The Rise of Biometric Cards
state of the art and future challenges for card manufacturers

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Agenda

- Fingerprint Consumer Acceptance Timeline
- What is a Biometric Smart Card?
- Template-On-Card
- Match-On-Card
- Biometric System-on-Card
- Biometric Card Applications
- Anatomy of a BSC
- Fingerprint Card Key Manufacturing Steps
- Fingerprint Card Personalization
- Fingerprint Cards Value Chain
- Key Trials / Pilots
- Key Companies
- The Offer
- Global BSC Shipment Forecast Y2017-2020
- Global BSC ASP Forecast Y2017-2020
- Normative References
- Fingerprint Cards Acceptance Factors
- Fingerprint Cards Potential Blocking/Risk Factors
- The Future
- Q&A
Fingerprint Consumer Acceptance Timeline

1998
Siemens and Triodata develop phone prototype with fingerprint sensor.

2000
Sagem launch MC 959 ID, phone with STM fingerprint sensor.

2011

2012
Apple buys AuthenTec for $356M

2013
Apple launch iPhone 5S
What is a Biometric Smart Card?

A Biometric Smart Card (BSC), Fingerprint Card or Biometric System-on-Card (BSoC) is a Smart Card where:

- Biometric sample capture (enrolment / verification)
- Minutiae Template extraction
- Template storage
- Templates matching

is performed within the card.

A BSoC shall never transfer any biometric sample and biometric reference data to any external terminal.
Template-On-Card (TOC)

**Enrolment**
- Fingerprint Acquisition
- Template Creation
- Transfer to Smart Card
- Template Stored in Secure Element

**Matching**
- Fingerprint Acquisition
- Biometric Terminal
- Transfer to Matching System
- Potential Man-in-the-Middle Attack

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**Potential Man-in-the-Middle Attach**

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**Match Result**

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Match-On-Card (MOC)

Enrolment:
- Fingerprint Acquisition
- Template Creation
- Transfer to Smart Card
- Template Stored in Secure Element

Matching:
- Fingerprint Acquisition
- Biometric Terminal
- Transfer to Smart Card
- Match Result
Biometric-System-on-Card (BSoC) (1/2)

**Enrolment**

- Fingerprint acquisition
- In-Card template creation
- Template stored in Secure Element or Secure Flash

**Matching**

- Fingerprint acquisition
- In-Card template creation
- In-Card templates matching
- Match result
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Biometric Card Applications

- Identity Verification
  - Proof of life
  - Government Ration/Subsidy Card
  - Driving License
  - Loyalty / Membership
- Secure Access
  - Door entry
  - System Login
- Online transaction
  - Online Gaming
  - Online Voting
- Healthcare & Insurance
  - Government Healthcare cards
  - Health Insurance Cards
- Financial
  - Debit / Credit Cards
  - eCommerce

Enabler of three-factors (3FA) authentication

- Something I have
  - CARD
- Something I know
  - PIN
- Something I am
  - FINGERPRINT
Anatomy of a Biometric Smart Card (BSC)
Anatomy of a BSC: the components

- Back Side Overlay
- Back Side Layer
- Inlay
- Front Side Layer
- Front Side Overlay
- Micro module
- Fingerprint sensor
- Sensor Bezel
Anatomy of a BSC: Card Body

Card body Construction

- Hot Lamination
  - Non-Moulded card body
  - Industry’s choice for mass production
  - Use existing production process
  - Additional step for FPS cavity making

- Cold Lamination
  - Moulded card body
  - Ok for prototyping / small volumes
  - Can be manual labour intensive
  - Popular in Taiwan / South Korea
  - Not necessarily cheaper than HL
  - Non-Moulded card body
Anatomy of a BSC: The Inlay

Inlay size is 1 – 2 mm (0.04 - 0.07 in) smaller than card W / H
Some BSC Integrators deliver inlays with FPS already embedded
Anatomy of a BSC: Operative Strategies

IC Power Supply

Power is supplied to SE only after successful fingerprint verification. No successful verification = no ATR.

APP Status

The terminal check APP status. Default APP state = Disabled. After successful fingerprint verification APP state = Enabled.

