Biometric Liveness Detection: Framework and Metrics

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Non-Subversive Presentation

Live Capture Subject

Subversive Presentation*

ARTIFICIAL

Artefact
(e.g., fake finger, patterned contact, face photo)

HUMAN

Cadaver
(e.g., dismembered fingers)

Altered
(e.g., mutilated finger, surgical alteration)

Nonconformant
(e.g., facial expression changes, side of finger)

Conformant
(e.g., zero-effort attack)

Coerced
(e.g., unconscious)

**Some cases may also not be deliberate attacks (e.g., patterned contact for cosmetic reasons, non-conformant due to improper use of system, etc.)*

A detection system cannot infer intent, therefore, is called* ***Suspicious Presentation Detection System*

Introduction—Definitions

- **Subversive Presentation**
  - Presentation of human or artificial biometric characteristics to the biometric capture subsystem in a fashion that interferes with or undermines the correct or intended policy of the biometric system.
- **Suspicious Presentation**
  - Presentation of a human or artificial characteristic to the biometric capture subsystem in a fashion that could interfere with the intended policy of the biometric system
- **Suspicious Presentation Detection (SPD)**
  - Automated determination of a suspicious presentation.
- **Examples of SPD**
  - Liveness detection failure
  - Artefact detection
  - Altered biometric detection
  - Others terms that have been used: anti-spoofing, biometric fraud, spoof detection, authenticity detection, etc.

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Also helps with this

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Evaluation of suspicious presentation detection systems

- The ability to correctly identify suspicious presentation attacks is quantified by a dedicated set of performance metrics
- The suspicious presentation detection error rates are defined based on the specific purpose of the suspicious presentation detection module:
  - E.g., live vs non-live, altered vs non-altered, artefact vs non-artefact, etc.
  - Performance metrics are confined to the defined goal
- Metrics for assessing suspicious presentation detection detection performance differ from those used for assessing matching performance

General Model for Performance Evaluation

- **Suspicious Presentation Detection**: When the system states that the presentation characteristic is suspicious
- **Non-Suspicious Presentation Detection**: When the system states that the presentation characteristic is not suspicious

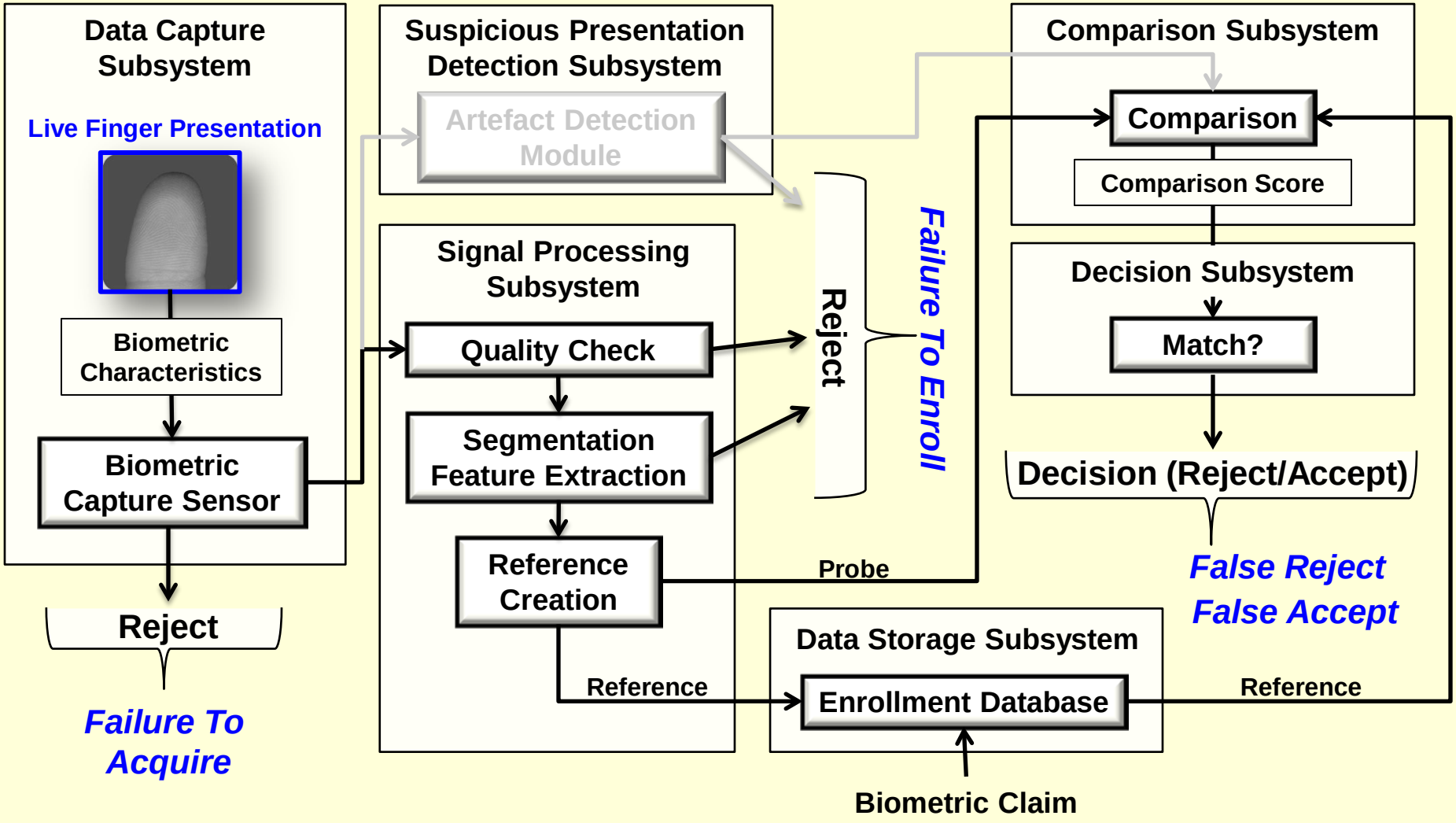
- **Metrics for error cases:**
  - **False Non-Suspicious Presentation Detection (FNSPD):** a suspicious presentation is incorrectly classified as being a non-suspicious presentation
  - **False Suspicious Presentation Detection (FSPD):** a non-suspicious presentation is incorrectly classified as being a suspicious presentation

Artefact Detection Case

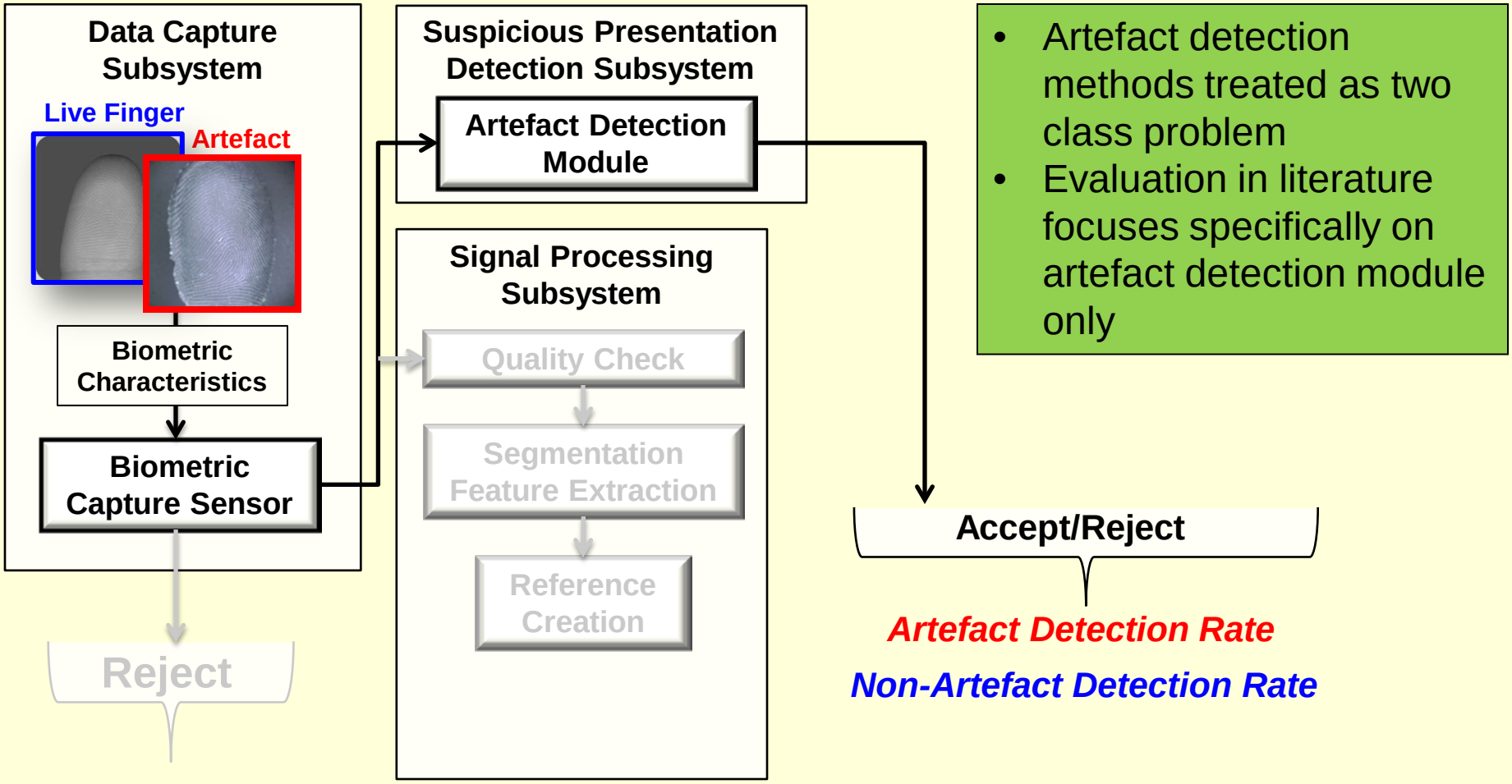
- **Goal:** Evaluation of module that is designed to distinguish the presentation of an artefact from a non-artefact
  - **Artefact Detection**: When the system states that the presentation characteristic is an artefact
  - **Non-Artefact Detection**: When the system states that the presentation characteristic is not an artefact

