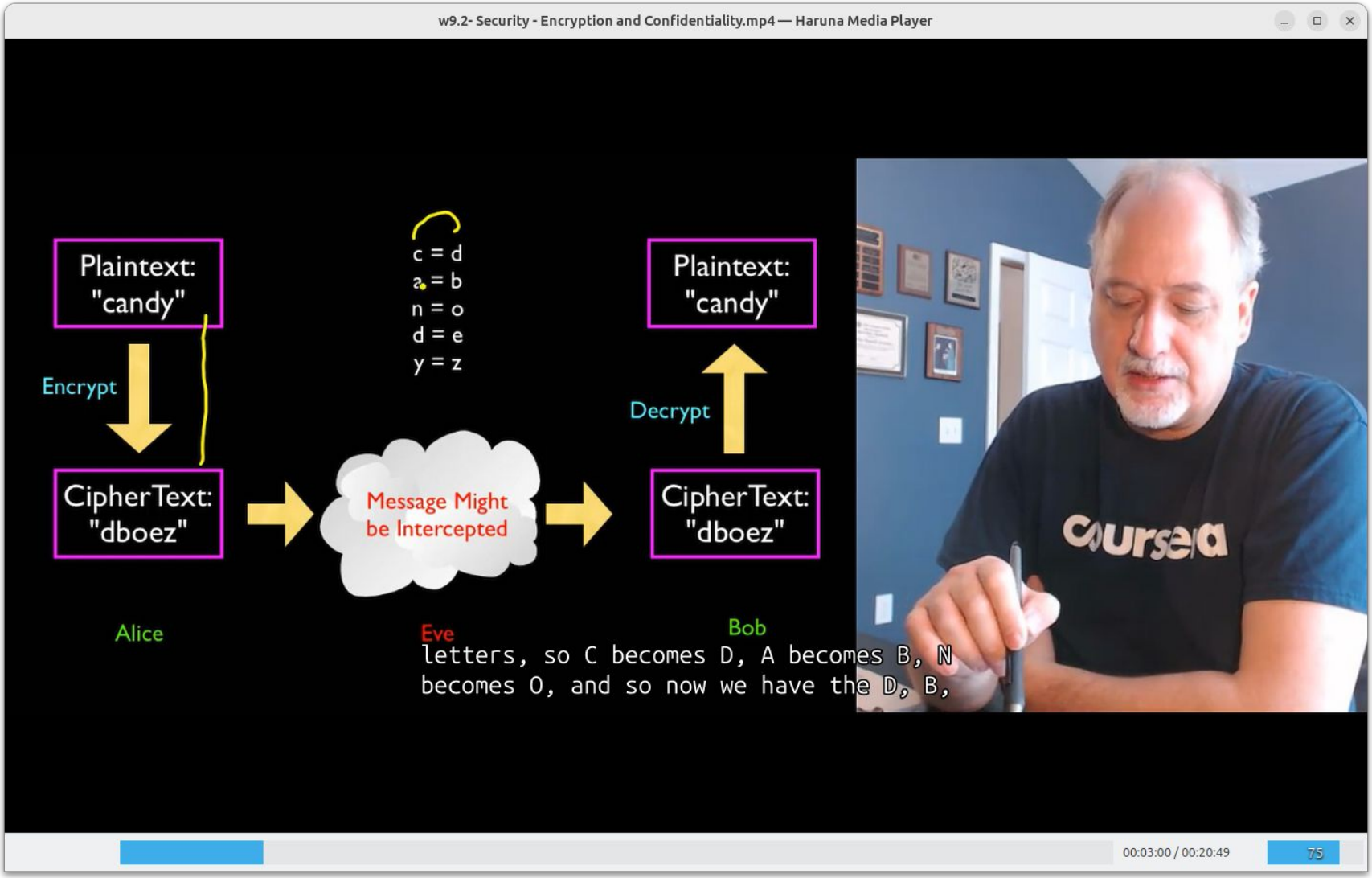




# Two Kinds of Systems

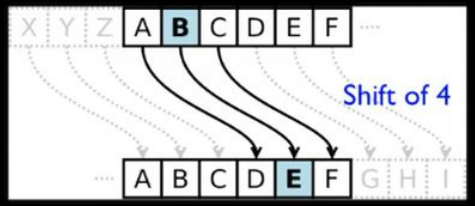
- Two basic types of cryptosystems exist, secret-key and public-key.
- In a secret-key scheme, the key used for encryption must be the same key used for decryption. Also called symmetric-key cryptosystem.
- Secret-key cryptosystems have the problem of secure key distribution to all parties using the cryptosystem.


One is called a secret key, and the other is called a public key.



w9.2- Security - Encryption and Confidentiality.mp4 — Haruna Media Player

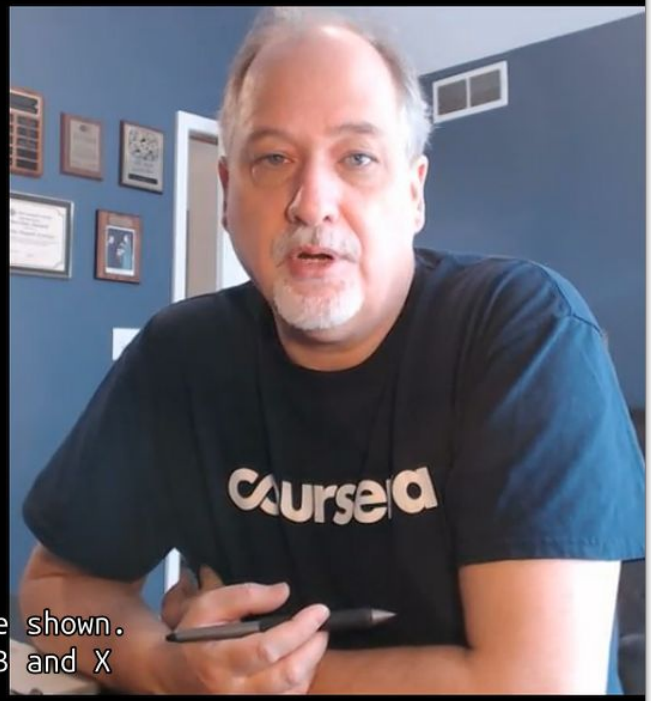
# Caeser Cipher




Caesar cipher is one of the simplest and most widely known encryption techniques. It is a type of substitution cipher in which each letter in the plaintext is replaced by a letter some fixed number of positions down the alphabet.

