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// How to future-proof your IoT device

Achieving 'Secure by Design' for IoT and connected devices

Developing a secure, smart consumer product from concept all the way through to operation, including manufacture and over-the-air (OTA) updates, means shifting to a security mindset. You need to think about security early in your IoT projects and product planning process, and invest in a secure development lifecycle.

2.5B cyberattacks on IOT devices since 2019*

Here we set out key stages you should go through when considering security in your Internet of Things (IoT) device to comply with the UK's Secure by Design (SbD) principles. It's worth noting that the UK Government is taking 'decisive action' on security; 'advocating a robust and staged approach to enforcing these principles through regulation' and 'leading efforts to create international alignment on IoT security'. The UK's consumer connectable product security regime will come into effect on 29 April 2024 and businesses involved in the supply chains of these products will need to be compliant with the region by this date.

Consult Red's experience in the design and development of smart, connected devices and systems can reduce your time to market and manage cyber security risks to deliver truly secure IoT products.

13 Principles in the UK Government's 'Secure by Design' Code of Practice

// Secure by Design - Guidance at a glance

SbD1 – No default passwords
All IoT device passwords must be unique and not resettable to any universal factory default value.

SbD2 – Implement a vulnerability disclosure policy
Provide a public point of contact so that security researchers and others are able to report issues.

SbD3 – Keep software updated
Software components in internet-connected devices should be securely updateable.

SbD4 – Securely store credentials and security-sensitive data
Any credentials must be stored securely within services and on devices. Hardcoded credentials in device software are not acceptable.

SbD5 – Communicate securely
Security-sensitive data, including any remote management and control, should be encrypted in transit.

SbD6 – Minimise exposed attack surfaces
All devices and services should operate on the 'principle of least privilege'.

SbD7 – Ensure software integrity
Software on IoT devices must be verified using secure boot mechanisms.

SbD8 – Ensure personal data is protected
Where devices and/ or services process personal data they should do so in accordance with data protection law.

SbD9 – Make systems resilient to outages
Resilience must be built in to IoT services where required by the usage or other relying systems.

SbD10 – Monitor system telemetry data
If telemetry data is collected from IoT devices and services, such as usage and measurement data, it should be monitored for security anomalies.

SbD11 – Make it easy for consumers to delete personal data
Devices and services should be configured such that personal data can easily be removed or deleted by the consumer.

SbD12 – Make installation and maintenance of devices easy
Installation and maintenance of IoT devices should employ minimal steps and should follow security best practice on usability.

SbD13 – Validate Input data
Data input via user interfaces and transferred via application programming interfaces (APIs) or between networks must be validated.

Access full definitions and details of the UK Government's Secure by Design principles here:

// A 7 stage approach to securing your IoT device

1 // The Beginning - Requirements Analysis

It's important to approach your product design with a security mindset and invest in a secure development lifecycle from the start. If security is not captured at the beginning, don't expect it to be there at the end!

This starts by ensuring your product and operational requirements comply with the SbD Code of Practice and includes features such as easy installation and update, deletion and protection of personal data, resilience to outages, software integrity, secure communication, and other requirements as appropriate.

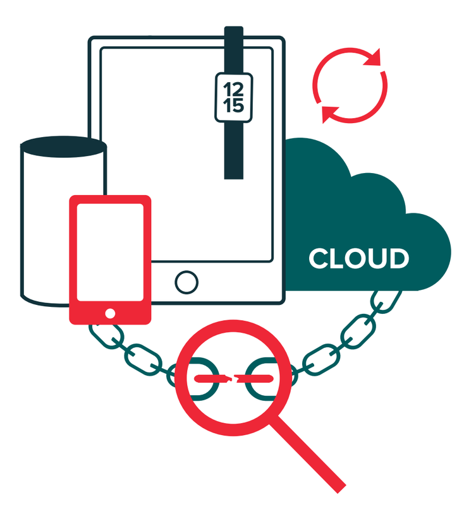
- SbD8 Ensure personal data is protected ✓
- SbD9 Make systems resilient to outages ✓
- SbD11 Make it easy for consumers to delete personal data ✓
- SbD12 Make installation and maintenance easy ✓

2 // Before Manufacture - Attack Surface Analysis

IoT expands the attack surface, so you'll need a system wide review of all physical, electrical and wireless interfaces to understand all vulnerabilities that could be exploited.