- **Metrics for error cases:**
  - **False Artefact Detection Rate (FADR):** proportion of non-artefact presentations incorrectly classified as being artefacts
  - **False Non-Artefact Detection Rate (FNDR)**: proportion of artefact presentations incorrectly classified as being non-artefacts

Traditional Metrics for Biometric Evaluation (Live Finger Input)

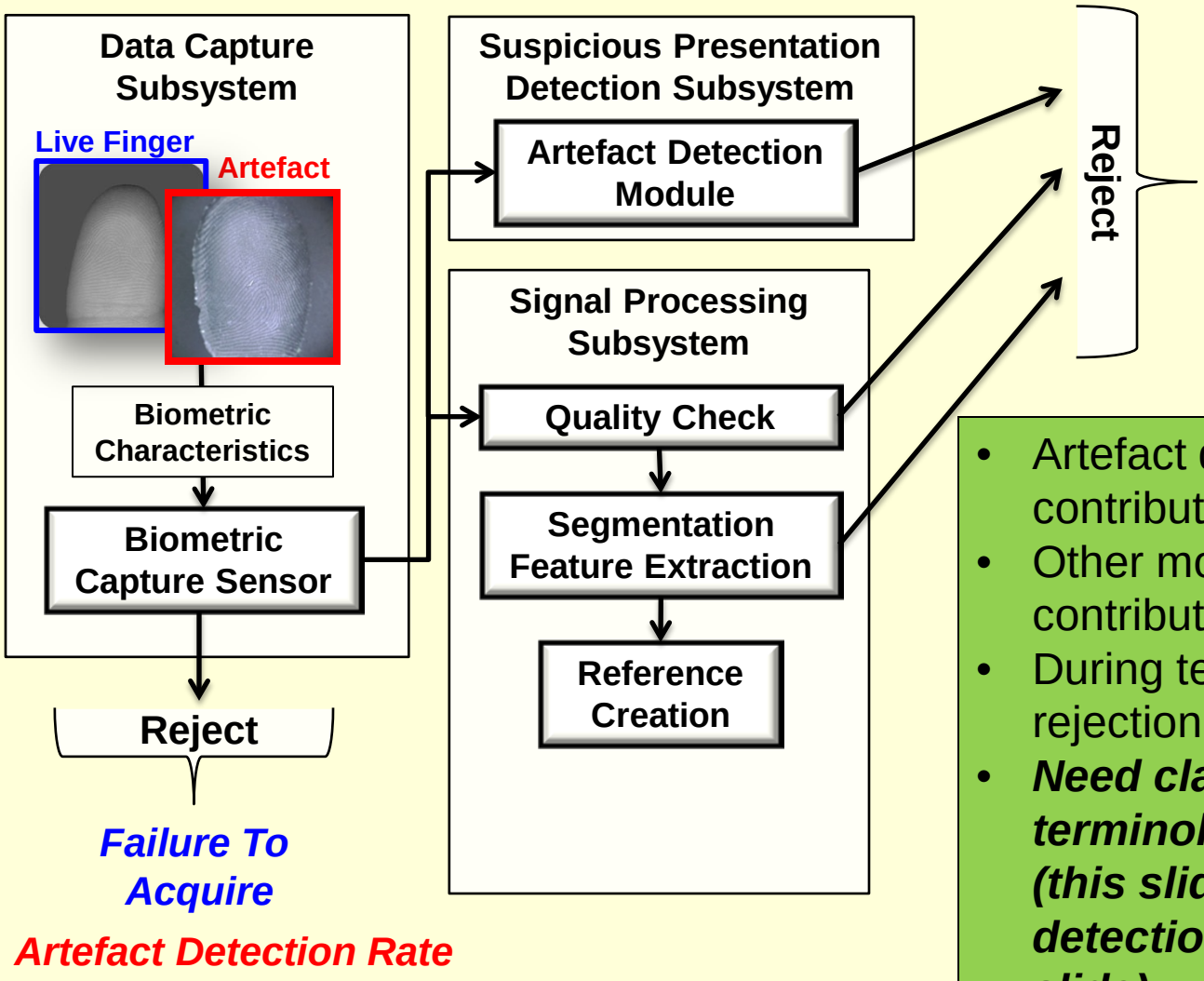


Additional Metrics (Artefact Input)



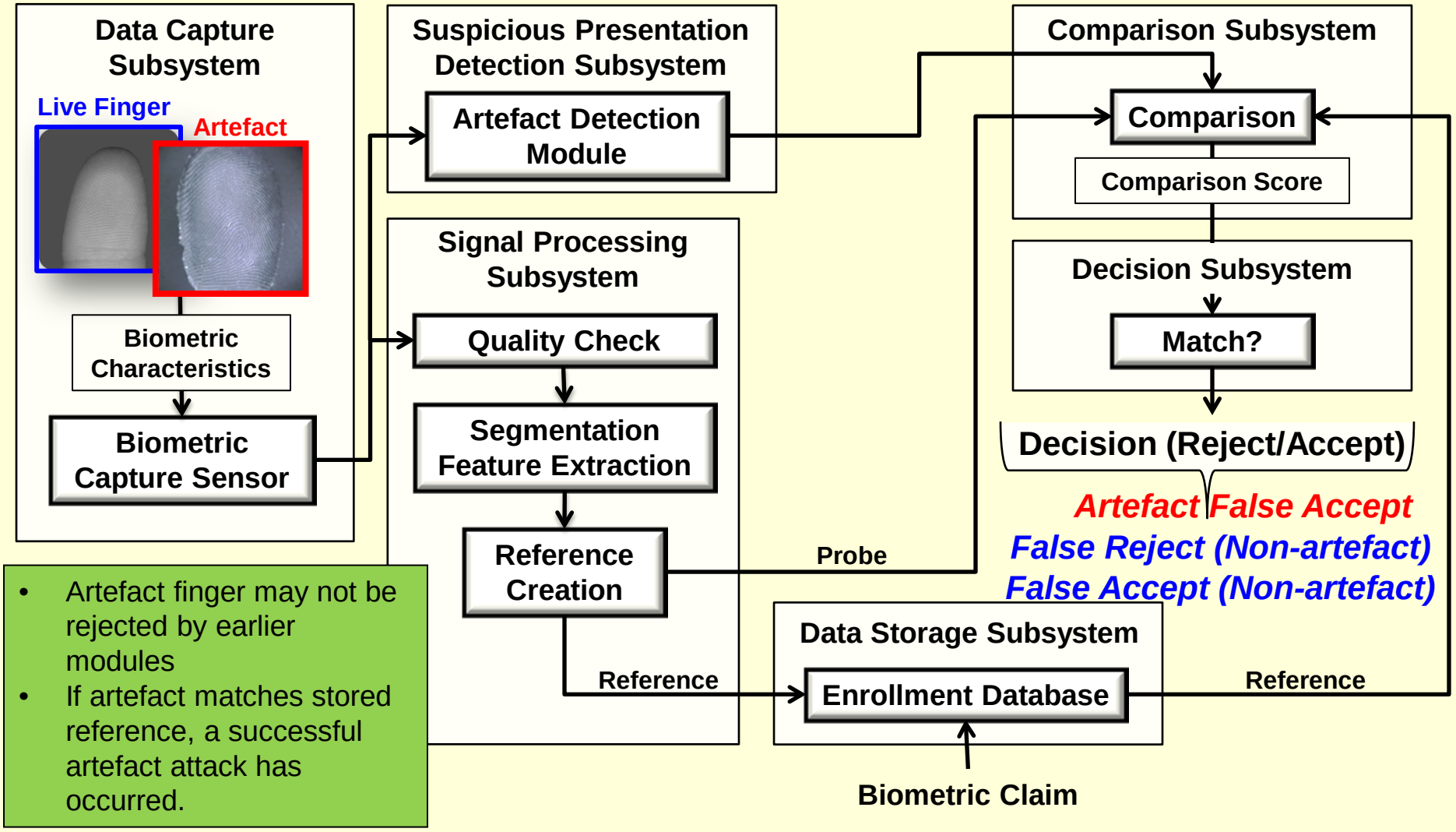
- Artefact detection methods treated as two class problem
- Evaluation in literature focuses specifically on artefact detection module only