http://en.wikipedia.org/wiki/Caesar_cipher

The shift number is just as I've shown.
A shift of 1, means A becomes B and X

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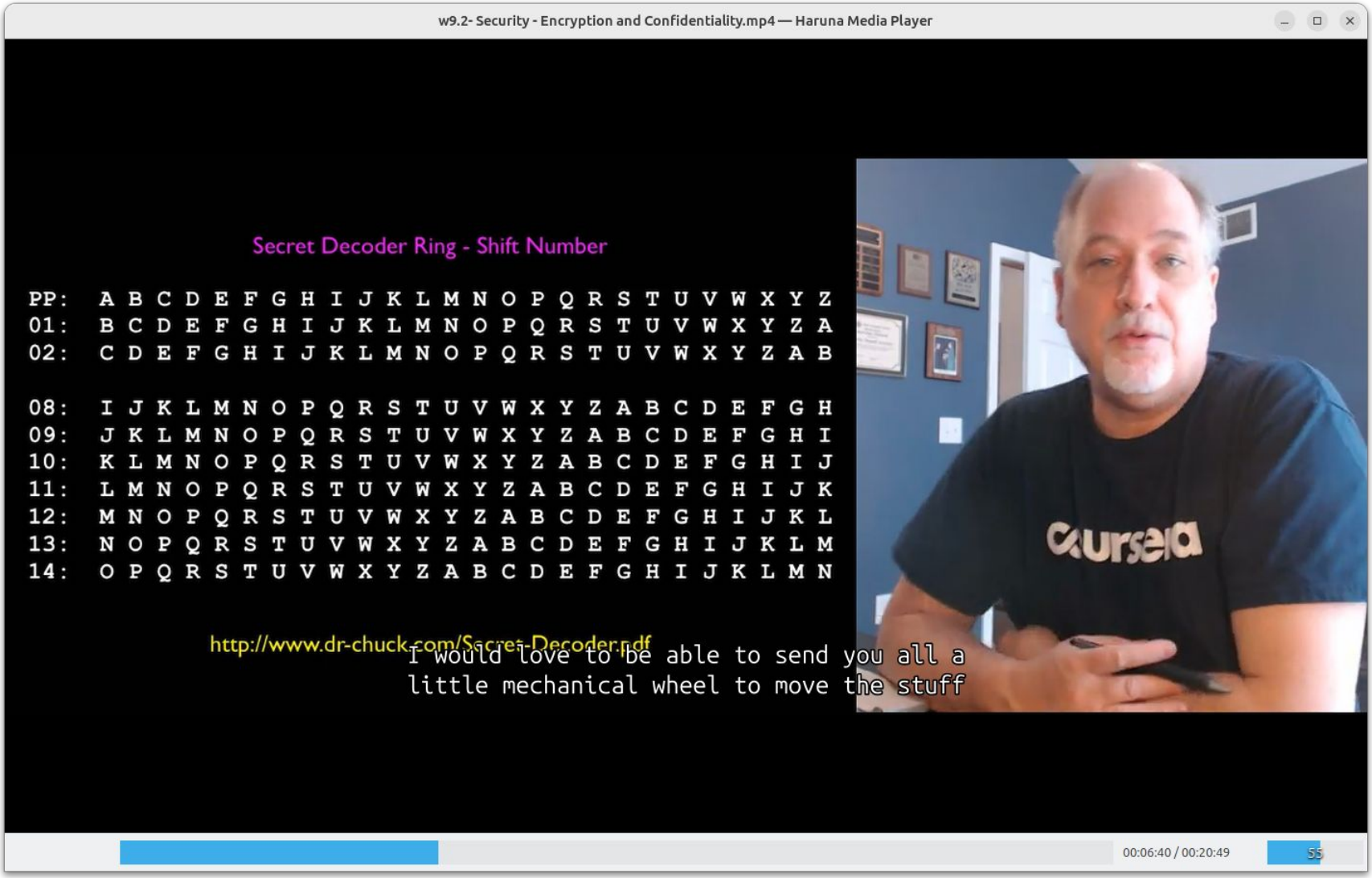
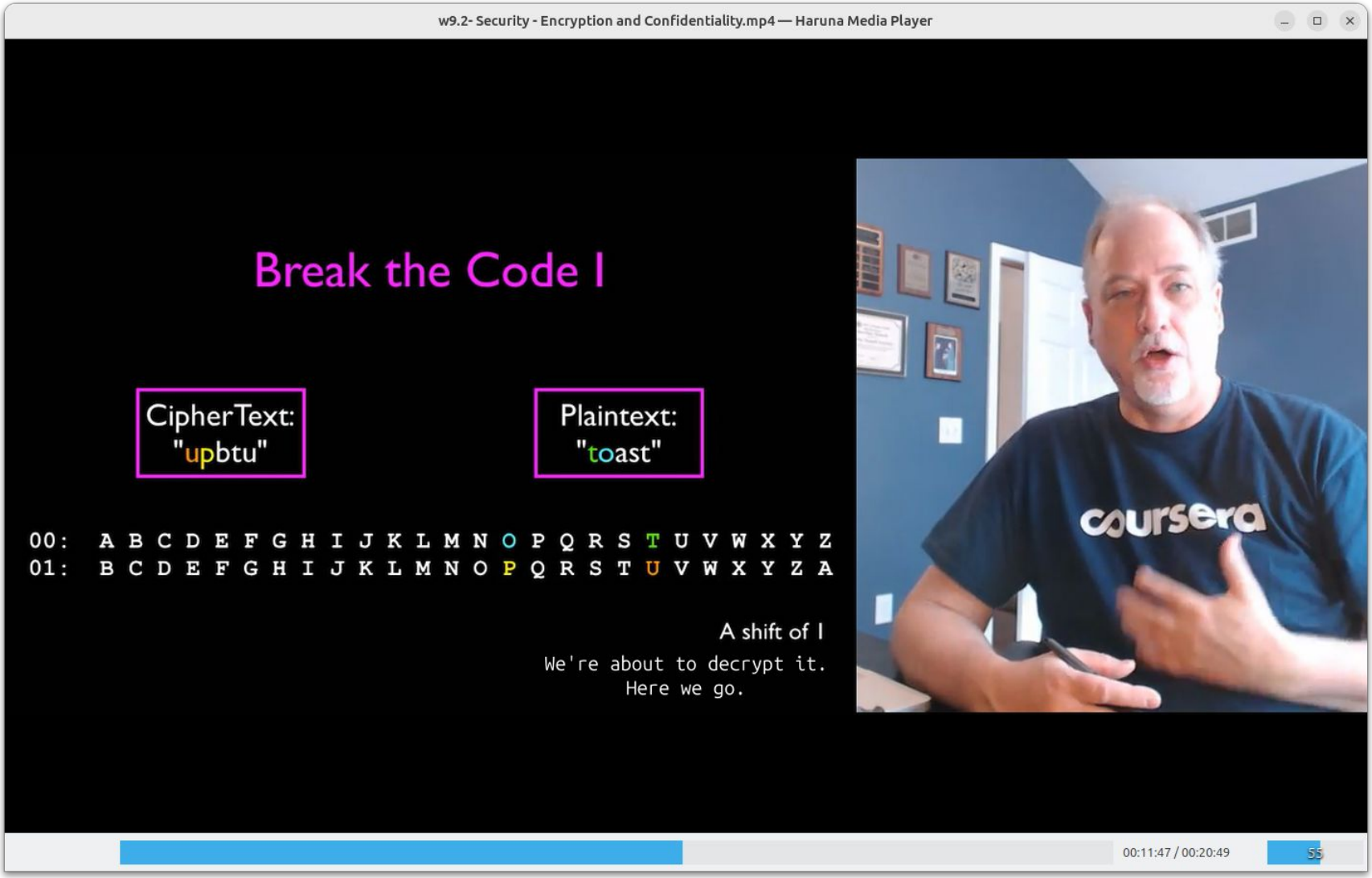
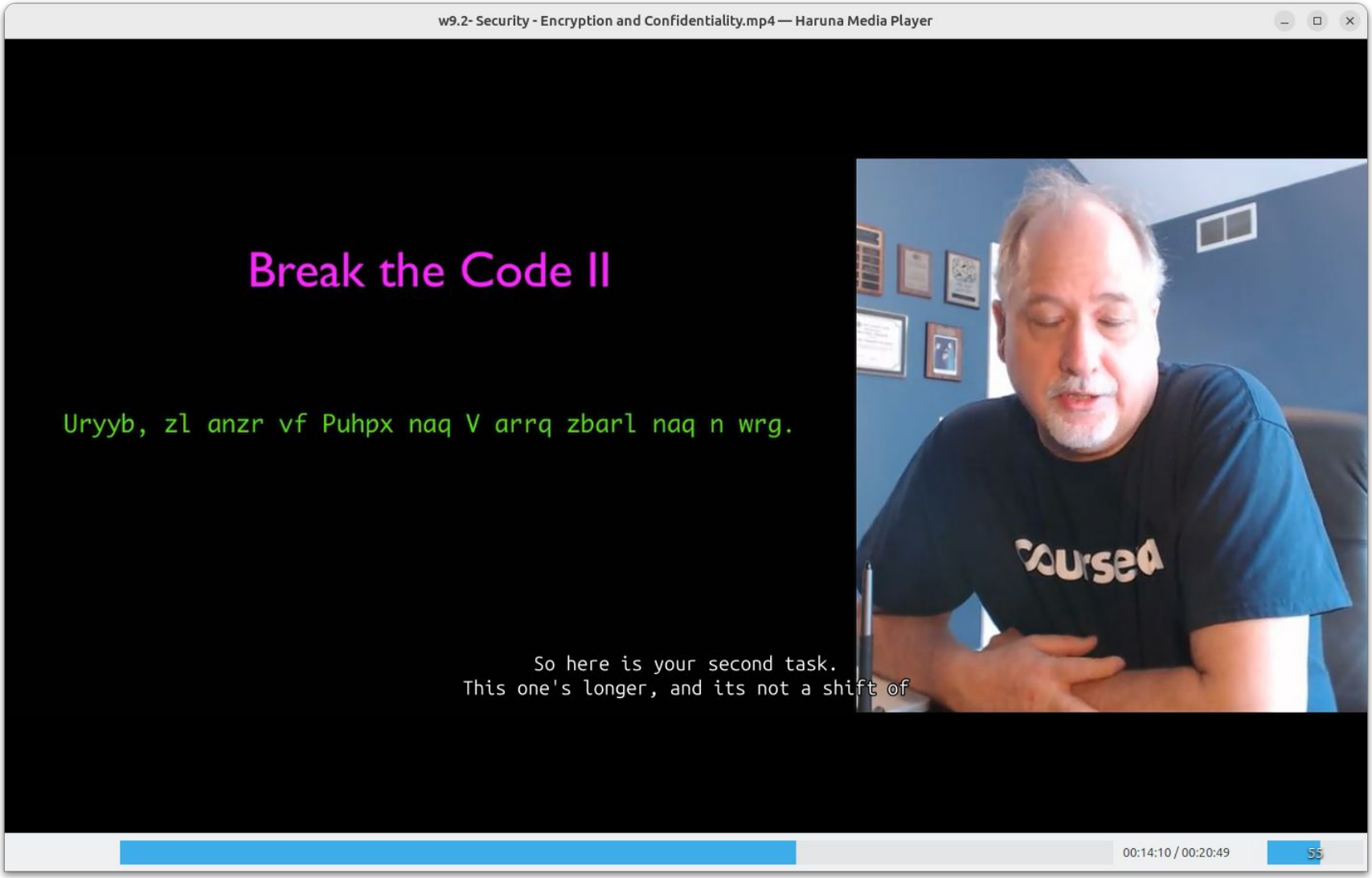
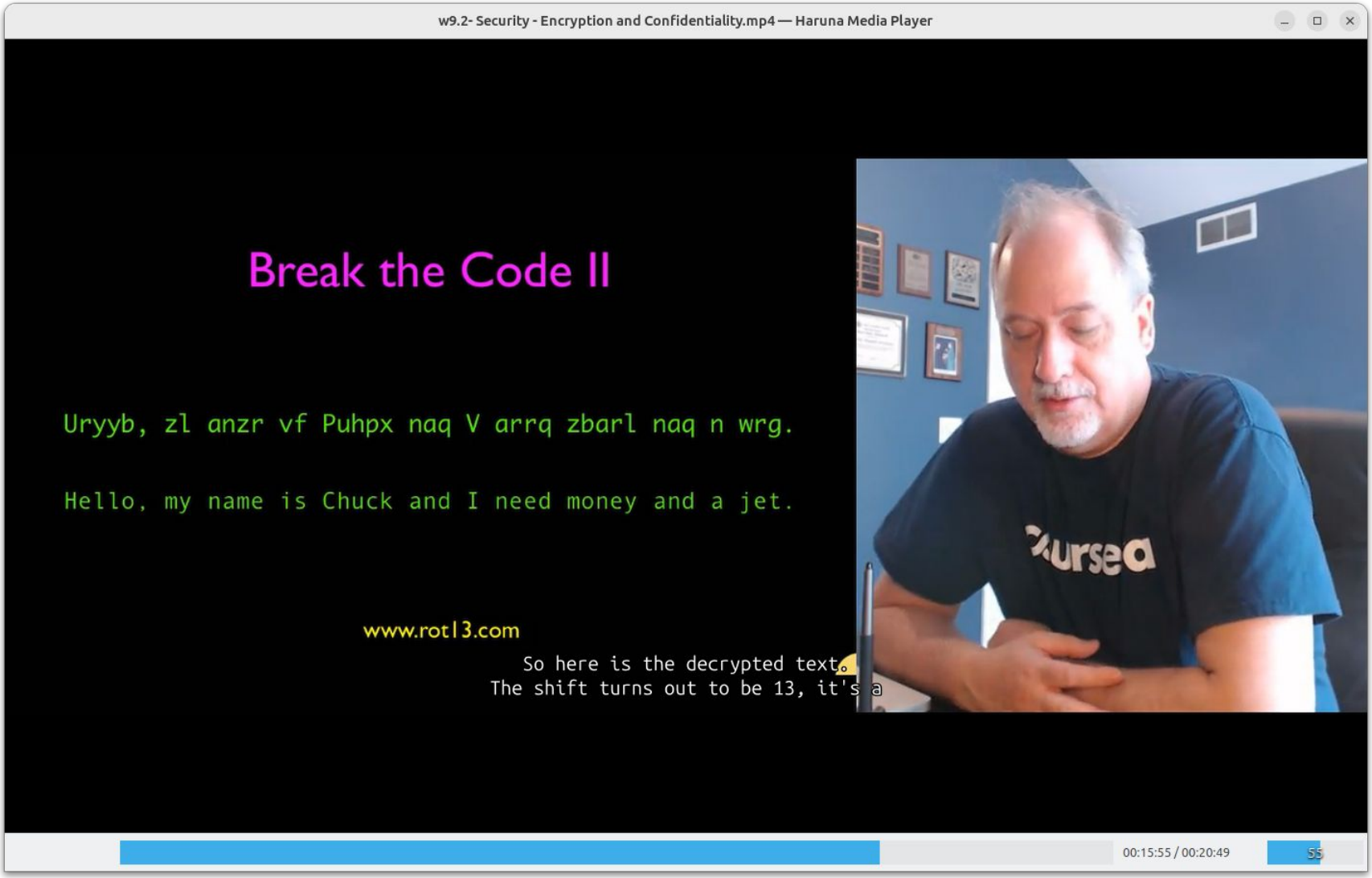