Double ATR

Terminal checks for a 2° ATR to occur within a predefined number of clock cycles. If Fingerprint verification after the first ATR fails, then the second ATR is not sent.
Anatomy of a BSC: Power Supply (1/2)

With Replaceable Battery

With Rechargeable Battery

Energy Harvesting

Chip Contact

With Non Rechargeable Battery

With Rechargeable Battery

Energy Harvesting

With Replaceable Battery

No Battery

Chip Contact

Energy Harvesting

Supercapacitor (SC)

In some contexts SC are considered Rechargeable Batteries

No Battery
Anatomy of a BSC: Power Supply (2/2)

• Flat, printed Lithium Ion batteries are easy to implement but can create issues:
  • Card heating
  • Transport issues (Air, Courier)
  • In some countries, treated as “Dangerous Goods”
  • In some countries, subject to certification
• Supercapacitors (SC) often used in Energy Harvesting BSC for short-term energy storage.
• BSC without battery requires card reader / NFC reader for enrolment.
• Replaceable batteries used in Non-ISO card (thickness) for Access Control applications.
## Anatomy of a BSC: FPS Cavity Making

<table>
<thead>
<tr>
<th>Technique</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sheet Punching</strong></td>
<td>Cavities punched out from PVC sheet</td>
</tr>
<tr>
<td></td>
<td>Requires precise alignment of lamination sandwich</td>
</tr>
<tr>
<td></td>
<td>Suitable for mass production</td>
</tr>
<tr>
<td></td>
<td>Operation performed after sheet printing</td>
</tr>
<tr>
<td><strong>Mechanical Milling</strong></td>
<td>Most popular method for cavity making</td>
</tr>
<tr>
<td></td>
<td>Requires modification to chip cavity milling equipment</td>
</tr>
<tr>
<td></td>
<td>Suitable for mass production</td>
</tr>
<tr>
<td><strong>Laser Milling</strong></td>
<td>Very precise</td>
</tr>
<tr>
<td></td>
<td>Color change issue with PVC / PETG</td>
</tr>
<tr>
<td></td>
<td>Technique under development</td>
</tr>
<tr>
<td><strong>Injection Moulding</strong></td>
<td>Chip and FPS sensor cavity are created during injection</td>
</tr>
<tr>
<td></td>
<td>Smooth and clean cavity</td>
</tr>
<tr>
<td></td>
<td>No debris removal</td>
</tr>
<tr>
<td></td>
<td>Complex industrialization for mass production</td>
</tr>
</tbody>
</table>
## Anatomy of a BSC: Swipe vs Area Sensors

<table>
<thead>
<tr>
<th></th>
<th>Swipe Sensors</th>
<th>Area Sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generate large Image</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small footprint</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easy bonding to FPCB</td>
<td></td>
<td>Flexible are ideal for smart cards</td>
</tr>
<tr>
<td>Unreliable in many applications</td>
<td>Subject to scratches</td>
<td></td>
</tr>
<tr>
<td>Significant learning curve</td>
<td>Large footprint</td>
<td></td>
</tr>
<tr>
<td>Problematic torsion/bending test</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Anatomy of a BSC: Key Sensor Makers

Datang Microelectronics
Elan Microelectronics
Fingerprint Cards
Flexenable

IDEX
Infinity Electronic Biotech
Innolux
Next Biometrics
Anatomy of a BSC: Area Sensors

- Average thickness ~ 0.3 mm (0.011 in)
- Full fingerprint scan ~ 1 sec
- 1.8 ÷ 3.3 V operations
- Resolution ≥ 500 dpi (sensors with lower resolution compensate with larger active area)
- Output 8 bit, 256 grey scale values
- Wakeup upon touch (few ms wait)
- Read fingerprint from any angle
- Protective coating to increase durability
- ESD Protection ±15 kV (IEC 61000-4-2)
- Durability ≥ 1 M touches
- Some models include Bezel into their design
- For mass production shall be delivered in Super 35 mm Tape format
Anatomy of a BSC: Bezel

Bezel, when present, have Operative and Aesthetic functions:

**Operative**
- ESD protection
- Electrically drive the fingertip during the sensing process
- Help keep sensor in place
- Protect sensor from environment

**Aesthetic**
- Cover sensor cavity walls
- Cover sensor bonding pads

Must be flexible enough to comply with dynamic torsional stress of ISO/IEC 10373-1