Additional Metrics (Artefact Input)



- Artefact detection module will contribute to decision to reject
- Other modules (e.g. quality) may contribute
- During testing specific reason for rejection may not be known
- ***Need clarification in terminology for system testing (this slide) and artefact detection module testing (last slide)***

What about matching? (Artefact Input)

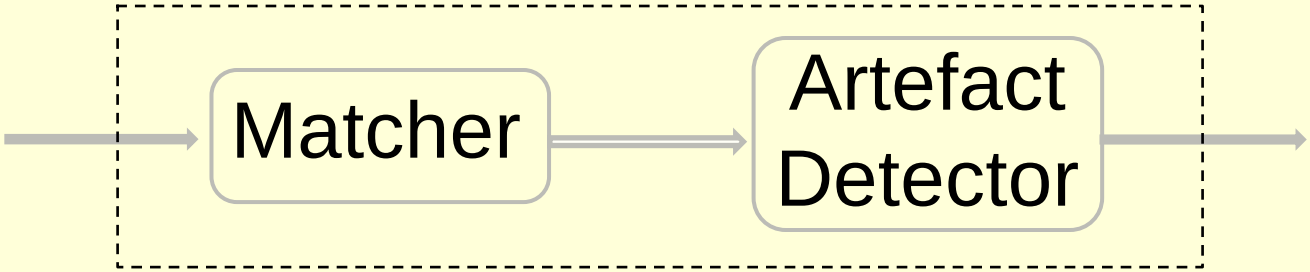


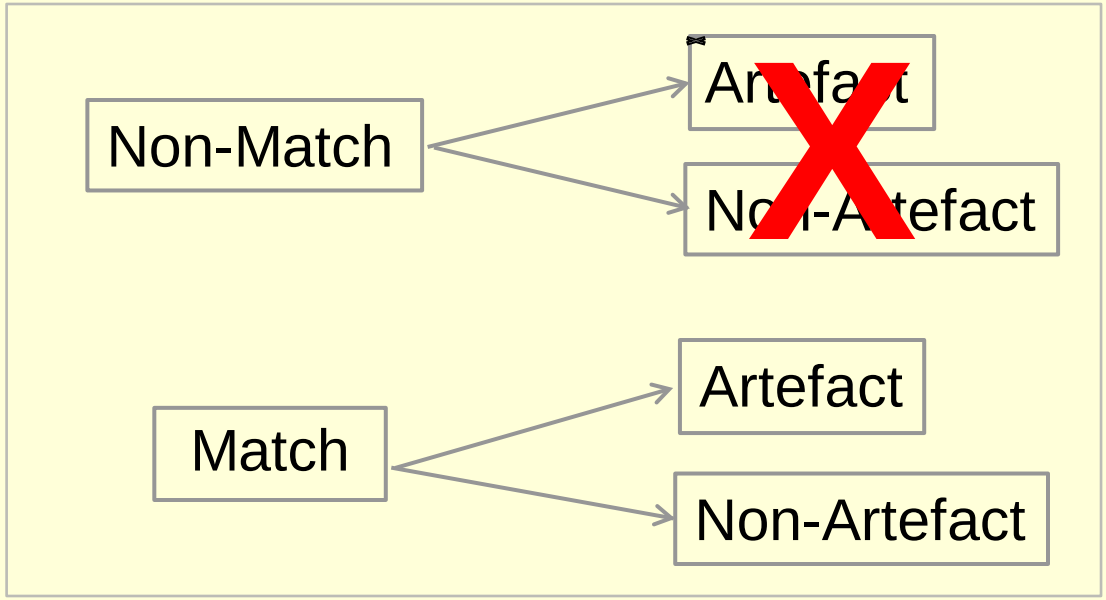
- Artefact finger may not be rejected by earlier modules
- If artefact matches stored reference, a successful artefact attack has occurred.

Performance Metrics for the Combination of Suspicious Presentation Detection System and the Matcher