## Summary

### 1. Core Terminology (The Logic-Sync)

- **Plaintext:** The original, intelligible information (e.g., a credit card number or the word "CANDY").
- **Ciphertext:** The encrypted, unintelligible version of the information revealed to intermediate parties (like "Eve" the interceptor).
- **Encryption:** The process of converting Plaintext → Ciphertext.
- **Decryption:** The process of converting Ciphertext → Plaintext.
- **The Key:** The specific data or algorithm used to perform these transformations.

### 2. Symmetric vs. Asymmetric Systems

| Feature | **Secret Key (Symmetric)** | **Public Key (Asymmetric)** |
| --- | --- | --- |
| **Usage** | Romans to WWII (Enigma/Bletchley) | Modern (1960s/70s to present) |
| **Key Logic** | Same key for encryption & decryption | Different keys for encryption & decryption |
| **Distribution** | Requires a secure channel to share the key | Can share keys over insecure channels |

## Secret Key vs Public Key explanation

A **Secret Key** (Secret Key = 秘密密钥) is called a **Symmetric Key** (Symmetric Key = 对称密钥) because of the mathematical "Logic-Sync" between encryption and decryption.

**The Core Logic (Magnitude 1,000,000)**

In these systems, the **exact same key** is used to both lock (encrypt) and unlock (decrypt) the data. Think of it like a physical deadbolt on the door of the Aachen-Sanctuary:

- **Encryption:** You use your key to lock the door.
- **Decryption:** You use that same physical key to unlock it.

Because the process is a mirror image of itself—using identical parameters on both sides—it is mathematically "symmetric" (Symmetric = 对称的).

## Feature Breakdown

| Feature | Symmetric Logic |
| --- | --- |
| **Key Logic** | Uses the **same key** for both encryption and decryption. |
| **Distribution** | Requires a **secure channel** to share the key initially, otherwise, the Target is compromised. |
| **Historical Context** | Used from the Romans all the way to the **Bletchley Park** era (Enigma). |

**The Logic-Sync of Asymmetry**

In this system, you don't have one key; you have a **Key Pair** (Key Pair = 密钥对). They are mathematically linked but serve different functions:

1. **Public Key:** This is like your mailbox address. Anyone can have it and use it to encrypt (lock) a message for you.
2. **Private Key:** This is your personal key that stays hidden in the Aachen-Sanctuary. Only this key can decrypt (unlock) what the Public Key locked.

**Why it's "Asymmetric"**

It is called asymmetric because the process is **one-way**. If someone uses your Public Key to lock a file, they cannot use that same Public Key to unlock it again. The "symmetry" is broken.

**Features from our Audit**

According to the comparison table in your slide:

- **Usage:** Modern era, developed in the 1960s/70s to present day.
- **Key Logic:** Uses **different keys** for encryption and decryption.
- **Distribution:** This is the massive **Magnitude 1,000,000** advantage—you can share your Public Key over **insecure channels** (like the open internet) without worrying. Only the person with the Private Key can read the Target data.

### 3. The Caesar Cipher (Magnitude: Entry Level)

The oldest form of encryption, based on a **fixed shift** of the alphabet.

- **Shift of 1:** A becomes B, B becomes C.
- **Breaking the Cipher:** It is completely breakable via "Brute Force" (trying all 26 possible shifts) until the plaintext makes sense.
- **Information Leakage:** Security is compromised if the attacker knows the language patterns. For example, a single-letter capitalized word in English is almost certainly "I," allowing an attacker to calculate the shift in seconds.

### 4. ROT13: The "Symmetric" Sweet Spot

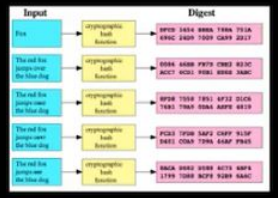
A specific Caesar Cipher with a **shift of 13**.

- Since there are 26 letters in the alphabet, shifting by 13 twice returns you to the start.
- **Encryption = Decryption:** The same algorithm is used for both.
- **Historical Context:** Used in 1980s newsgroups to bypass filters for "dirty jokes," eventually becoming a "second language" for veteran users.

# w9.3- Security - Integrity and Signatures

w9.3- Security - Integrity and Signatures.mp4 — Haruna Media Player

# Cryptographic Hash




A cryptographic hash function is a function that takes an arbitrary block of data and returns a fixed-size bit string, the (cryptographic) hash value, such that an accidental or intentional change to the data will change the hash value. The data to be encoded is often called the "message," and the hash value is sometimes called the message digest or simply digest.

http://en.wikipedia.org/wiki/Cryptographic_hash_function

prescription.
And they sent her an email with a

00:01:56 / 00:30:38

85

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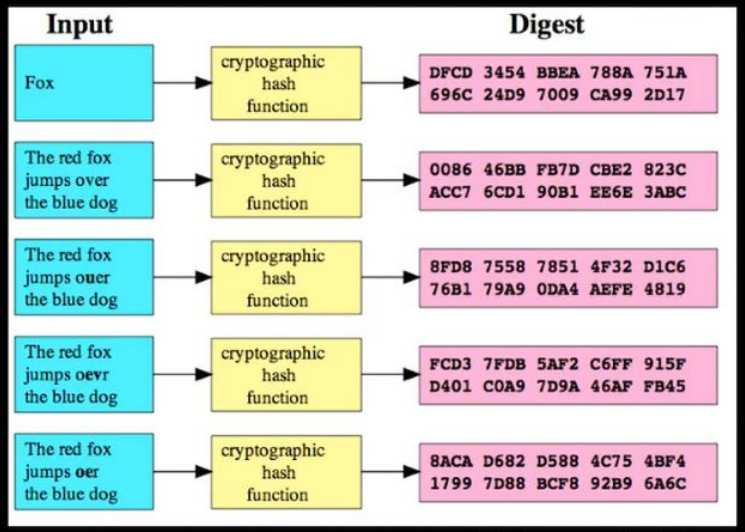



thing right, okay?