* For bezel not embedded into sensor design
Anatomy of a BSC: Cross Section

Gap between card front surface and sensor active surface:
- Reduce FPS wear & tear
- Avoid contact with plate during lamination

Bezel should not extend over card surface to avoid scratches

For sensors mounted on Inlay before lamination

* For sensors mounted on Inlay before lamination
Anatomy of a BSC: MCU / ASIC

• ARM Cortex M4, 32bit RISC de facto standard as general purpose MCU
• Perform Template Match when this is not done by SE
• Coordinate/control BSC components
• Most BSC makers are designing their own ASIC:
  • Integrate FPS IC + MCU + Flash + RF IC.
  • Cheaper when manufactured in volume.
  • Easier to integrate (less components).
  • Will drive inlay cost down.
  • Can be done only when product with generic MCU reach maturity.
  • Time-to-Market 18-24 months.
Anatomy of a BSC: RF IC

• The RF IC perform multiple tasks:
  • Harvest power from RFID excitation field
  • Voltage Regulator
  • Clock Generator / Clock Regulator
  • Reset Generator
  • Anti-collision mechanism
  • Distribute power supply to both SE + BSC MCU/ASIC + FPS
  • When present, charge Rechargeable Battery or Supercapacitor
Anatomy of a BSC: Led / Buzzer / LCD

Other elements that can be present on a Biometric Card:

- LED
- Buzzer
- Flexible LCD / e-paper

BSC Contactless Interfaces / Transponders ICs

- ISO 14443 Type A, B, C
- NFC
- Bluetooth
- HID 125 kHz / HID iClass
- Mifare Classic / DESFire EV1
- Legic Advant
- Atmel 5577

Popular on BSoC Access Cards
Anatomy of a Fingerprint Card: Making of FPCB

- FPCB
- Copper Plating
- Laser Drill
- Line Formatting
- AOI & PSR
- Gold Plating
- Marking
- SMD / COF
- Solder Paste
- Mount
- Reflow
- Bonding
- Sensor mount on Inlay
- Prelam / Packaging
- Placement on Template
- Prelam sheets making
- Sheets Packing
- Inlays Packing
- Inlays Packing
- Sheets Packing
- Delivery also possible as prelam Sheets
- Flexible PCB often made of polyimide

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Fingerprint Card Key Manufacturing Steps

1. Sheets Printing
2. Sheet FPS Cavity Punching
3. Layers Collation
4. Sheets Lamination
5. Sheet Punching
6. Cards Gathering
7. Micromodule Cavity Milling
8. Micromodule Embedding
9. FPS Cavity Milling
10. Anisotropic conductive epoxy on contact pads

- FPS Embedding
- Bezel Placement
- cavity walls coated with adhesive epoxy

Single steps when bezel is integrated into FPS design
Fingerprint Card Personalization

- Laser engraving
- Inkjet
- Direct-To-Card
- Overlay
- Rear Indent
- Retransfer
- Emboss
- Front Indent
- Overlaminate

Sensor bezel / card thickness can potentially create interference / jam in personalization equipment
The Biometric Card Solution Provider can design Biometric Engine, ASIC and Inlay in house.
Key Companies: CardLab ApS

- Founded: 2003
- HQ: Denmark
- Type: Private
- CEO: Frank Sandeløv
- WEB: Cardlab.com

• Strong IP Portfolio focusing on Powered Smart Cards
• Partnership with QuardLock for development of a OTP BSoC
• 50K€ funding by EU under Horizon 2020 project
• Own development of minutiae algorithm
• Trials in USA and UAE
• Hot laminated products under industrialisation (Thailand), expected launch Q1/Y2018

Key Products:
• Non-rechargeable battery dual interface BSC inlay and cards
• Non-rechargeable battery contactless NFC BSC inlay and cards
• Inlays with multiple items: fps + display + dynamic magstripe + led
Key Companies: Card-Tech S.r.l.