Artefact Detector and Biometric Matcher

Configuration type 1



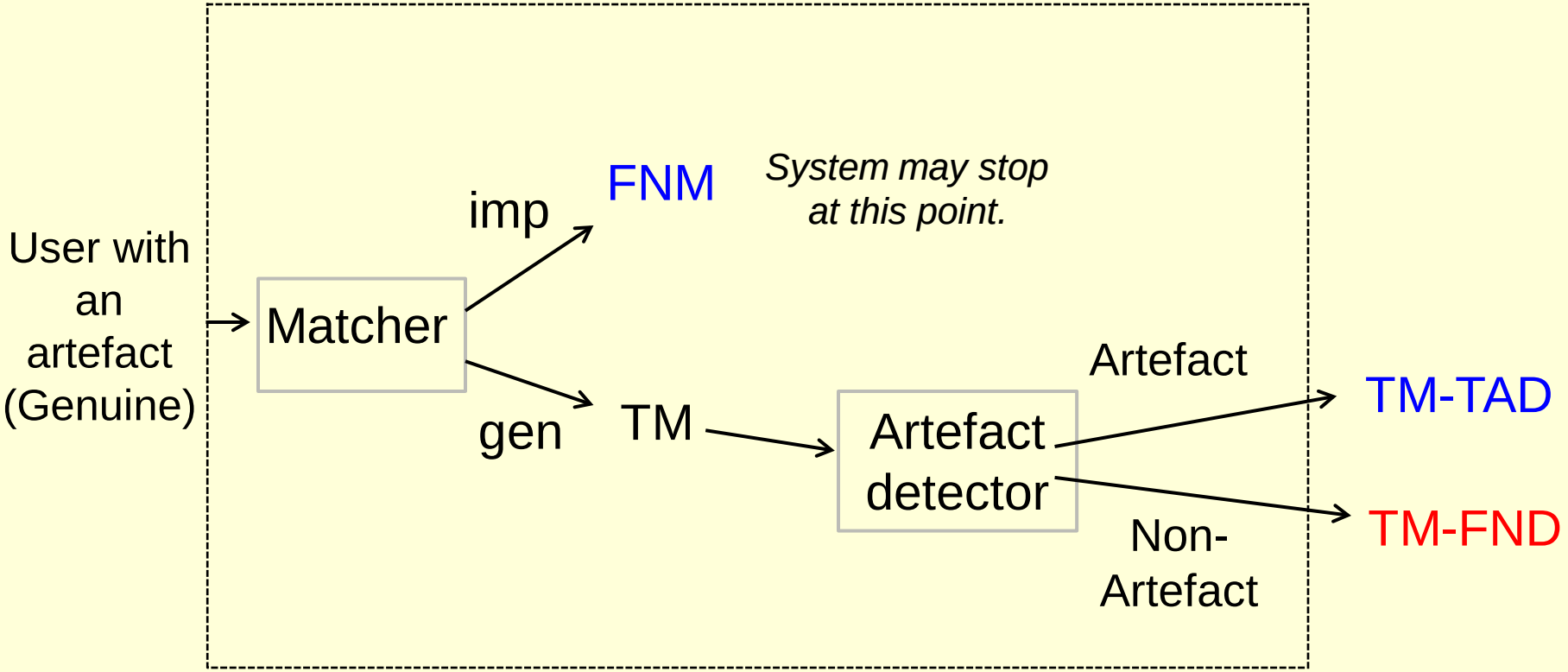


Configuration type 1

The combination of Artefact Detection and Matcher should REJECT the artefact

False accept of the artefact

Correct rejection of the artefact



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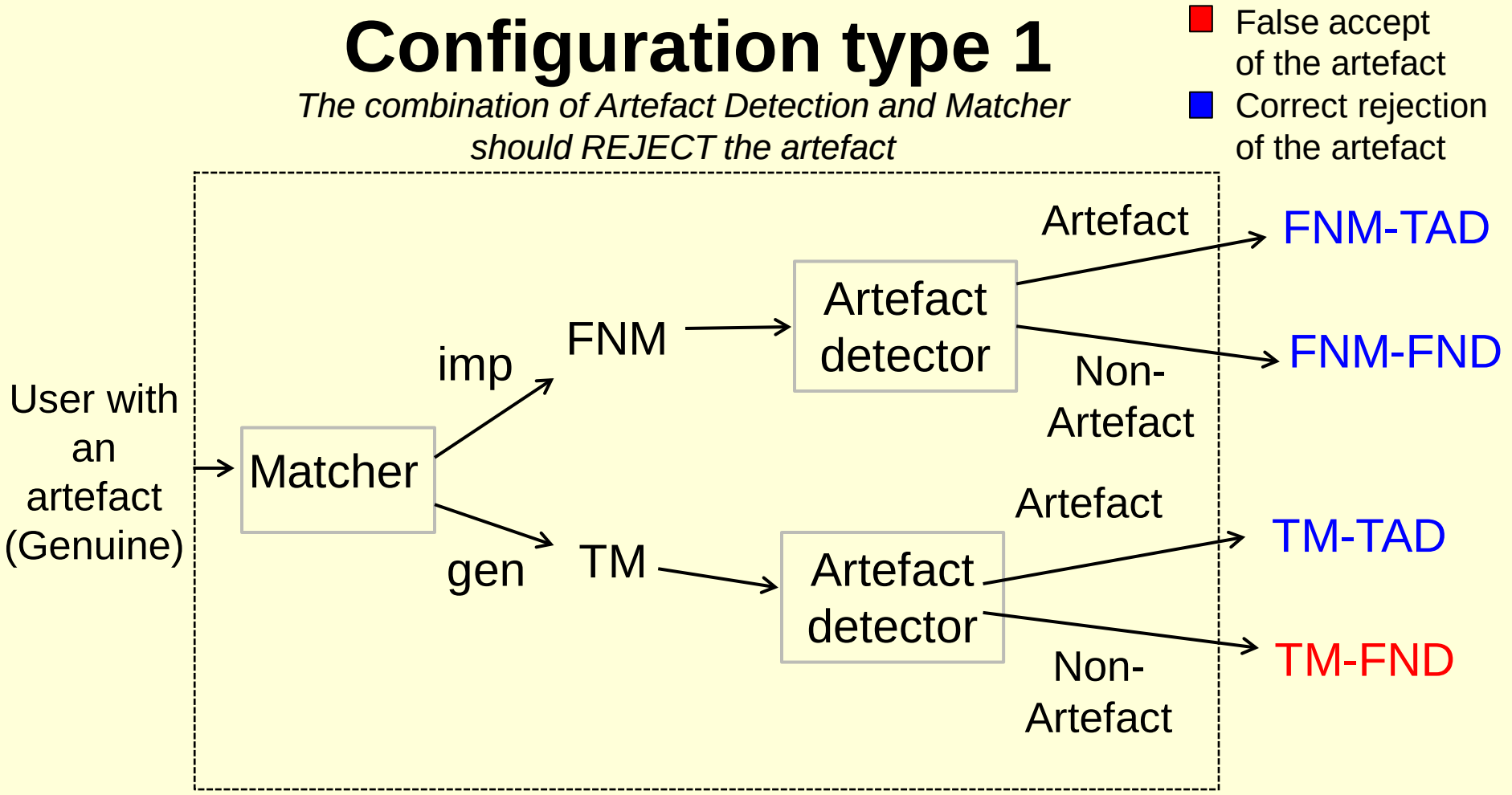

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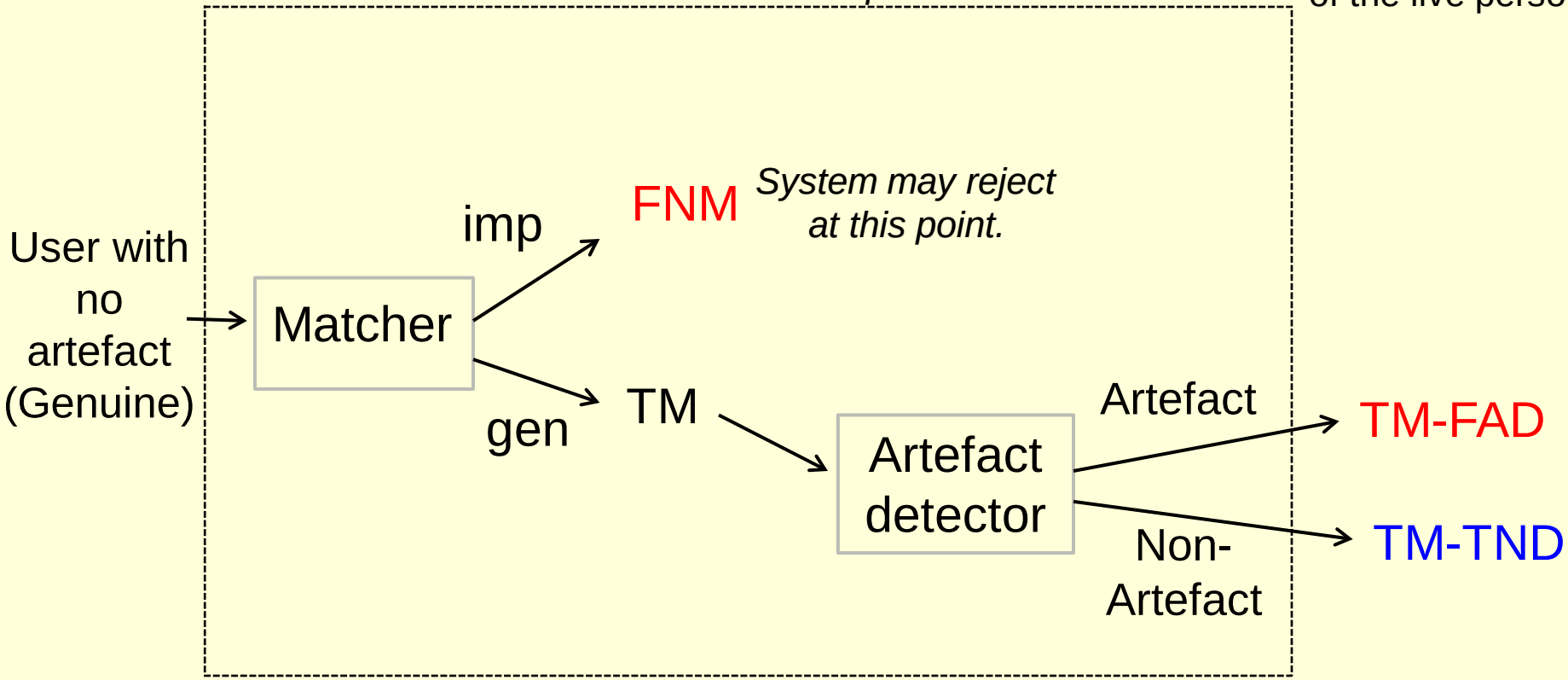

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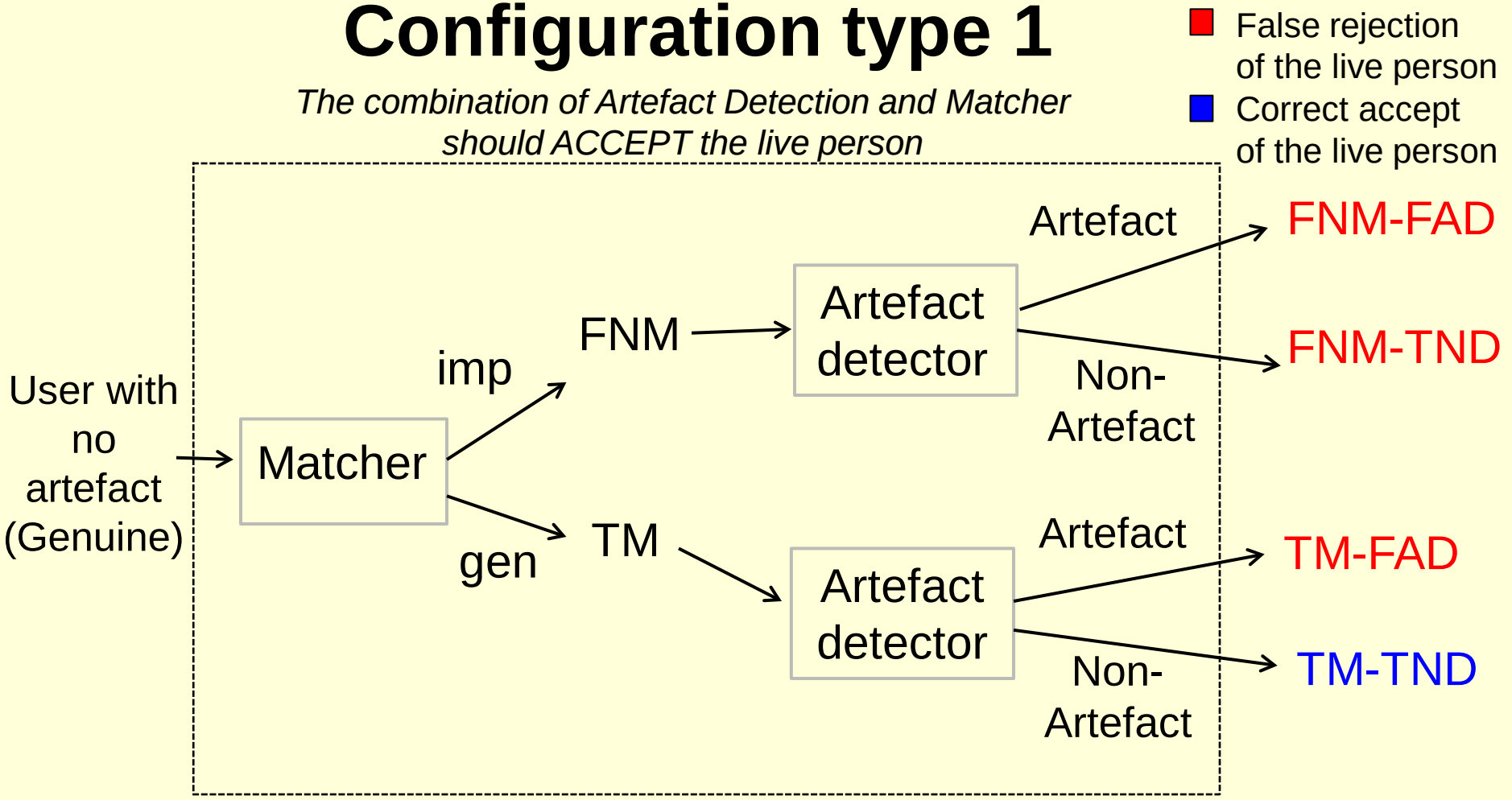