The goal of the review is to minimise and mitigate risk, so it needs to include product development, scaling to volume manufacture and product rollouts.

- SbD6 Minimise exposed attack surfaces ✓



Attack surface considerations:

- **Deterrence:** What can be done to deter attacks in the first place?
- **Prevention:** This generally drives the implementation, it can involve aspects such as encryption or signing or one time programming.
- **Detection:** How will we know if security is breached?
- **Correction & Counter Measures:** How is a breach managed? This may involve the revocation of keys, certificates or software.

Needs more analysis

3 // Before Manufacture - Design and Development

Incorporate your attack surface analysis into the product design. Our design approach always seeks to leverage proven and approved security technologies.

Implementation can introduce vulnerabilities, so review and testing are important at this stage.

For instance, this is when negative testing can be used to check input data is being correctly validated or impaired network testing can verify resilience.

In some cases, an independent audit may be needed. It's likely you'll go back and forth between these stages a few times until you get something that works and is secure.

- SbD5 Communicate securely ✓
- SbD13 Validate input data ✓

4 // Before Manufacture - Production Planning

Planning how you'll securely manufacture and deploy your device in the field is an important step.

For instance, if you're considering emailing product security keys to the factory, then your products won't be secure. If you're deploying unique passwords to each device, how will you communicate that password?

This is an often overlooked step but taking shortcuts can compromise your device later on (and prove costly to fix).

- SbD1 No default passwords ✓
- SbD2 Implement a vulnerability disclosure policy ✓

5 // During Manufacture - Secure Key Generation

To be truly secure, each device needs at least one (or more) unique keys securing different functions. These keys must never be available in the clear.

In the following example, we supplied hardware to the factory in China, to ensure chip-to-cloud security. This approach can be adopted for manufacturing sites anywhere in the world and seamlessly scales from proof of concept to millions of devices.