- Founded: 2006
- HQ: Italy
- Type: Private
- CEO: Fabrizio Borracci
- WEB: card-tech.it

- PinKey Smart, BSoC with swipe sensors, launched Cartes Y2014
- Holds patents on In-Card biometric verification
- Manufacturing partnership with top-tier card vendor
- Partnership with IDEX for sensors, sensor embedded on inlay
- No bezel
- Template Matching on smart card chip
- Key Products:
  - Contact BSC inlay
  - Dual Interface Energy Harvesting BSC inlay (under development)
Key Companies: Datang Microelectronics

- Founded: 1996
- Headquarters: China
- Type: Private
- CEO: Yanhui Yang (杨延辉)
- Website: dtm.com.cn

- Belonging to Datang Telecom Technology, a State owned 3.3B$ industrial group
- China largest design house + foundry for Smart Card ICs
- In-house development + production of Capacitive Area and Swipe sensors
- In-house development + production of MCU + RF Chip
- In-House development + production of flexible BSC inlays
- China strongest company in smart card-related development
- Key Products:
  - Contact BSC with rechargeable battery
  - Dual Interface BSC with rechargeable battery
  - Access Control BSC (rechargeable battery)
Key Companies: Jinco Universal Co. Ltd.

- Founded: 2005
- HQ: Taiwan
- Type: Private
- CEO: Ted Lin (林武旭)
- WEB: Jinco.com.tw

- Asia’s strongest OEM/ODM of customized powered smart cards / inlays
- Partnership with Korea Smart ID (KSID) for Card Production
- Partnership with Elan Microelectronics for sensors
- Strong promotion in South Korea / China / Taiwan / South East Asia
- Specific patents on BSoC
- Working on retina recognition smart card (patented)

Key Products:
- Contactless BSC with rechargeable battery
- Dual Interface, energy harvesting BSC
- Dual Interface, rechargeable battery BSC with dynamic magstripe and display
Key Companies: Mereal Biometrics Ltd.

- Founded: 2009
- HQ: Hong Kong
- Type: Private
- CEO: Philippe Blot
- WEB: merealbiometrics.com

- Investment by French Groupe Partouche (Casino, Hotel, Events)
- Co-founded by Philippe Blot (UINT CEO)
- Patented Acoustic / RFID OTP transmission to terminal
- Sales & Marketing base in Hong Kong
- UINT Limoges (France) engineering & manufacturing plant
- Current production capacity ~250K cards / month
- Key Products:
  - Dual Interface, rechargeable battery BSC with Swipe Sensor
  - Dual Interface, rechargeable battery BSC with Area Sensor from FPC
  - Contactless Portable Charger
Key Companies: MoriX Co., Ltd.

- Founded: 2005
- HQ: Japan
- Type: Private
- CEO: Morihiko Kubota (久保田守彦)

• Partnership with Toshiba Solutions Corp.
• Selling Cards & Fingerprint Sensors
• In-house Fingerprint Matching algorithm development
• COF Sensor Co-developed with ASD: 508 dpi, 9.4 x 11 mm active area
• NFC BSC under development
• Key Products:
  • BSC contact with non-rechargeable battery
  • BSC contact with display and non-rechargeable battery
  • Fingerprint Sensor module
Key Companies: Tactilis Pte

- Firm founded by industry seasoned professionals
- Privately funded
- Exclusive, patented manufacturing process
- Fully equipped plant in Penang, Malaysia
- Offering BSC Inlays & complete cards
- Supporting a tier-one card vendor
- Integrate secure flash up to 4GB
- Low profile communication strategy
- Key Products:
  - Dual interface, energy harvesting, BSC with large area sensor card + inlay
Key Companies: Zwipe AS

- Founded: 2009
- HQ: Norway
- Type: Private
- CEO: Kim Kristian Humborstad
- WEB: zwipe.no

- Strongest IP Portfolio for Biometric solutions with >50 patents
- Kuang-Chi Group partner for China JV and 20.1% stake
- First company to have trials with MasterCard
- Inlay-based solution tailored for card manufacturers
- Sensor agnostic solution, currently delivering FPC FPS
- Ongoing development of custom ASIC to reduce components + costs
- Key Products:
  - Access Control BSC (non-ISO, replaceable battery)
  - Contactless Energy harvesting BSC (ID)
  - Dual Interface Energy Harvesting BSC inlay (Payment)
# The Offer: Whom is Offering What