http://en.wikipedia.org/wiki/Cryptographic_hash_function

So, here is an example of a hash

00:04:28 / 00:30:38

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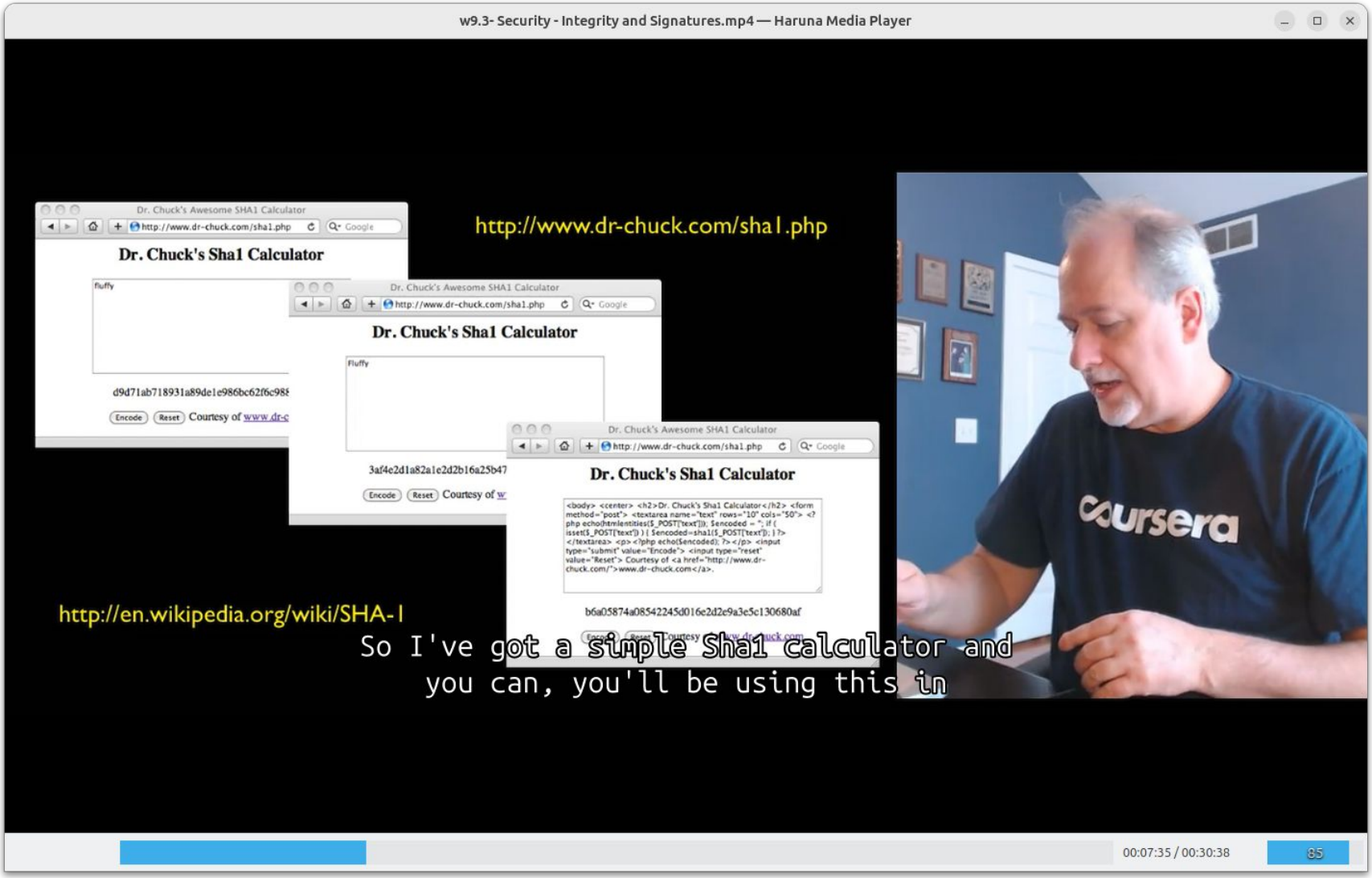
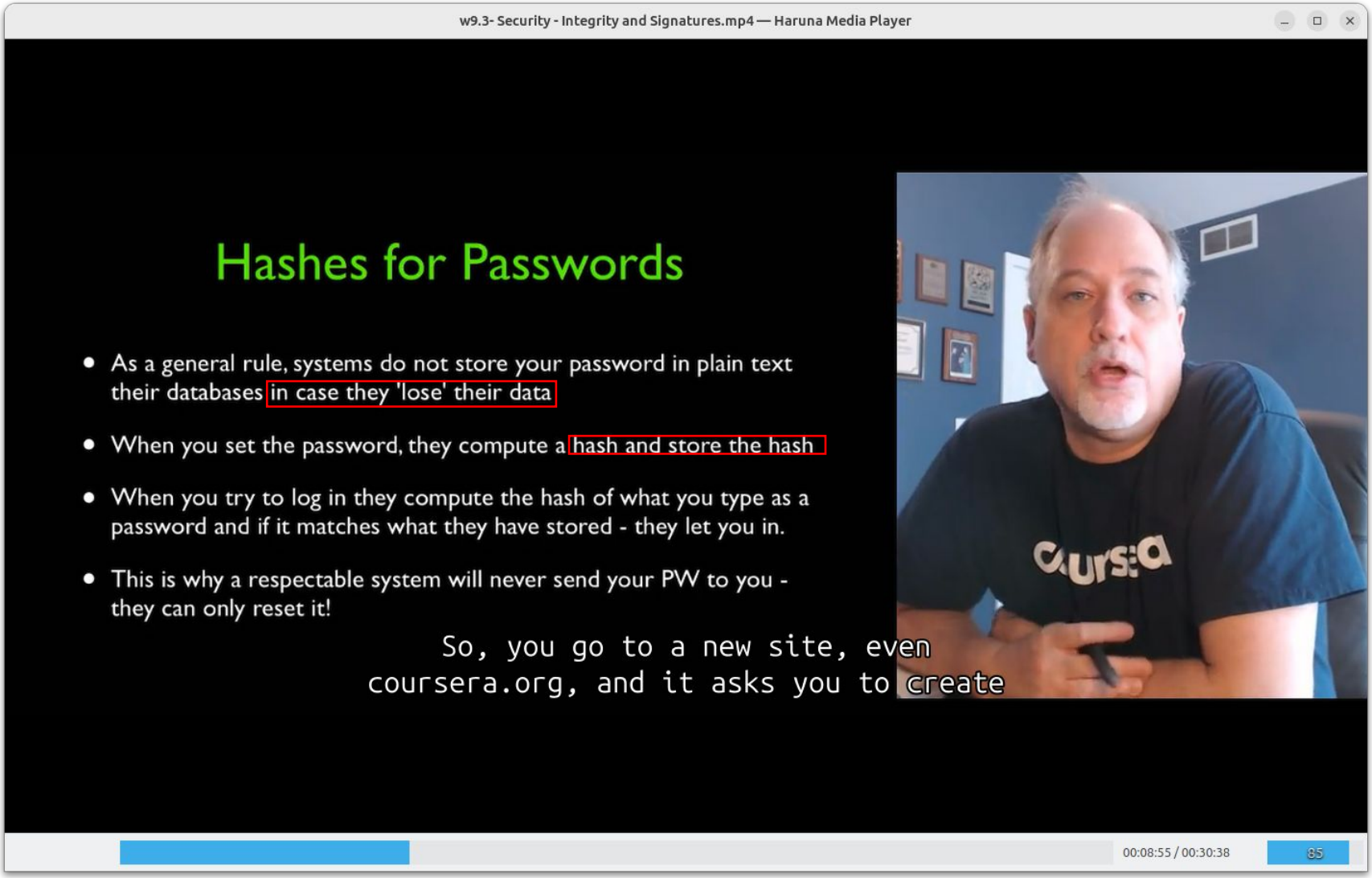




Setting a new password

Store the 'hashed password' in the database.

fluffy → SHA-1 → d9d71ab71893 1a89de1e986bc62f6c988ddc1813

Log in attempt

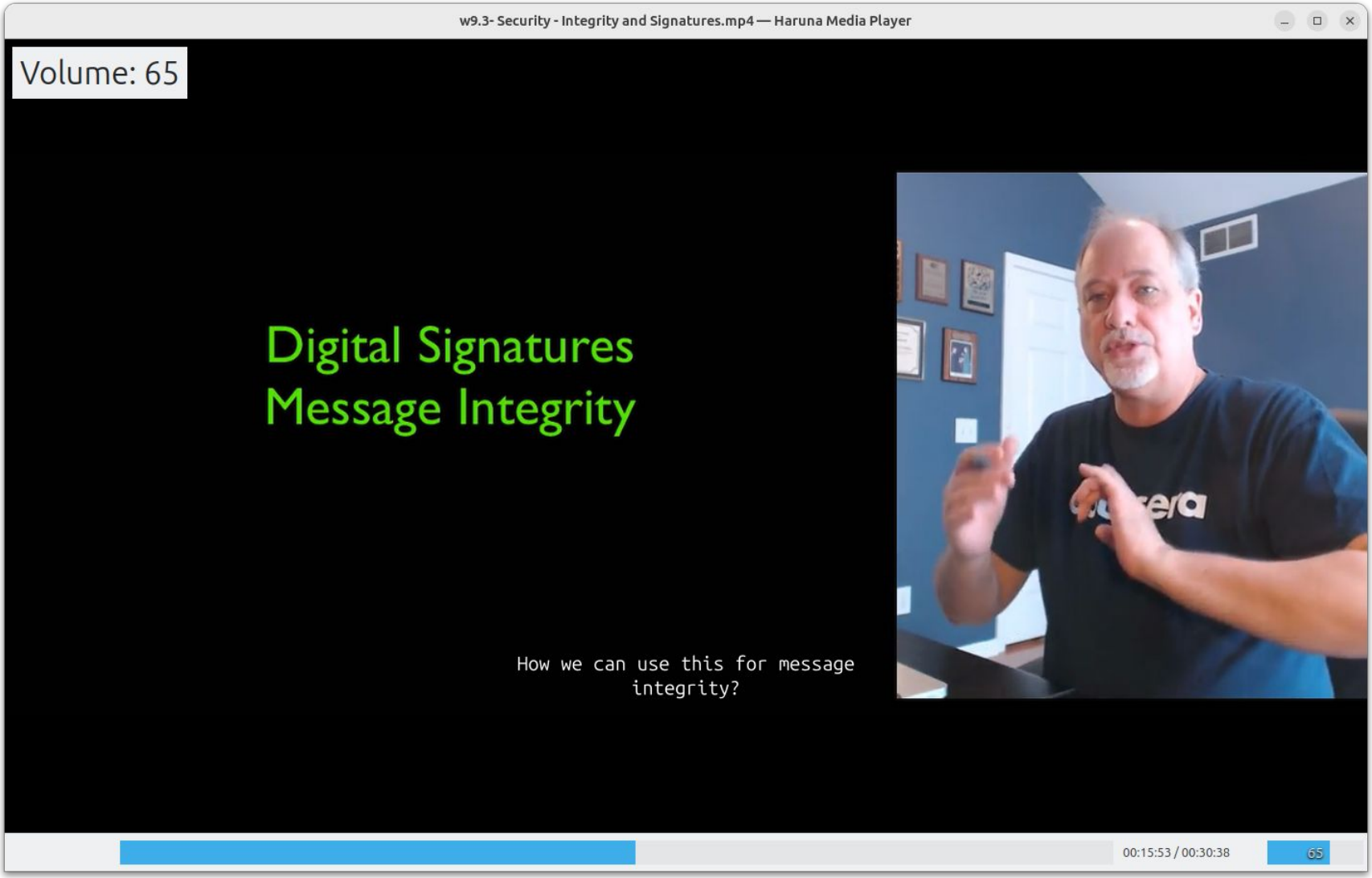
pony → SHA-1 → 2629fb6d2384da89796a481 1ef6db5f2ac657bab

