Digital Calibration Certificates in IoT

Internet of Things (IoT) devices can generate enormous amounts of measurement data from many different kinds of applications. The data is often gathered to gain insights about processes and environments, and to make data-driven decisions, for example by applying AI. However, if the measurement data is not accurate enough for its application, it will not be useful. This is why metrology and traceable calibrations are important for IoT. While metrology has conventionally used analogue paper-based calibration certificates there has been a development of digitalization in metrology through machine-readable calibration certificates in recent years.

Digital Calibration Certificate

A Digital Calibration Certificate (DCC) is a digital document that replaces the analogue calibration certificate. A DCC is not a simple digitalization of paper-based calibration certificates, such as a PDF, but it provides all the calibration data in a machine-readable format. This means that the information of the certificate can be transferred directly and automatically to all digitally supported processes, hence supporting digitalization and Industry 4.0.

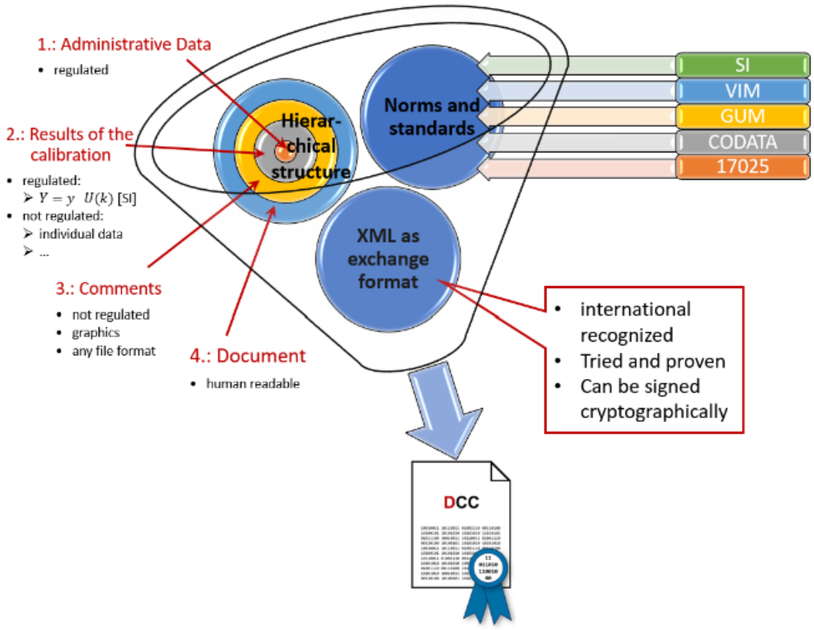
Development

The development of the DCC is running under active cooperation of numerous organizations and persons. It was initiated in 2017 by PTB and later the EMPIR project SmartCom, that ran from 2018 to 2021, was the first to develop a concept for the requirements of DCCs. While SmartCom focused on the definitions of the DCC, the current project GEMIMEG-II running from 2020-2023 focuses on the development of DCCs based on the definitions from SmartCom. Parallel to these there is also a EURAMET project TC-IM 1448 that works on the development of DCCs running from 2018 to 2023, one activity of which will be to define the minimum requirements regarding content and interfaces.

The DCC is developed in accordance with international standards within metrology, such as ISO/IEC 17025 and GUM. It is worth mentioning, that the DCC is also using the D-SI (digital system of units) meta data format as its basis, which has been established for the easy-to-use, safe, harmonised, and unambiguous digital transfer of metrological data.

Structure of the DCC

The DCC proposed by PTB consists of four layers. First, there is the administrative data which is a regulated part of the DCC. It must contain regulated information for unique identification of several entities related to the calibration. The next layer is the calibration results. Part of this is regulated information about values and units. There can be additional non-regulated individual data. The third layer is optional and not regulated and contains additional comments or graphics. The last layer is also optional and can contain a human-readable version of the calibration certificate, e.g., a PDF of the analogue certificate.



Basic structure of the DCC by PTB. Source: www.ptb.de

The DCC is based on the widely used format for data exchange, called XML (Extensible Markup Language), which makes it machine-readable. An XML schema definition (XSD) that describes this DCC structure has been developed by PTB, the existence of which makes the DCC not only machine-readable but also machine-executable. It is also equally important to have a DCC that is machine-interpretable, which is the reason why a set of Good Practice guides for DCCs is being developed. These will refer, at the first stage, to temperature calibrations and then at a later stage to pressure, humidity, and mass.

Furthermore, METAS has created a different structure for the DCC where data is embedded in a PDF/A-3 document.

Value of the DCC for IoT

The value of DCCs for IoT and Industry 4.0 is first and foremost that they convey the measurement uncertainty of the devices and ensure the metrological traceability of the measurement results by providing a direct reference to the traceability chain. Especially for Industry 4.0 and its data-centric approach, the DCC can play a key role since it will be possible to assess the quality and check the validity of the measurements through uncertainty and traceability in real or quasi-real time. Ultimately the data collected through IoT sensors in Industry 4.0 applications will be used by machine learning algorithms and/or digital twins, therefore the use of DCCs will also help increase the trustworthiness of these algorithms and models. Another benefit associated with using DCCs in IoT applications is that due to the standardized structure and the good practice guides around the DCC, interoperability between different systems and sensors will be facilitated.

Furthermore, the use of DCCs provides new added-value opportunities, apart from the easiness in the exchange of calibration results. Developing a system to exchange digital calibration certificates between the national metrology institutes, the designated calibration laboratories and the industry will allow enterprises to receive and process certificates with less costs and faster, reducing at the same time the human errors by simply reducing the human intervention. Lastly, the availability of calibration data from a series of calibrations in a machine-readable format will enable a more thorough analysis of the data to better understand the state and behaviour of the devices.

Security

Another important aspect regarding DCCs is security. Data security in IoT has often been given lower priority partly due to cost, but when applying DCCs it becomes even more important. If a DCC cannot be authenticated or the integrity cannot be proven the value of a DCC is lost since the DCC is used to assess the quality and therefore the value of data. However, if the DCC cannot be trusted neither can that assessment. Moreover, the confidentiality of the DCC must be ensured such that it's only available for the entities which need it. One way of securing a DCC is to use digital signatures. A digital signature is a common and effective cryptographical way of securing files based on public-key cryptography. Digital signatures are already in use on analogue calibration certificates in PDF format and can also be used on DCCs.

Challenges

Using DCCs in IoT systems entails certain challenges compared to other use cases, for example in specialized laboratories. Some of these challenges stem from the fact that IoT systems can be complex simply due to the number of devices. Calibrating thousands of devices can be comprehensive and there are different approaches both in relation to performing the calibrations, for example through reference sensors, but also regarding the storage of calibration certificates such that the calibration data is available within the system when needed. The DCC might commonly be stored on the cloud, but in some cases, it could be beneficial to store the DCC, or part of it, on the IoT device itself. That might be relevant for example in edge computing where more data processing is carried out on the device itself.

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