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Artefact Detector and Biometric Matcher

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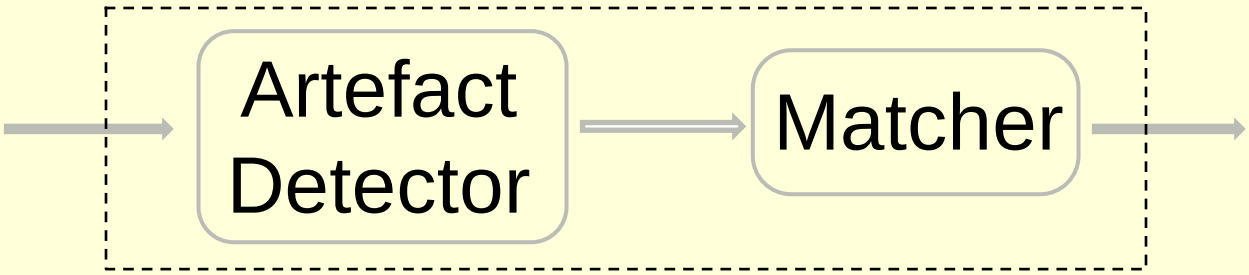

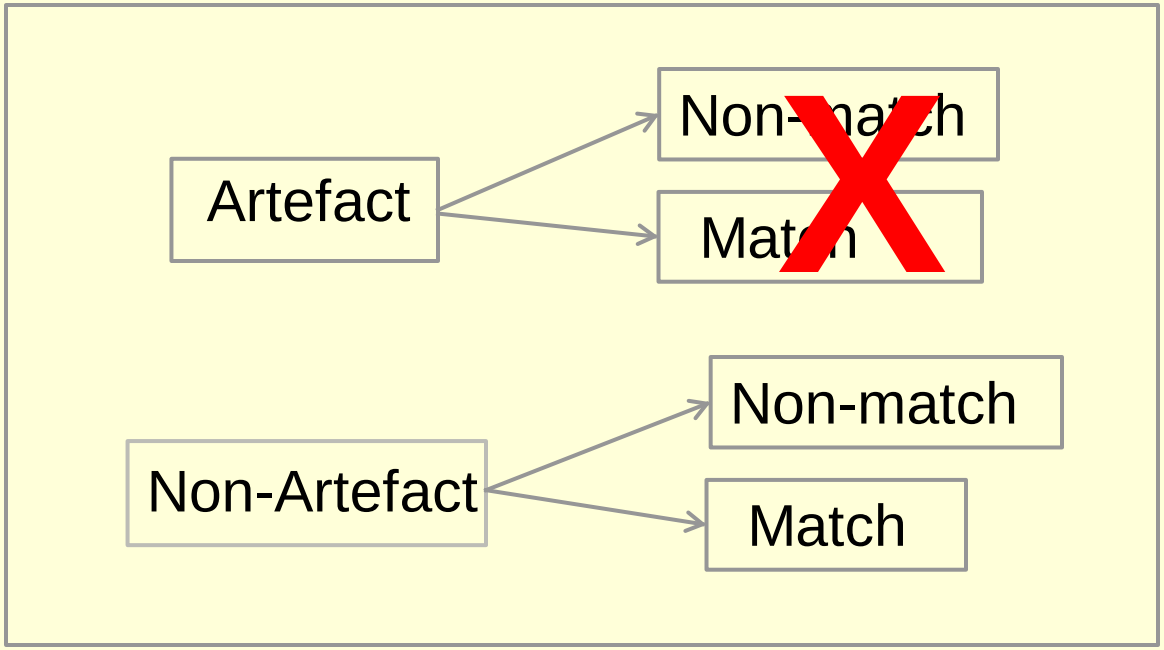

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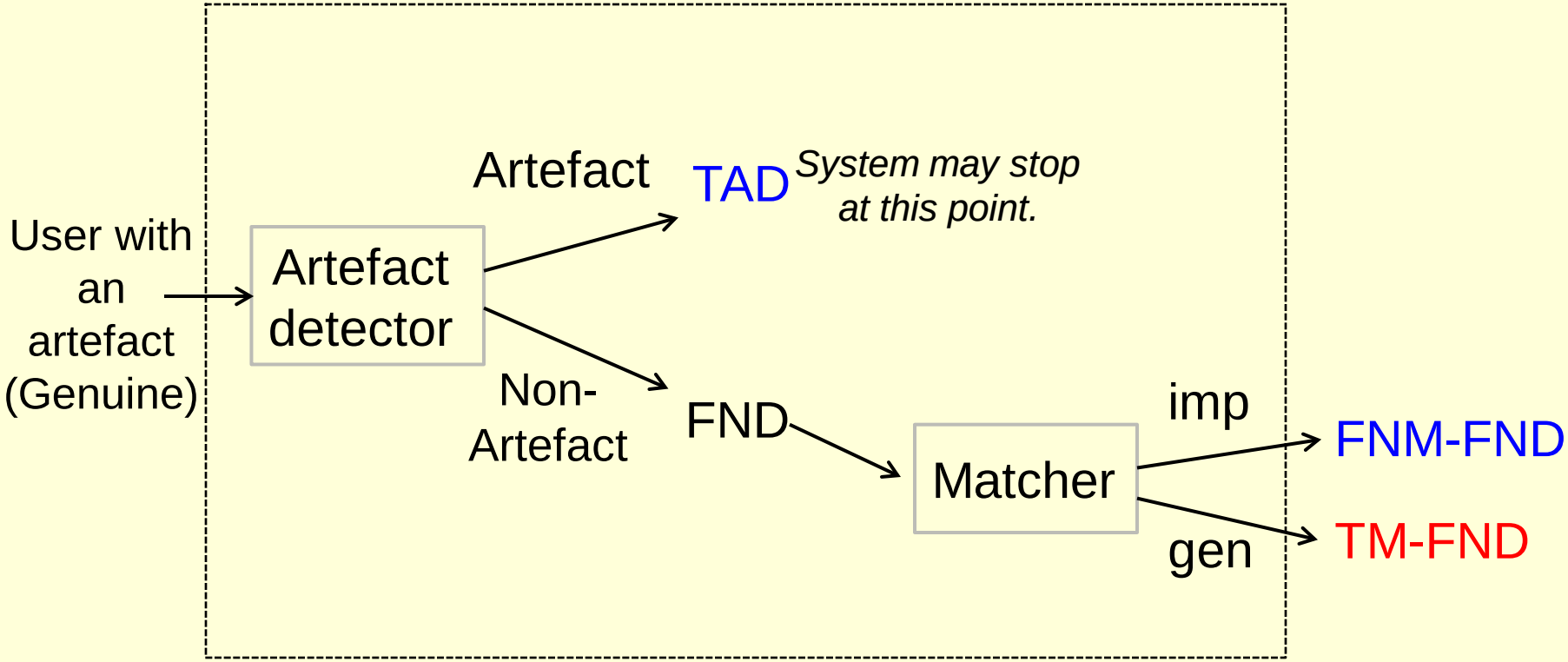