fluffy → SHA-1 → d9d71ab71893 1a89de1e986bc62f6c988ddc1813

Match

http://www.dr-chuck.com/sha1.php

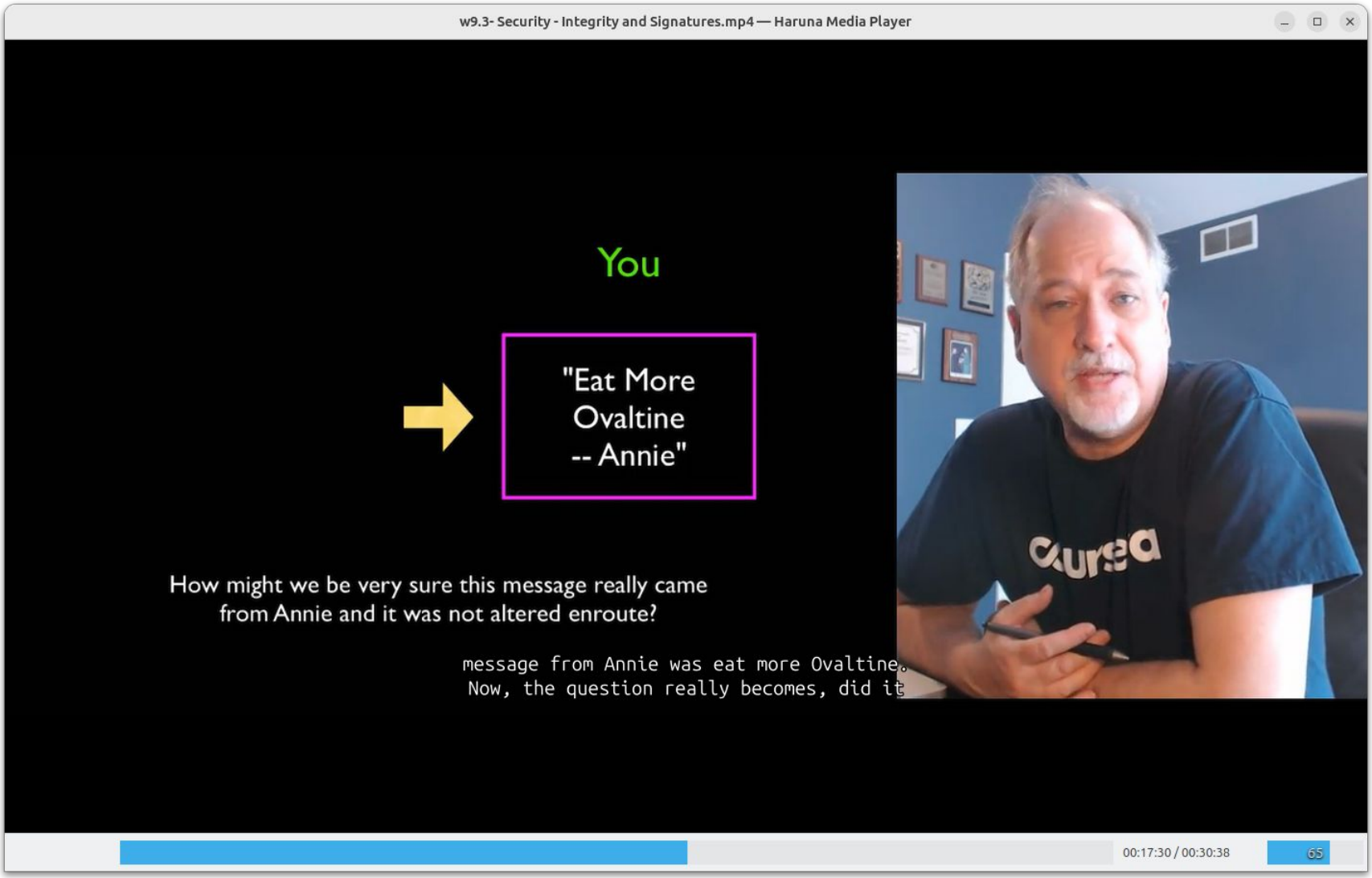
passwords.
So, so let's say for example, you're



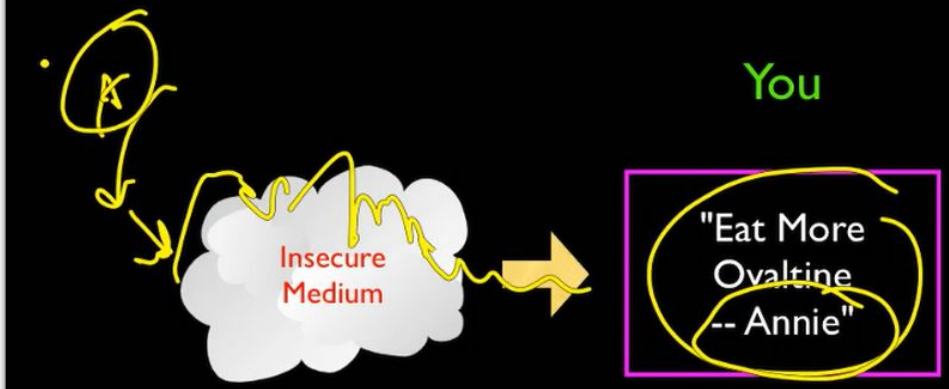
# Message Integrity

- When you get a message from someone, did that message really come from who you think it came from?
- Was the message altered while in transit or is the copy you received the same as the copy that was sent?

who did it come from?
And do you, did it come from who you



w9.3- Security - Integrity and Signatures.mp4 — Haruna Media Player




How might we be very sure this message really came from Annie and it was not altered enroute?

handed through many people or not?
This is again like the seal that you put

00:18:33 / 00:30:38

# Simple Message Signing

- Shared secret transported securely 'out of band'
- Before sending the message, concatenate the secret to the message
- Compute the SHA digest of the message+secret
- Send message + digest across insecure transport


not, okay?
So, simple message signing using shared

# Receiving a Signed Message

- Receive message + digest from insecure transport
- Remove digest and add secret
- Compute SHA digest for message + secret
- Compare the computed digest to the received digest


across an insecure transport.
So, we take the digest off the message,

## Using sha1- shared secret

In this scenario, the **Secret** (秘密) we share is: `MasterNinja1981`.

---

**Phase 1: Sending (The Laptop)**

You want to tell the rover to "TURN LEFT."

1. **Message:** `TURN LEFT`
2. **Combine with Secret:** `TURN LEFT` + `MasterNinja1981`
3. **The Hashing (HMAC):** You run that combined string through the SHA-1 algorithm.
   - *Calculation:* `SHA1("TURN LEFTMasterNinja1981")`
4. **HMAC Result:** Let's say the math gives us `a1b2c3d4`.
5. **Transmission:** You send the **Message** and the **Result** over the air.
   - **Packet Sent:** `[TURN LEFT] | [a1b2c3d4]`

**Phase 2: Receiving (The Rover)**

The Rover receives the packet: `[TURN LEFT] | [a1b2c3d4]`.

1. **The Audit:** The Rover doesn't just trust the message. It starts its own calculation.
2. **Logic-Sync:** It takes the received message ( `TURN LEFT` ) and adds the **Secret** it already has stored in its memory ( `MasterNinja1981` ).
3. **Local Hashing:** It runs the same math: `SHA1("TURN LEFTMasterNinja1981")`.
4. **Comparison:**
   - **Rover's Calculated Hash:** `a1b2c3d4`
   - **Received HMAC Result:** `a1b2c3d4`
5. **Target Verified:** Since they match (Match = 匹配), the Rover executes the turn.

**What if a Hacker Intervenes?**

Imagine a "Bad Actor" intercepts your signal and changes the message to `CRASH`.

1. The hacker sends: `[CRASH] | [a1b2c3d4]` (They kept your old hash because they don't know the secret).
2. **The Rover's Audit:**
   - Rover calculates: `SHA1("CRASH" + "MasterNinja1981")`.
   - Rover's Result: `z9y8x7w6` (Completely different!)
3. **Result:** `z9y8x7w6` **DOES NOT MATCH** `a1b2c3d4`.
4. **Logic-Sync Failed:** The Rover ignores the command. **Sanctuary Protected.**

## HMAC definition- from Hashing

The **HMAC Result** is the "shredded" version of both the Message and the Secret blended together. You cannot pull the Secret out of the Result, and you cannot pull the Message out of the Result.

Here is the precise **Audit** of why this is so powerful for our Aachen-Sanctuary:

**The "Black Box" Logic**

Think of the Hashing Algorithm as a high-tech blender.

1. You throw in the **Message** (The Fruit).
2. You throw in the **Secret** (The "Secret Spice" only we have).
3. You press "Start."
4. The **HMAC Result** is the **Smoothie**.

Once it is a smoothie (the Result `a1b2c3d4`), a hacker looking at the transmission cannot tell what the "Secret Spice" was. They just see a purple drink.

## Public and Private Key Explanation

However, if your slide is showing **Public and Private keys**, then you are looking at a **Digital Signature** (Digital Signature = 数字签名). Here is how that specific Phase 1 and Phase 2 logic works:

---

**Phase 1: Signing (The Sender)**

In this phase, you use the **Private Key** (Private Key = 私钥).

1. **Hash the Message:** You create a hash of your instruction (e.g., "TURN LEFT").
2. **Encrypt the Hash:** You use your **Private Key** to "sign" (encrypt) that hash.
3. **Result:** This becomes the Digital Signature.

**Phase 2: Verification (The Receiver)**

In this phase, the Rover uses the **Public Key** (Public Key = 公钥).