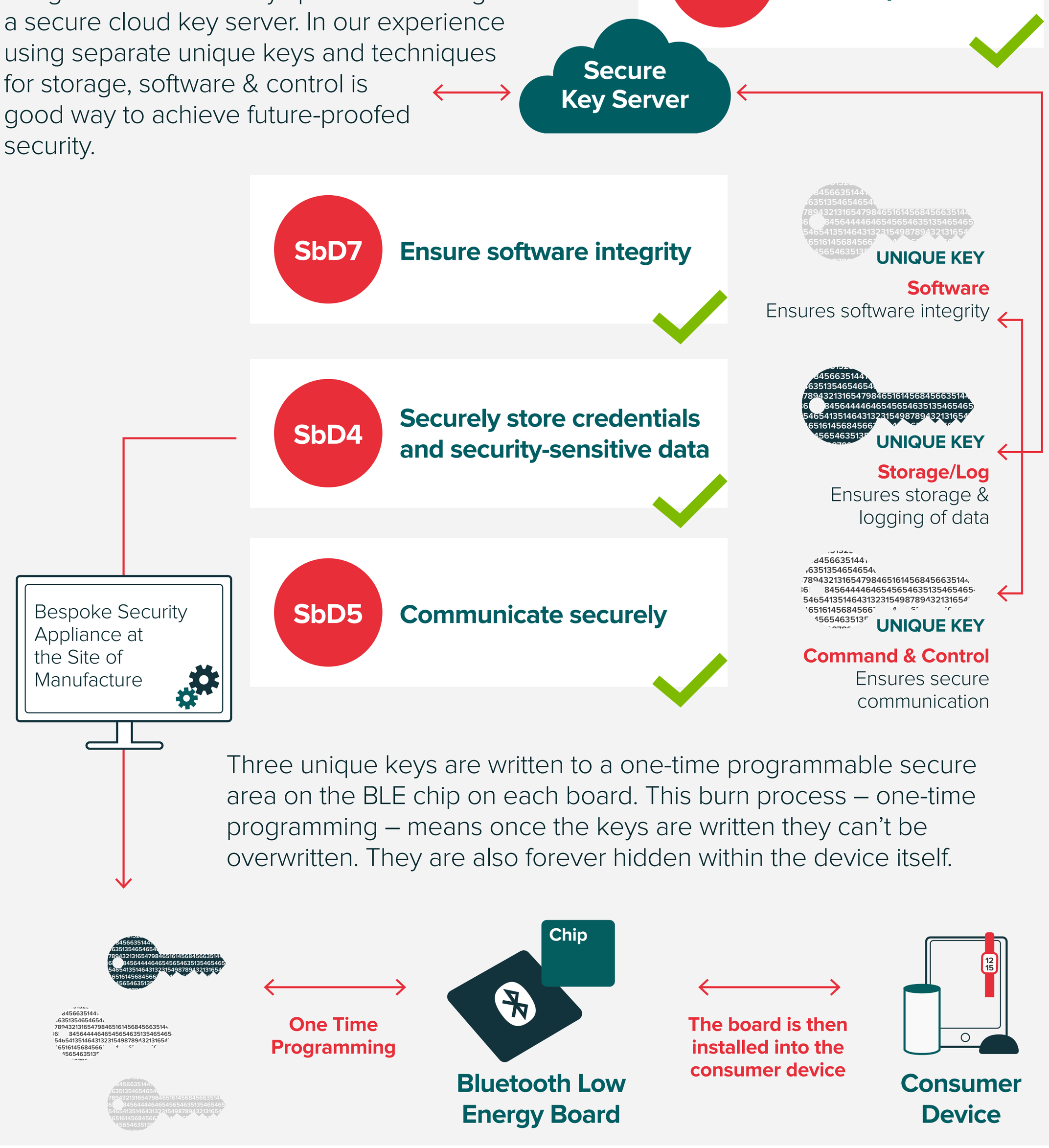
// Example: Delivering Secure IoT during Manufacture

How we delivered turn-key, future-proof and secure IoT during manufacture. The implementation of a Bluetooth Low Energy board with secure multiple key injections in a smart device.

Keys generation process

We generated three keys per device using a secure cloud key server. In our experience using separate unique keys and techniques for storage, software & control is good way to achieve future-proofed security.

- SbD7 Ensure personal data is protected ✓
- SbD7 Ensure software integrity ✓
- SbD4 Securely store credentials and security-sensitive data ✓
- SbD5 Communicate securely ✓

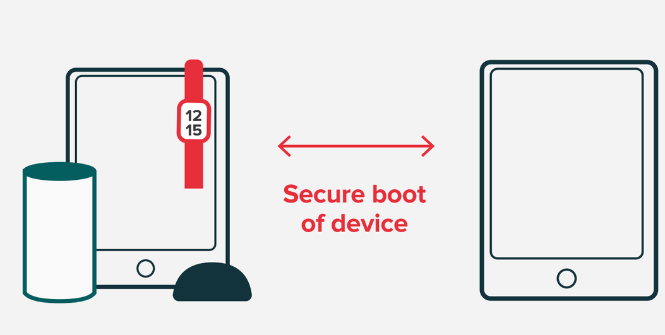


Three unique keys are written to a one-time programmable secure area on the BLE chip on each board. This burn process – one-time programming – means once the keys are written they can't be overwritten. They are also forever hidden within the device itself.

6 // Operation & Updates - Consumer Device in the Field

Any unprotected device in the field will have its weaknesses – multiple potential attack points, such as interfaces and data exchanges.

The ability to disable the device if tampering is detected adds further security in the field.