<table>
<thead>
<tr>
<th></th>
<th>Non-Rechargeable Battery</th>
<th>Rechargeable Battery + Chip Contact</th>
<th>Rechargeable Battery + Energy Harvesting</th>
<th>No Battery + Chip Contact</th>
<th>No Battery + Energy Harvesting</th>
<th>Replaceable Battery</th>
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<tr>
<td>CardLab</td>
<td>✓</td>
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<td>MeReal Biometrics</td>
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<td>Morix</td>
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The Offer: Tier 1 Company Developments

Gemalto
- Ongoing Industrialization in France & Germany R&D / plants
- Marketing activity started
- Expected Launch Q1/2018

Idemia
- First among top card vendors to have completed industrialization
- BSC in production
- Leverage Morpho expertise in biometric
- Active joint promotion with MasterCard
- In-house inlay production, no OEM sell
- Current solution with non-rechargeable battery

G+D
- Not aware of any development
- Could continue development of Bundesdruckerei GoID! fibre composite card if migrated to Veridos portfolio

Korea Smart ID (KSID)
- So far, KSID is the company with the largest quantity of Biometric Cards produced
- Key Customers:
  - UN
  - Instanbul Municipality
  - Woori Bank

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Global BSC Shipment Forecast Y2017-2020

Normative References

Standards developed by Technical Committee ISO/IEC JTC 1/SC 17
Cards and personal identification

The current area of work for JTC 1/SC 17 consists of:
• Identification and related documents
• Cards, and
• Security devices associated with their use in inter-industry applications and international interchange

Details at https://www.iso.org/committee/45144.html
Normative References

ISO/IEC 17839-1:2014 - Biometric System-on-Card
Part 1: Core requirements

<table>
<thead>
<tr>
<th>Type S1 “conventional”</th>
<th>Type S2 (ID-T) “ticker” – NEW FORMAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions ID-1 as ISO/IEC 7810</td>
<td>Card is 2.5 mm (0.098 in) thick</td>
</tr>
<tr>
<td>Torsion and bending as ISO/IEC 7816-1</td>
<td>2.5 mm thick card cannot be inserted in card slot by mistake</td>
</tr>
<tr>
<td>Contact interface as specified in ISO/IEC 7816-3</td>
<td>Width / height as an ISO/IEC 7810 card</td>
</tr>
<tr>
<td>USB interface as specified in ISO/IEC 7816-12</td>
<td>Need not conform to ISO/IEC 7816-1 flexibility</td>
</tr>
<tr>
<td>Contactless interface as specified in ISO/IEC 14443</td>
<td>Supports only ISO/IEC 14443 contactless interface</td>
</tr>
</tbody>
</table>

Regardless of S1 or S2, a BSC must have some form of feedback mechanism such as LCD display, LED or buzzer

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Normative References

ISO/IEC 17839-1:2014 - Biometric System-on-Card
Part 1: Core requirements

The minimum size of an area sensor shall be 169mm²
(13 × 13 mm or 0.512 × 0.512 in)

In the case of a swipe sensor, the effective area of fingerprint capture is bigger than the sensor size. A swipe sensor shall have a minimum width of 13 mm (0.512 in)

Allows fingerprint sensor, voice microphone, camera for facial image, signature input pad
Normative References

ISO/IEC 17839-3:2016 - Biometric System-on-Card --
Part 3: Logical information interchange mechanism

ISO/IEC 17839-3:2016 covers:

• Commands and data structures
• Internal Enrollment and External Enrollment
• Initiation of verification
• Status feedback
• Processing time management and extension
• Capability discovery mechanism
Normative References

Other ISO TS / TR

- ISO/IEC 24787:2010 - On-card biometric comparison
- ISO/IEC 18584:2015 - Conformance test requirements for on-card biometric comparison applications
Normative References

Focus on EMV® 2\textsuperscript{nd} Generation Specifications

- EMV 2\textsuperscript{nd} Generation Specifications in progress:
  - Biometric Terminal effective from Jan 1, 2018
  - Biometric Card in progress, next meeting Paris Nov. 2017
- EMV 3-D Secure 2.0
  - Specifies use of multiple options for step-up authentication, including biometrics

Visa, MasterCard and Amex have updated their Payment Applet specs allowing Fingerprint Verification to be used as PIN alternative.
Normative References