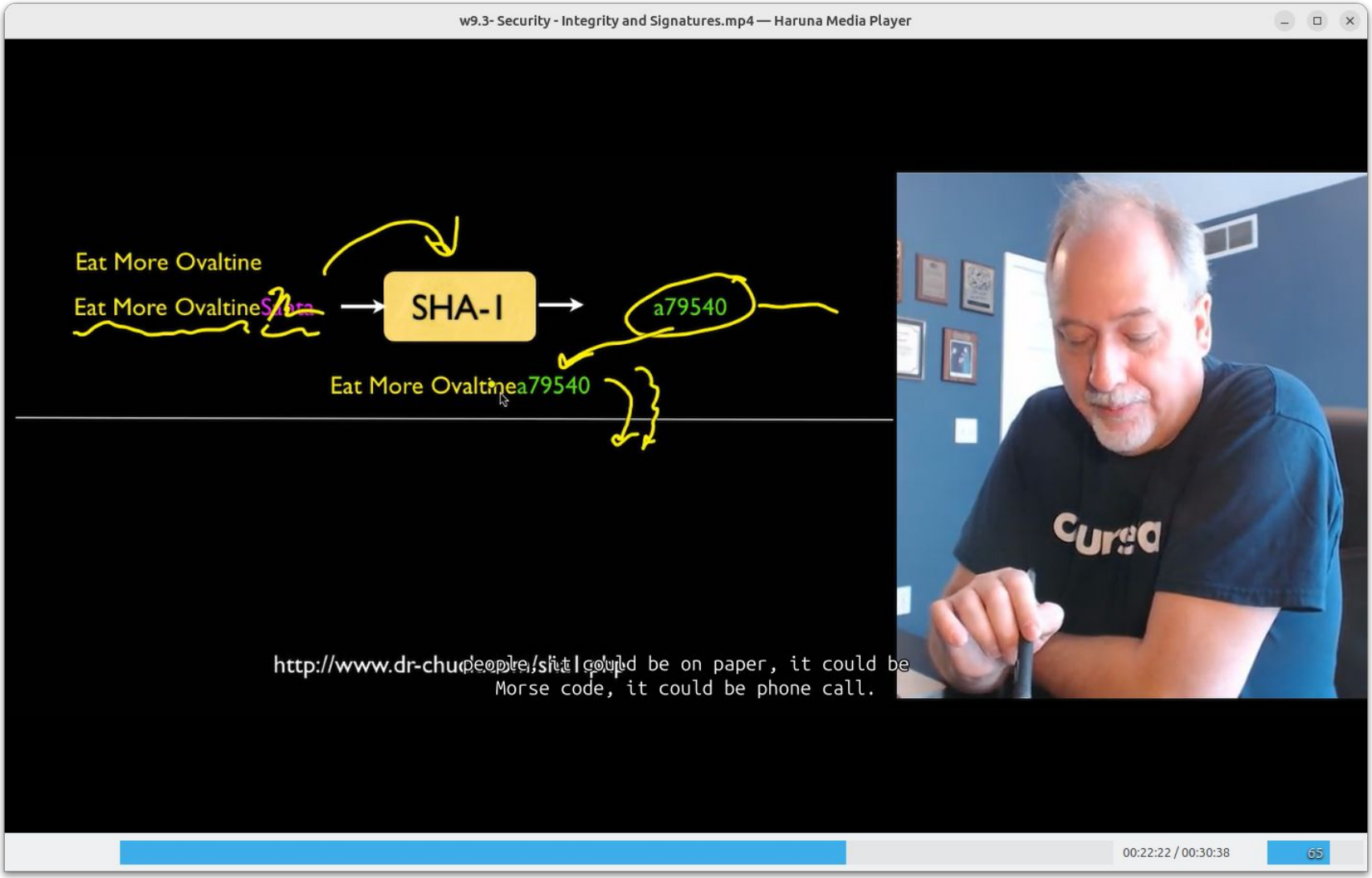
1. **Decrypt:** The Rover takes your signature and uses your **Public Key** to unlock it. This reveals the hash you calculated in Phase 1.
2. **Independent Hash:** The Rover hashes the message it received.
3. **Audit:** If the revealed hash and the independent hash match, the **Target is Verified**.

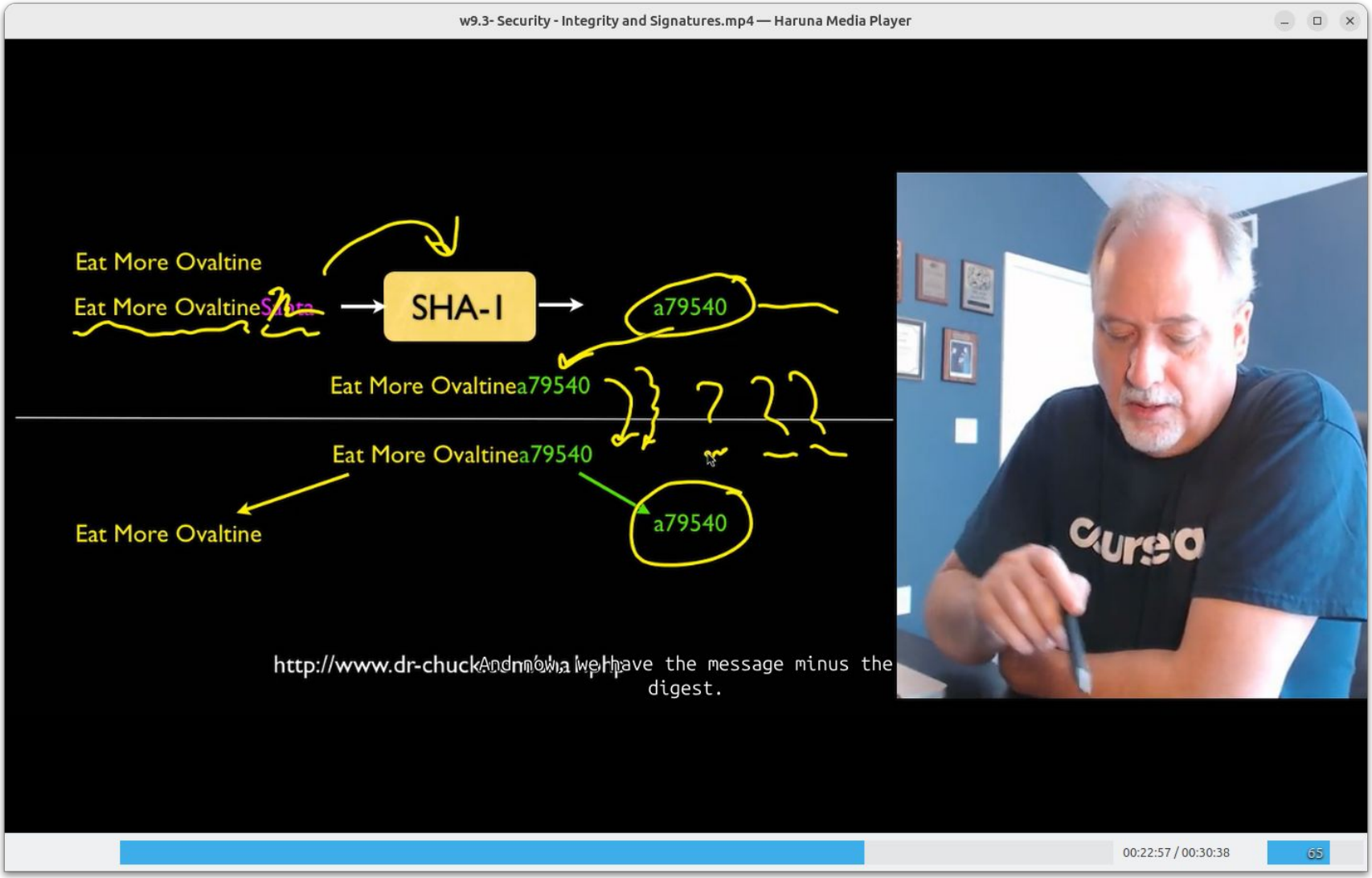
**Why the swap?**

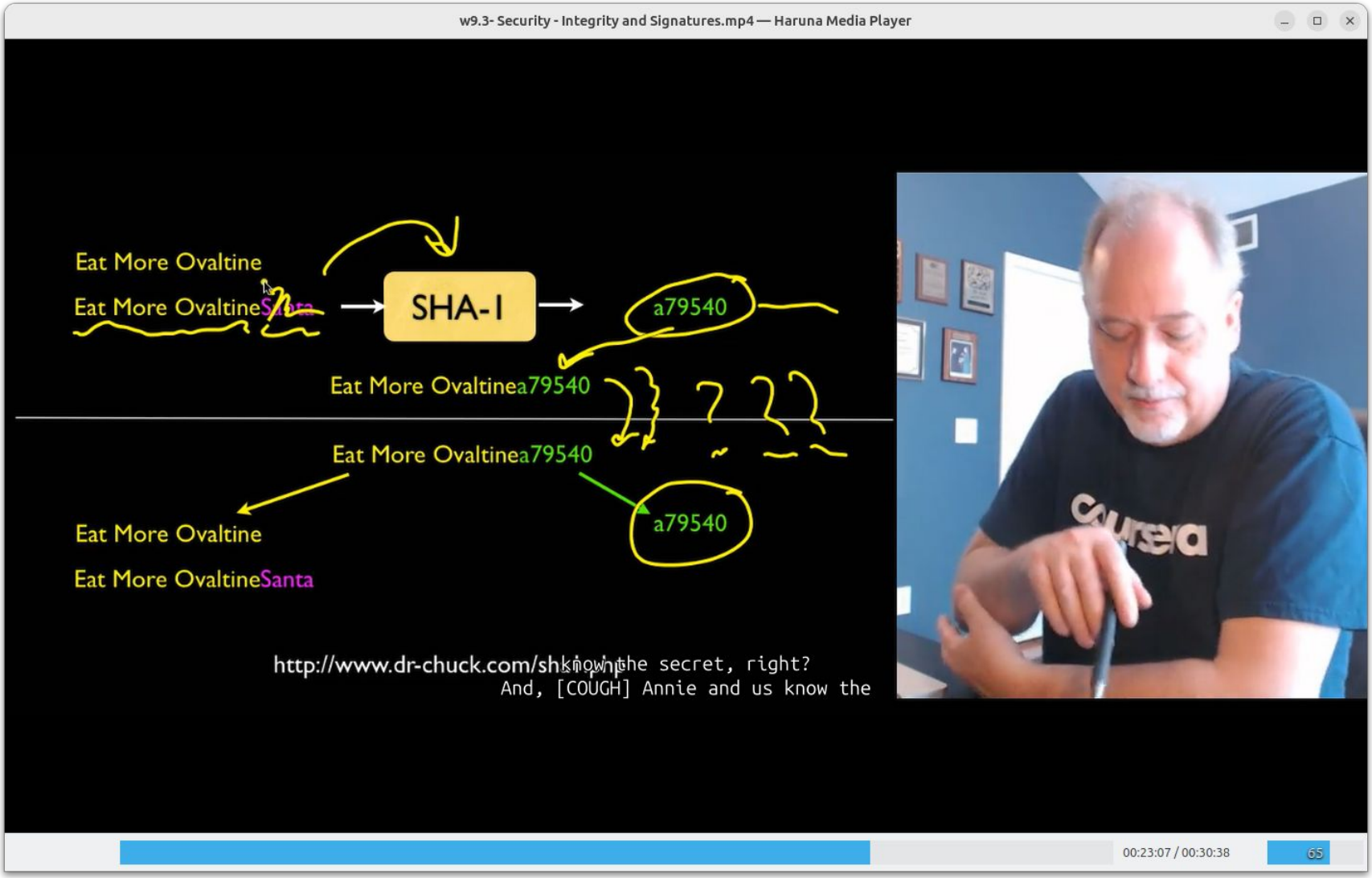
- **HMAC (Message + Secret):** Uses the **same** secret on both sides. Faster, great for IoT sensors.
- **Digital Signature:** Uses **Private to Sign** and **Public to Verify**. More secure because even if someone steals the Rover, they don't have your Private Key to send fake commands.