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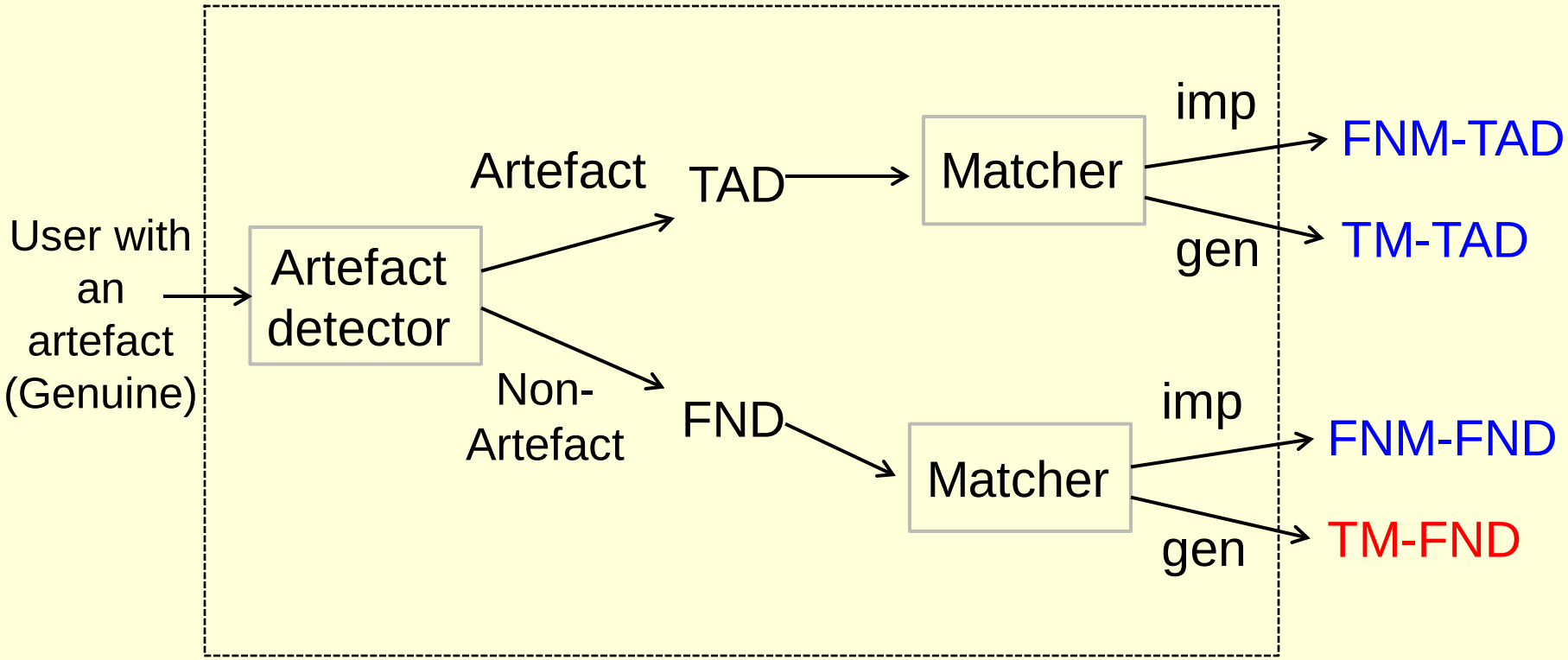

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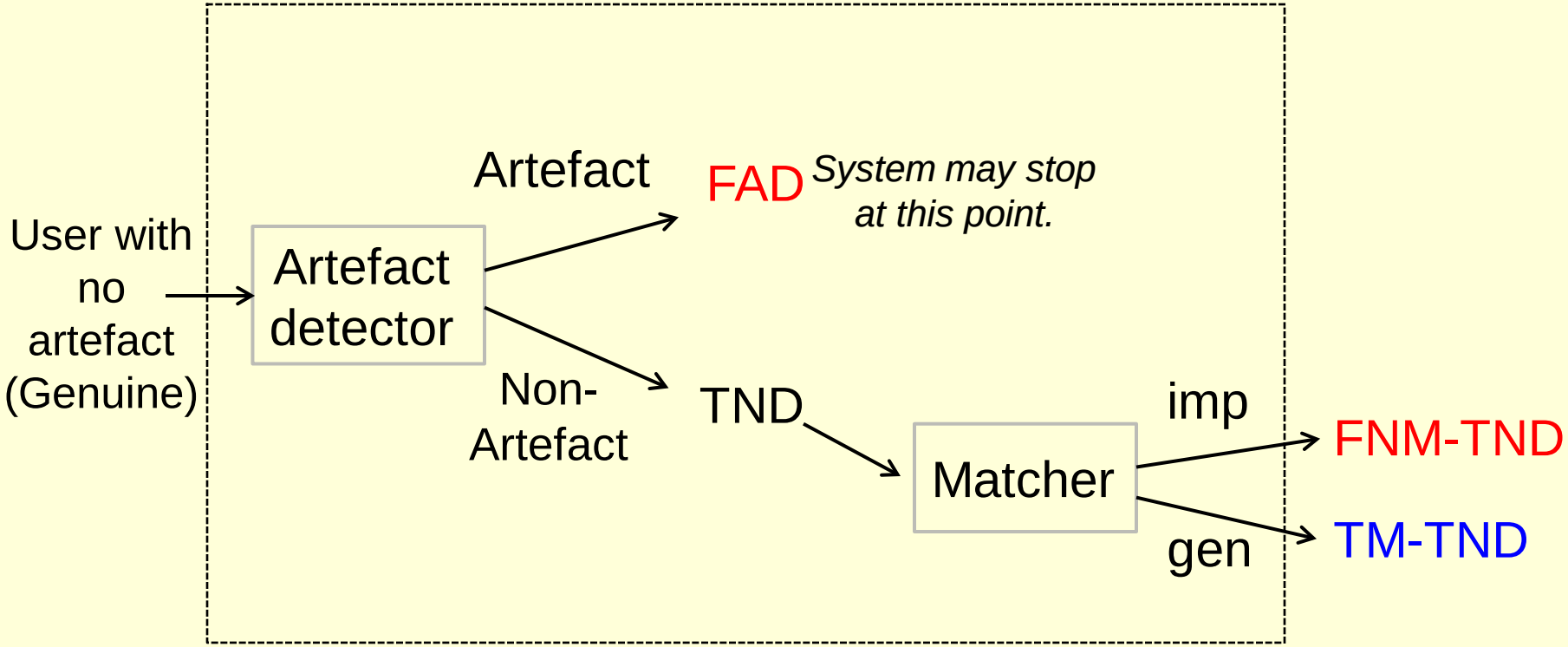

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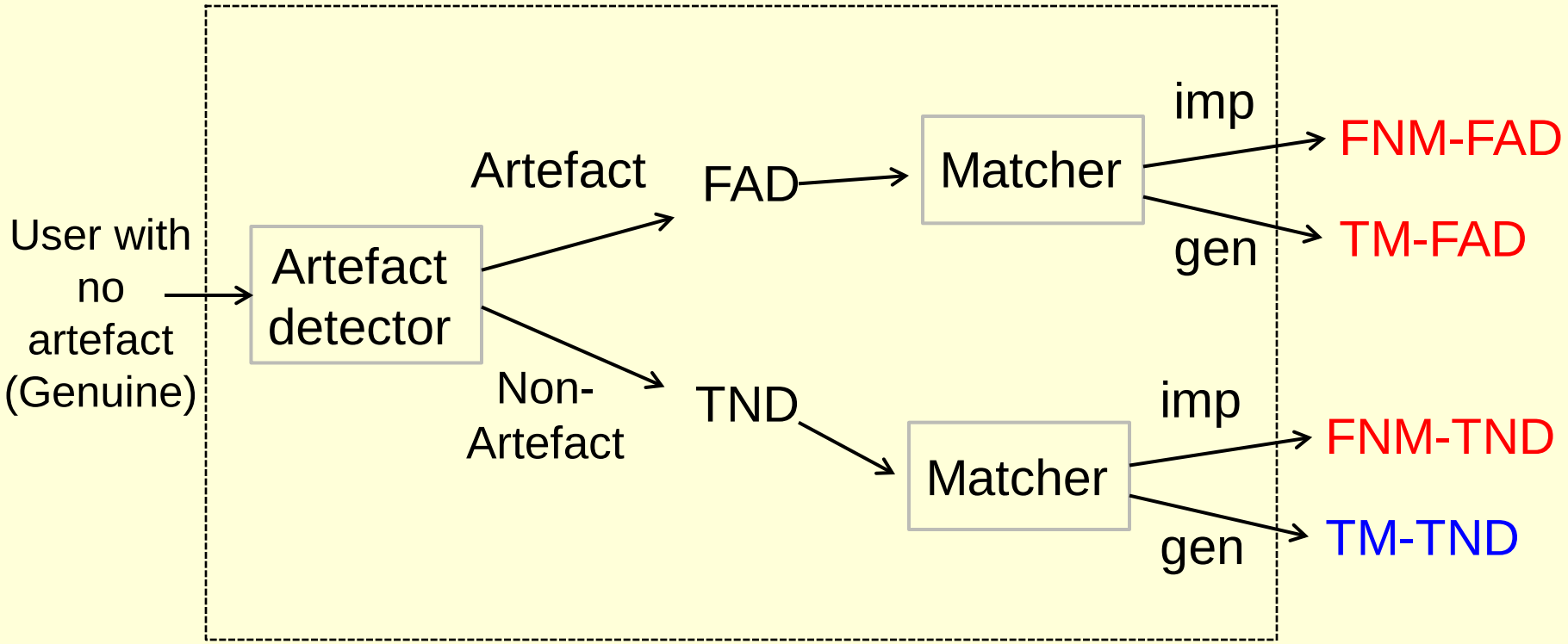