Payment service (PSD2) – Directive (EU) 2015/2366

- It provides the legal foundation for the further development of a better integrated internal market for electronic payments within the EU.
- It puts in place comprehensive rules for payment services with the goal of making international payments (within the EU) as easy, efficient and secure as payments within a single country.
- Requires **Strong Customer Authentication**, using at least two independent elements categorized as:
  - **Knowledge**: PIN
  - **Possession**: Card
  - **Inherence**: Fingerprint
Normative References

ICAO Doc Series 9303 – Machine Readable Travel Documents

- ICAO – Doc 9303 – Part 9: Deployment of Biometric Identification and Electronic Storage of Data in eMRTDs
- ICAO – Doc 9303 – Part 10: Logical Data Structure (LDS) for Storage of Biometrics and Other Data in the Contactless Integrated Circuit (IC)

Focus on storage / format / interoperability of biometric data into eMRTD.

No references to BSoC.
Fingerprint Cards Acceptance Factors

**CONSUMERS**
- Familiarity with smart cards
- Familiarity with smartphones
- Increasing acceptance for new technologies
- Slow acceptance of mobile payments

**LEGAL**
- Compliant with most regional / national legal frameworks demanding biometric data not to be stored in public DB.
- EU GDPR effective May 2018 prohibits processing of “Biometric Data”

**INDUSTRY**
- Need to reduce Card-Present Fraud
- Improve Identification / Verification processes
- Growing focus on Safety/Security of physical assets
- Minor or no infrastructure upgrade cost
- Rising immigration control & MRTD verification

**HEALTH**
- Risk of infection transmission with standalone Fingerprint scanner (rotavirus, norovirus, hepatitis A virus, respiratory syncytial virus, rhinovirus, influenza virus, Shigella dysenteriae, Enterohemorrhagic Escherichia coli, etc.)
Fingerprint Cards Potential Blocking/Risk Factors

• Rejection due to personal reasons.
• Cultural incompatibility.
• Absence of respective biometric feature.
• Insufficient characteristics of the respective biometric feature.
• Abnormal characteristic of the respective biometric feature.
• Criminal organizations might develop techniques to fool fingerprint sensor (liveness detector, blood detector, etc.).
• Because Biometric features are static, stolen (capture, cloned, forged) biometric cannot be revoked or changed.
• Challenge to get product working in Hot / Dry / Dirty environment.
• Competing mobile payment technology may impact the smart card market.
The Future

- Vein sensing capability
- Blood flow / heartbeat detection
- FPS IC + RF IC + MCU integrated into Smart Card Chip
- FPS under conductive plastic
- Contactless fingerprint
- Behavioural biometric
- DNA scanner
Thanks!

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- https://www.youtube.com/watch?v=jw_4uaRNsBA&t=1228s
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Biometric Application Programming Interface (API) for Java Card, NIST/Biometric Consortium Biometric Interoperability, Assurance, and Performance Working Group, version 1.1 (August 2002)


Privacy-preserving biometric authentication: challenges and directions, Elena Pagnin, Aikaterini Mitrokotsa Chalmers University of Technology Gothenburg, Sweden (2017)


Specs


ISO/IEC 17839-2:2015 Biometric System-on-Card: physical characteristics


ISO/IEC 19785-3 Information technology – Common Biometric Exchange Formats Framework – Patron format specifications


ISO/IEC 19794-2:2011/Cor 1:2012 – XML encoding and clarification of defects

ISO/IEC 19794-2:2011/Amd 1:2013 – Conformance testing methodology and clarification of defects

ISO/IEC 19794-2:2011/Amd 2:2015 – Conformance testing methodology and clarification of defects


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Acronyms

2FA  Two-Factors Authentication
3FA  Three-Factors Authentication
ASIC Application-specific integrated circuit
AOC Authentication On Card
ASP Average Selling Price
BSC Biometric Smart Card
BSoC Biometric System on Cards
CBEFF Common Biometric Exchange File Format
COF Chip On Film
FPC Fingerprint Card
FPCB Flexible Printed Circuit Board
FPS Fingerprint Sensor
JV Joint Venture
MOC Match-on-Card
MCU Micro Controller Unit
NFC Near field communication
OTP One Time Password
PC Polycarbonate
PETG Polyethylene terephthalate
PII Personally Identifiable Information
PSD2 Payment Service Directive
PVC Polyvinyl chloride
RFID Radio-frequency identification
SC Supercapacitor
SE Secure Element
SW Software
TOC Template-On-Card