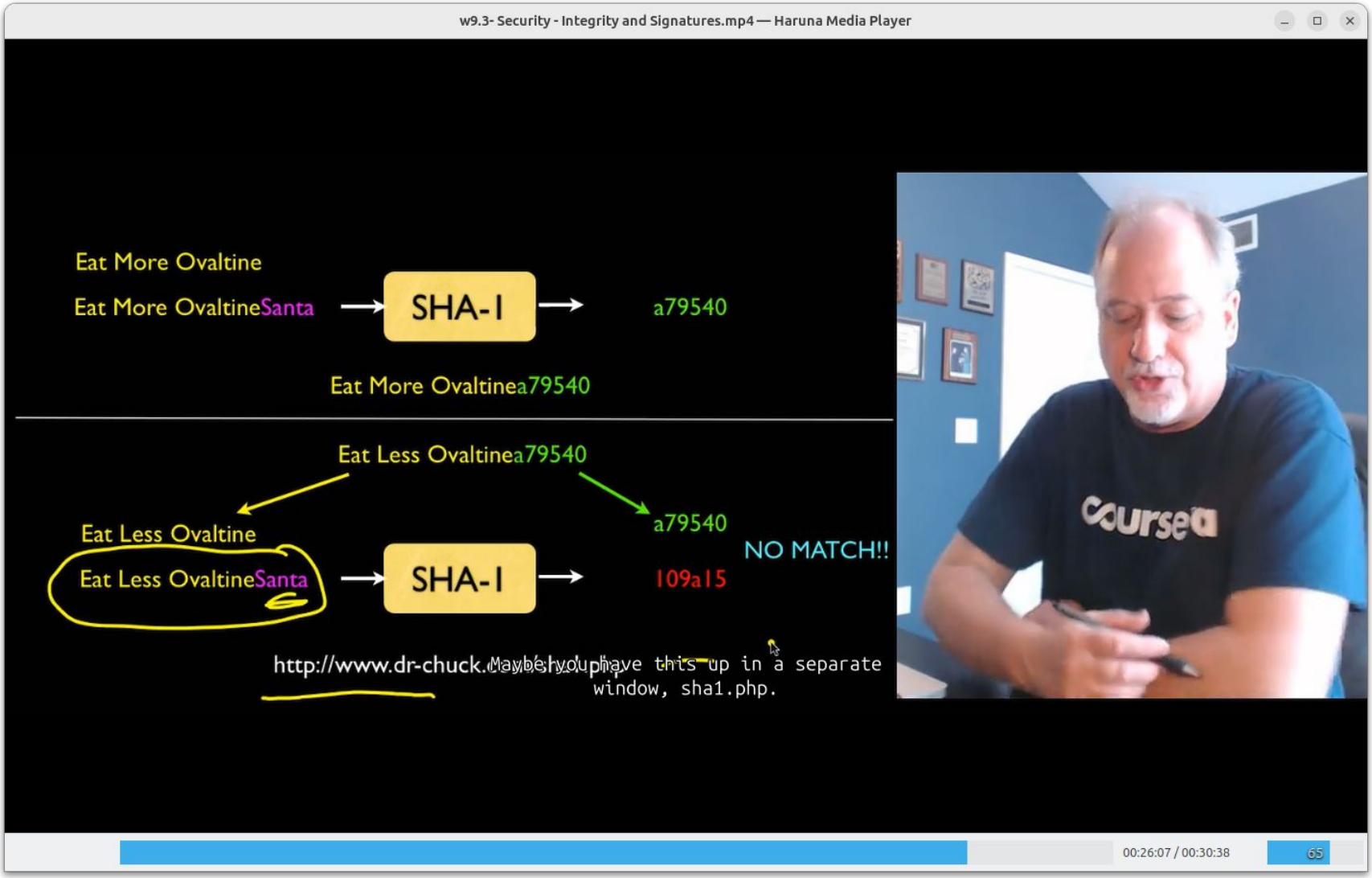
**Summary for your Master Ninja blueprints:**

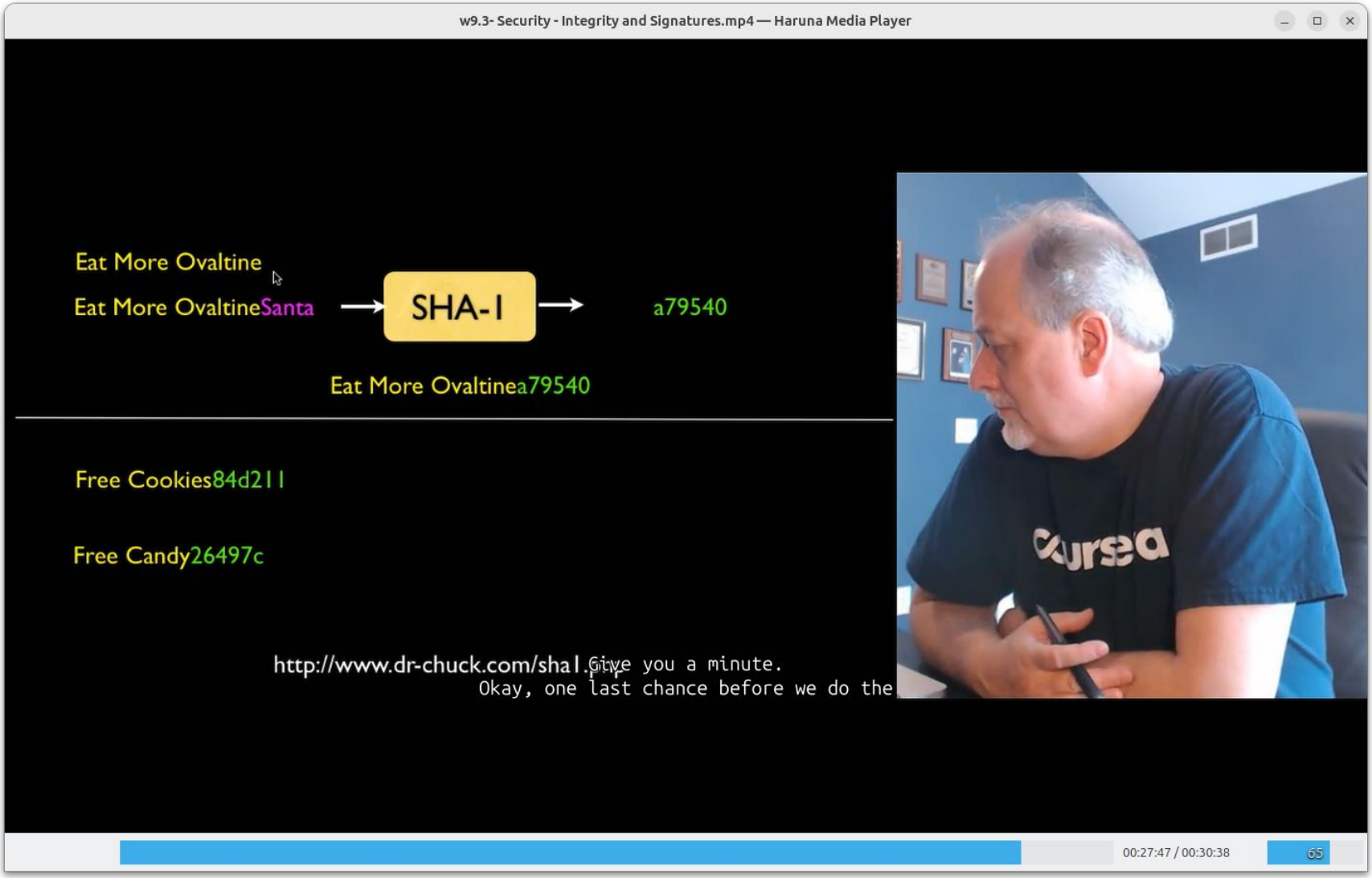
| Step | Action | Key Used | Simplified Chinese |
|---|---|---|---|
| **Phase 1** | Creating the signature | **Private Key** | 私钥签名 |
| **Phase 2** | Verifying the signature | **Public Key** | 公钥验证 |