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Overall Summary

- **Categories of Subversive Presentation**
  - Artificial (Source and Production Methods)
  - Human (altered, coerced, non-conformant, conformant, cadaver)
- **Suspicious Presentation Detection**
  - Liveness Detection, Artefact Detection, Altered Finger Detection
- **Metrics for measuring performance**
  - False Suspicious Presentation Detection (FSPD)
    - e.g., False Artefact Detection (FAD)
  - False Non-Suspicious Presentation Detection (FNSPD)
    - e.g., False Non-Artefact Detection (FND)
- **Liveness and Challenge Response**

Extra Slides

Suspicious Presentation Detection (SPD) Location

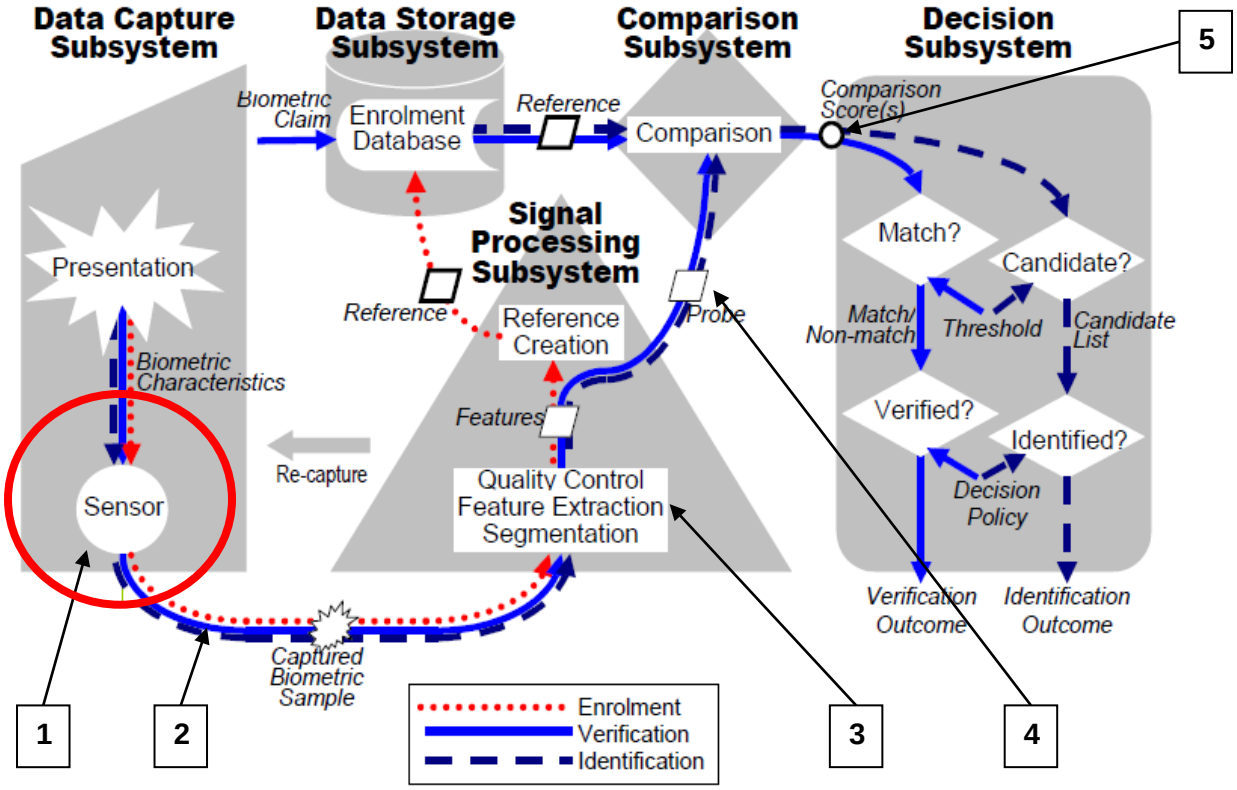

Figure 1 — Components of a general biometric system

- SPD at biometric sensor component level
- Based on hardware's intrinsic differentiation between real and artificial presentation
- No basis for evaluation of SPD performance

- Independent hardware-based SPD
- State of SPD could be recorded by system
- Upon successful SPD, sample may or may not be transmitted to signal processing subsystem

Suspicious Presentation Detection (SPD) Location

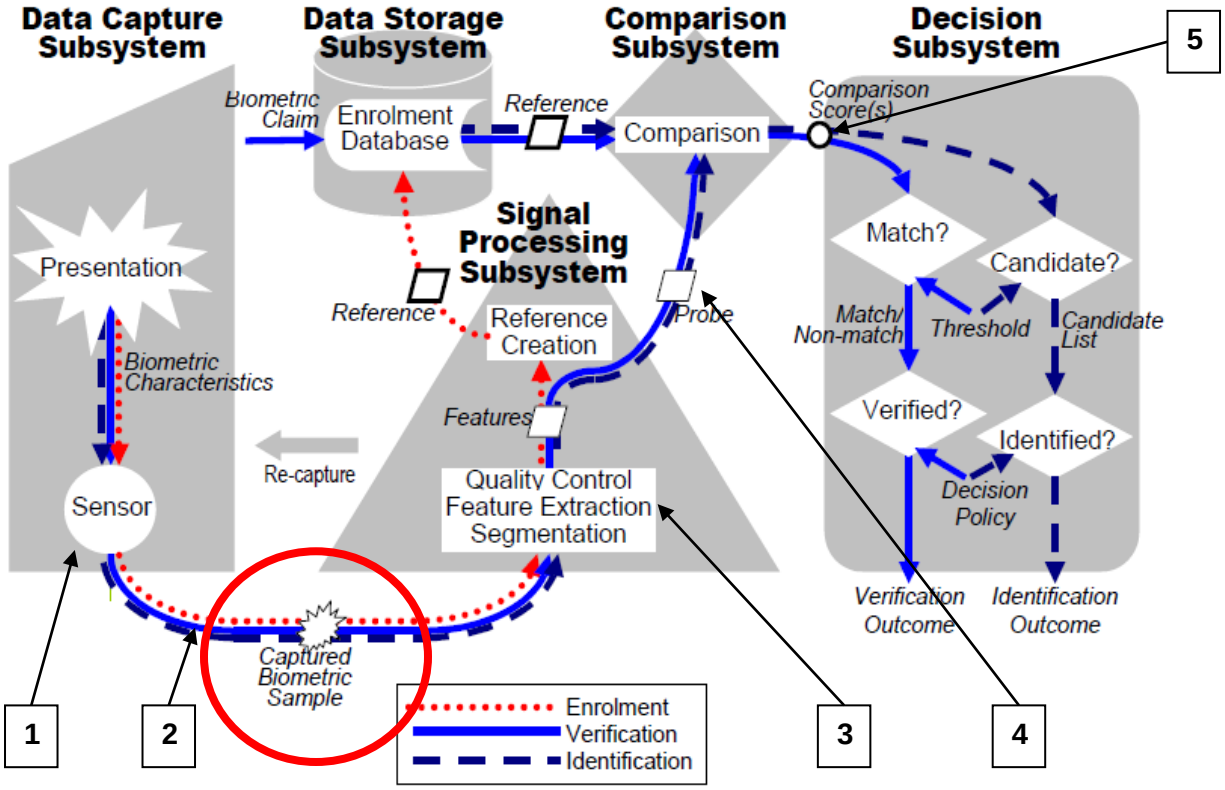

Figure 1 — Components of a general biometric system

- SPD after sensor component level
- Based only on captured sample
- In case of successful SPD, image may not be transmitted to signal processing subsystem
- State of SPD recorded by system