Secure Software Display

- Measured metrics and communicated data
- Firmware version
- Error code

Keys are never sent in the clear but are asymmetrically encrypted for the target application. Because of the unique keys per device generated during manufacture, communication between the consumer device and the server is all encrypted.

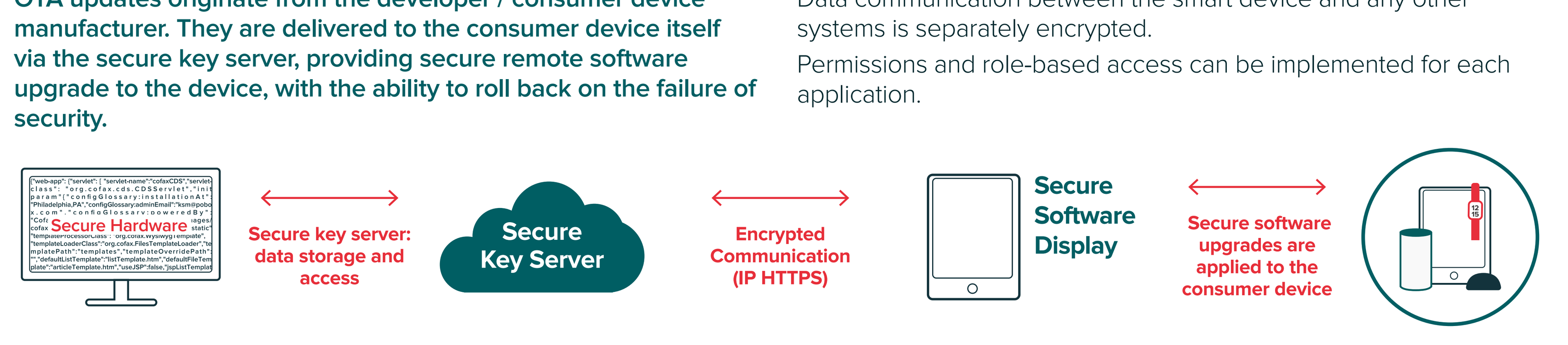
- SbD3 Keep software updated ✓

7 // Operation & Updates - OTA Updates and Data Communication

OTA updates originate from the developer / consumer device manufacturer. They are delivered to the consumer device itself via the secure key server, providing secure remote software upgrade to the device, with the ability to roll back on the failure of security.

Data communication between the smart device and any other systems is separately encrypted.

Permissions and role-based access can be implemented for each application.



Software signing service within the cloud, which securely generates encryption keys for new images and securely wraps them for individual devices.

Each smart device has its own unique keys which means there are **no default passwords.**

Logging: there is an upload logging, decipher and audit function that is used to detect tampering and disable the device, which supports the disclosure process.

- SbD7 Ensure software integrity ✓
- SbD1 No default passwords ✓
- SbD2 Implement a vulnerability disclosure policy ✓
- SbD5 Communicate securely ✓

// Total Life Cycle - Maintaining Trust

Threats emerge over time. Secure by Design requires a vulnerability disclosure policy for your product and you will need to monitor vulnerability disclosures and security updates of any third-party components you have used. This requires ongoing vigilance, monitoring of breach detection, looking for unusual behaviour and active follow up. Maintaining trust requires product life cycle management.

- SbD2 Implement a vulnerability disclosure policy ✓
- SbD10 Monitor system telemetry data ✓

// Securing Your IoT Device - IoT Security Checklist Is It Secure?

If you're looking to design, develop or deploy a trustworthy, futureproof, secure IoT product, then why not download our Secure by Design product development checklist?

Consult Red is a technology development partner helping clients deliver connected devices and systems, supporting them through the entire product development journey.

We've helped to develop hundreds of connected devices and systems - from concept to millions of deployed products - for some of the world's largest brands. We know the journey and can help you manage risk and get to market faster.

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*Reference: The Internet of Things Security Market – Forecasts from 2022 to 2027 report released by Research and Markets.