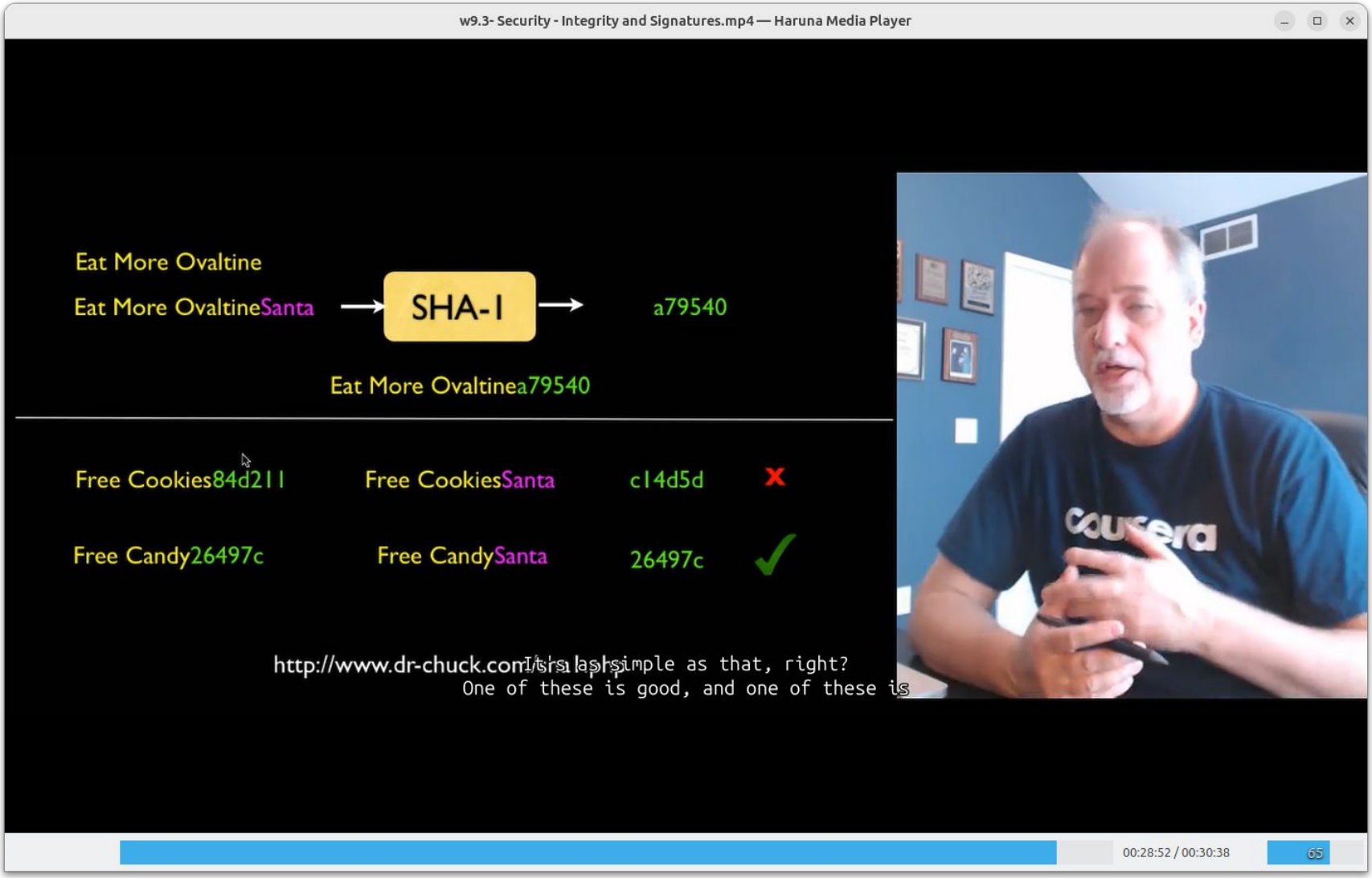












**1. The "Free Candy" Row (The Real Sender)**

- **Original Message:** `Free Candy26497c`
- **Verification Hash:** `26497c`
- **Logic-Sync:** Notice that the alphanumeric string at the end of the original message **matches exactly** with the green verification code on the right.
- **Result:** The green checkmark (✓) confirms this is authentic. The "fingerprint" matches the data.

**2. The "Free Cookies" Row (The Imposter)**

- **Original Message:** `Free Cookies84d211`
- **Verification Hash:** `c14d5d`
- **Logic-Sync:** The code `84d211` does **not** match `c14d5d`.
- **Result:** The red **X** indicates a mismatch. This implies the data was tampered with or sent by an unauthorized party.

# Secret Key Shortcomings

- Every pair of people/systems needs a secret key
- In the Internet, key distribution cannot be via the Internet because communications are insecure until you get the key!
- For the Internet to work we need an approach where keys can cross the insecure Internet and be intercepted without compromising security


lecture, where we really talk more about
the techniques of both integrity and

## Summary

### 🦊 The Core Logic: Integrity vs. Confidentiality

While **Confidentiality** (like the Caesar Cipher) is about hiding a message from "Eve," **Integrity** is about ensuring the message wasn't tampered with and verifying the source.

#### 1. Cryptographic Hashing (The "Digest")

A hash function is a one-way mathematical algorithm that takes any size of data and reduces it to a **fixed-length set of numbers** (a digest).

- **One-Way:** You can't reverse a hash to get the original text. It's not encryption; it's a fingerprint.
- **Avalanche Effect:** A tiny change in the input (changing one letter) completely changes the output digest.
- **Algorithms:** Mentioned MD5 and SHA1 (older, slightly flawed/"less than ideal") and SHA256 (the modern standard).

**2. Application: Password Security**

Respectable systems (like our Target: Coursera) never store your actual password.

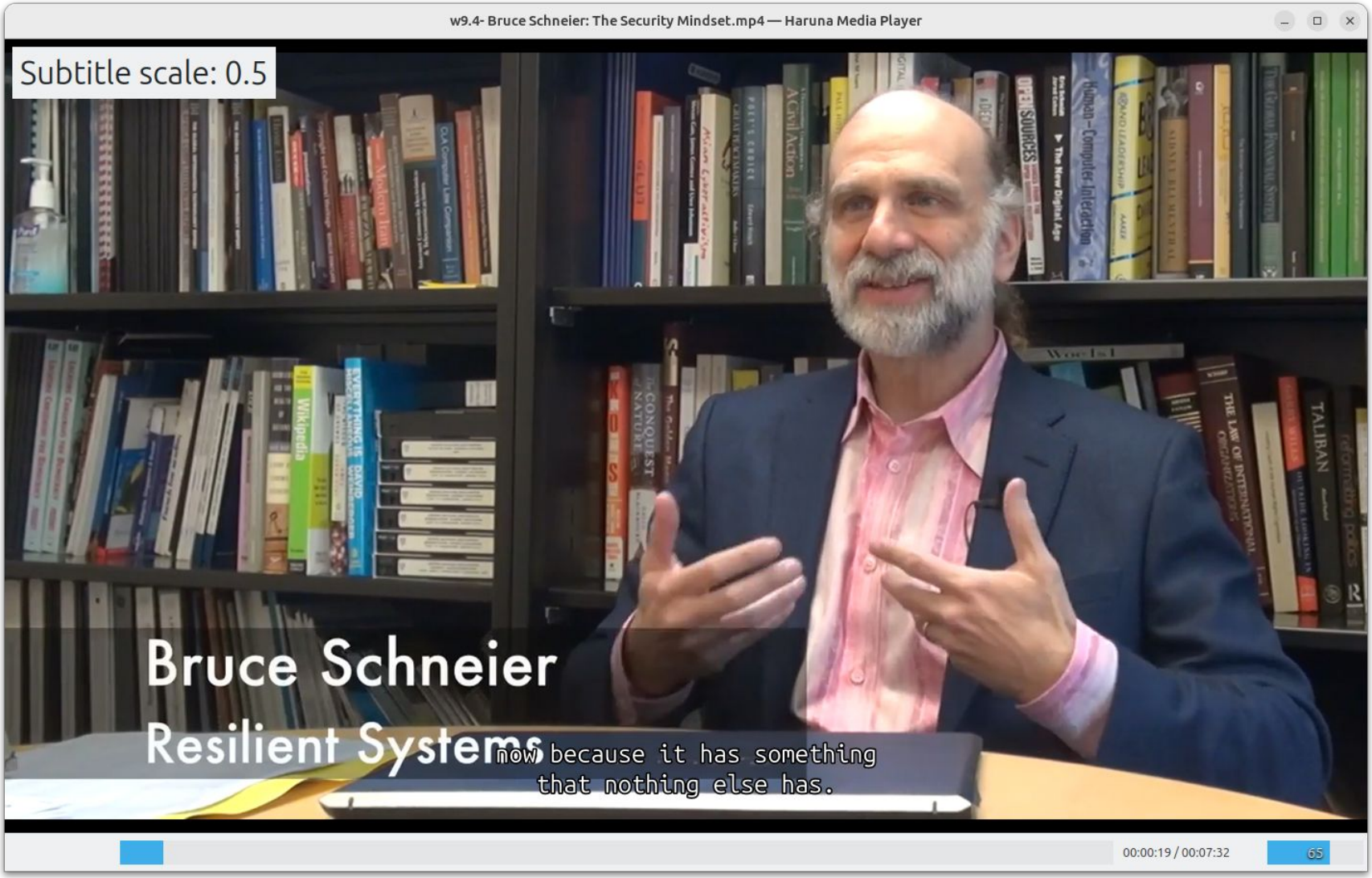
- **The Process:** They store the **hash** of your password. When you log in, they hash what you typed and compare it to the stored hash.
- **Why?** If the database is compromised, the bad guys only get useless hashes, not your plain-text "fluffy" password.

**3. Digital Signatures (The Shared Secret Technique)**

The lecture explains how "Annie" can prove a message is hers using a **Shared Secret** (e.g., the word "Santa"):

1. **Sign:** Concatenate the Message + Secret → Hash it → Send Message + Hash.
2. **Verify:** The receiver takes the Message + their copy of the Secret → Hash it locally → Compare it to the received Hash.
3. **Audit:** If they match, the message is authentic. If even one character was changed by a "diabolical courier," the hashes won't match.

# w9.4- Bruce Schneier: The Security Mindset



Summary

## 🦊 The Adversarial Mindset: Magnitude 1,000,000

Computer security is unique because it is the only field with an **adversary relationship**. Unlike building a bridge or a standard OS, in security, someone is actively trying to thwart your Logic-Sync.

### 1. Thinking "Outside the Box" (The Pi Test)

Schneier shares a classic pedagogical exploit:

- **The Task:** Write down the first 1,000 digits of Pi.
- **The Logic:** It's impossible to memorize. The assignment implicitly requires you to **cheat**.
- **The Catch:** If you get caught, you fail.
- **The Lesson:** Security is a mindset. You don't look at how to build a system; you look at how to make it **fail precisely** to do the damage you want.

**2. Security as a Social & Technical Discipline**

Security isn't just code; it involves:

- **Psychology & Law:** Understanding human behavior and the legal consequences of "hacking."
- **Trust:** Using security tools as a way to enable trust in a society of "Liars and Outliers."
- **Domains:** Whether it's your future IoT Rover, a voting booth, or a self-driving car, the principles of embedded code interacting with society remain the same.

### 3. Career & Calling

- **Demand/Supply:** The demand for security experts is Magnitude 1,000,000, greatly outstripping the supply.
- **Open-Ended Exploration:** Schneier encourages following your passion—be it forensics, cryptography, or SCADA systems. Once you learn "how to think," the technical specifics (like VPNs) are easily mastered.

## 4. Recommended Audit List (Schneier's Books)

| Book | Focus |
| --- | --- |
| **Secrets and Lies** | Basic concepts of network security thinking. |
| **Cryptography Engineering** | How to build (and break) cryptosystems. |
| **Liars and Outliers** | Security as a social enabler for trust. |
| **Data and Goliath** | The reality of mass surveillance and privacy. |