Suspicious Presentation Detection (SPD) Location

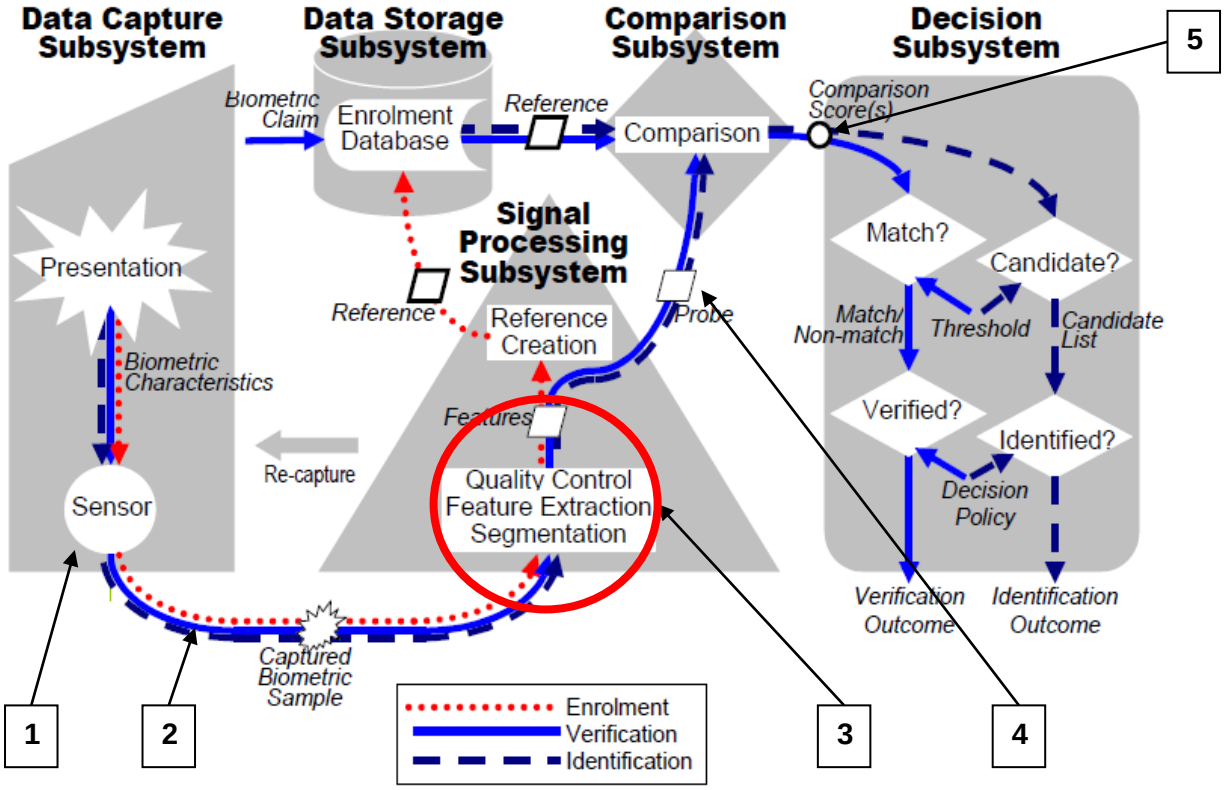

Figure 1 — Components of a general biometric system

- SPD at signal processing component level
- Based on captured sample
- Allows for quality control on sample before SPD
- In case of successful SPD, biometric features may not be transmitted to comparison subsystem

Suspicious Presentation Detection (SPD) Location

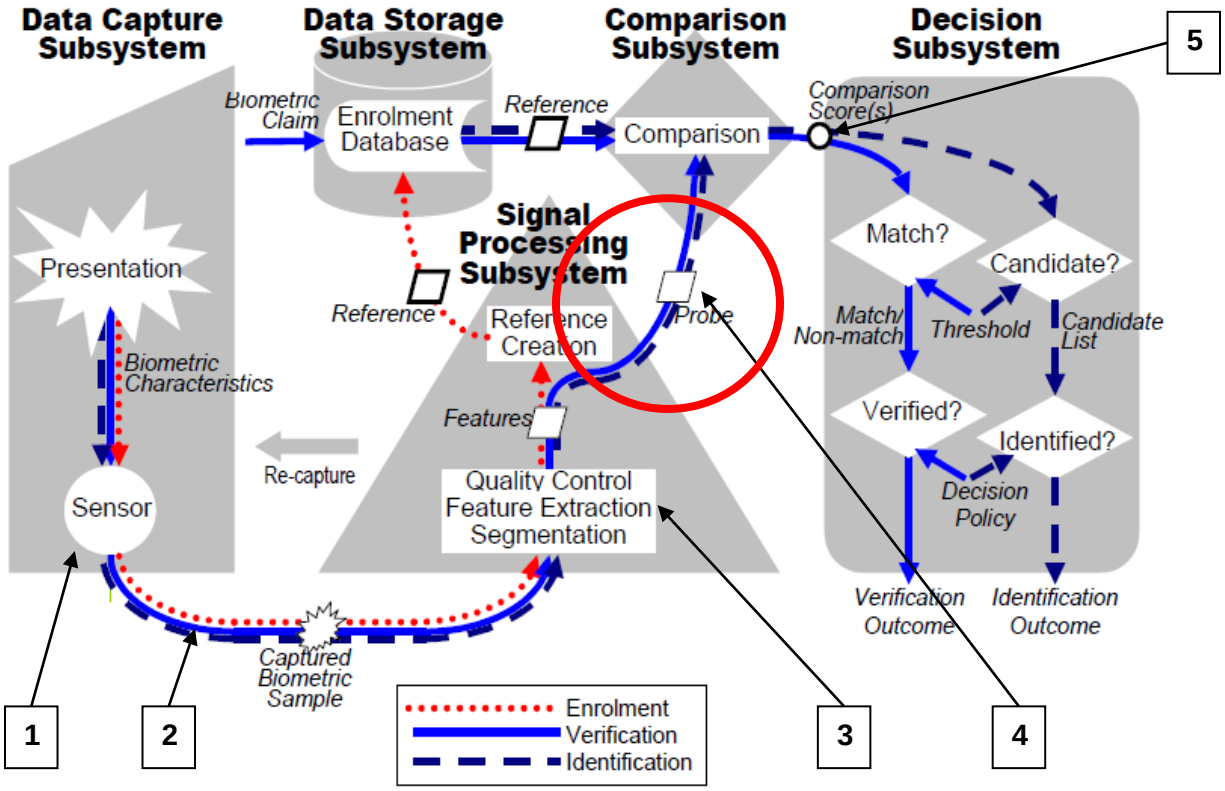

Figure 1 — Components of a general biometric system

- SPD after signal processing component level
- State of SPD transmitted with biometric features to comparison subsystem

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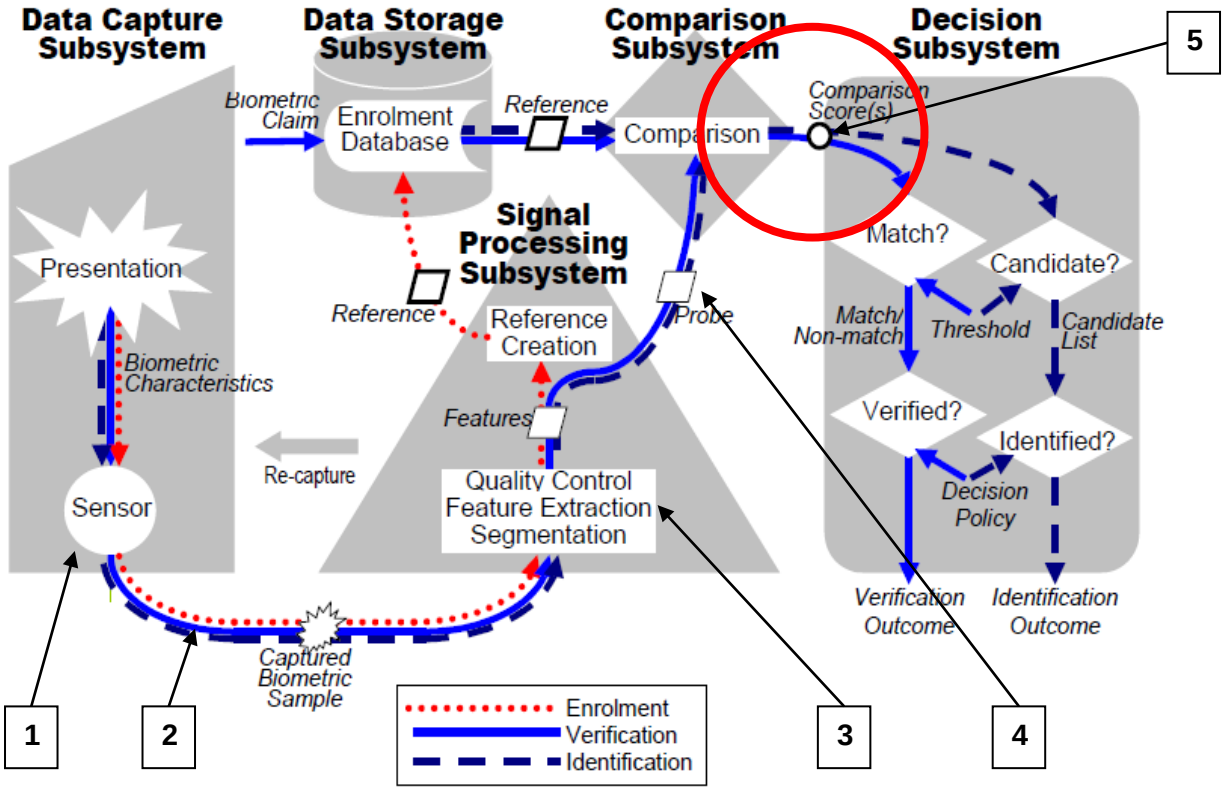

Figure 1 — Components of a general biometric system

- SPD after comparison subsystem
- State of SPD transmitted with biometric comparison score to decision subsystem
- Allows for fusion of SPD output with comparison score