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Digital calibration certificate in metrology

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Abstract

The current practices regarding traceability and handling of metrological data are lacking definitive standards that would allow a higher level of digitalization. The traceability of metrological instruments is verified with calibration certificates that are currently either paper documents or pdf files. This means that many of the processes where metrological data, such as calibration data, are handled still require human operations. EMPIR project SmartCom aims to define an Extensible Markup Language (XML) based structure for machine readable and processable digital calibration certificates and establish a framework, which allows unambiguous and secure handling and transfer of metrological data in Internet of Things (IoT) and cloud applications. Establishing this framework requires changes in the current practices especially in the areas of authentication and data security. Due to the significance of these changes, a lot of co-operation between institutions, companies and authorities in the field of metrology will be needed for successful global standardization of digital transfer of metrological data.

Digital calibration certificate, Calibration, Metrology, Traceability

1. Introduction

In order to verify that metrological instruments are providing accurate measurement results, the instruments must be regularly calibrated by using a more accurate and precise instrument or measurement standard for validation. This procedure is required for creating a link between the measurement instrument and the corresponding physical quantity.

The current practice in the handling of calibration data has been that when an instrument has been calibrated the information from the calibration will be included in a calibration certificate and provided to the owner the instrument as either a paper or a pdf document. As these formats are not machine readable, manual work is required for inputting the relevant calibration data into data management systems. Some manufacturers have implemented electronic data sheets such as Transducer Electronic Data Sheets (TEDS), but a standardized way for including metadata into the measurement devices does not exist. The lack of automation in data handling processes cause difficulties in data integrity and demands additional work in e.g. quality management in production environments where precise measurements are needed. Additionally, in facilities where a large number of measurement instruments are used storing a large number of paper certificates requires a lot of space and strict safety precautions.

2. Digital calibration certificate format

SmartCom EMPIR project aims to define an Extensible Markup Language (XML) based structure for machine readable and processable Digital Calibration Certificates (DCC) and establish a framework, which allows unambiguous and secure handling and transfer of metrological data in Internet of Things (IoT) and cloud applications.

The concept of DCC used as the basis for SmartCom was originally presented by PTB. XML was selected as the basis of the concept due to its machine-readability and its suitability for securing data with cryptographic methods. To minimize the need for changes in the current practices, the concept was developed based on the existing standards in metrology. [1-5]

2.1. Digital system of units D-SI

Since numerical values and units are required for correct presentation of metrological data, a format for their digitalized presentation is required. Digital System of Units (D-SI) was developed in SmartCom as a proposal for a standardized format for the digital presentation of the numerical measurement values combined with units. Additionally the D-SI includes presentations for metadata such as measurement uncertainty, descriptions of uncertainty distributions and time stamps. [6] To avoid errors due to misinterpretations of units the D-SI is based on the SI system. Since there are several different units used globally that are not included in the SI units, the D-SI format is defined to allow presenting numerical values using different units than the SI units, but in these cases the numerical values must also be presented in SI. [6, 7]

2.2. Standardization

Since the current practises and regulations concerning calibrations can be very different in different countries close co-operation between the National Metrology Institutes (NMI), industries and authorities is required globally to ensure that the digitalized format fulfils all the requirements. The DCC and D-SI proposals will be provided by SmartCom, but a lot of work and co-operation will still be required for standardizing the digital transfer of metrological data globally. Currently the standardization process is being carried out by the International

Committee of Weights and Measures (CIPM) in the Working Group on Data and the Task Group on the Digital SI.

3. Security of DCC

The current practises for authenticating calibration certificates are either hand written signatures or stamps for paper documents and electronic signatures for pdf documents. However, even electronic signatures do have weaknesses in terms of data authenticity and integrity.

3.1. Digital signatures

The security of the DCCs can be improved in comparison to the current certificate formats by using digital signatures for authenticating the documents, as digital signatures are more suitable for verifying and thus preventing manipulations or counterfeits. This can be achieved with public-key cryptography.

However, transition to using digital signatures to secure certificates requires a lot of attention to be paid on managing the private and public keys required for creating and verifying digital signatures. For this purpose, globally established key management infrastructures and regulations are needed.

The Electronic Identification, Authentication and Trust Services (eIDAS) is the regulation under which EU citizens and organisations can add digital signatures to documents and verify the authenticity of digitally signed documents [8]. The eIDAS is one of the references used in SmartCom for defining a concept for a global identification infrastructure for metrology.

3.2. Distributed ledgers

One possible way to secure DCCs and calibration chains is using Distributed Ledger Technologies (DLT) for storing digital fingerprints i.e. hashes of the DCCs. Hashes stored using DLTs could be used for verifying when a certificate was signed and by whom and whether the signature is valid or revoked. The main benefit of DLTs is that counterfeiting a document and its hash will effect any subsequent hashes in that ledger. This means that counterfeiting any of the documents, which has its hash in the ledger would require that hash to be counterfeited as well as every subsequent hashes in the ledgers, which will also have their corresponding documents or in this case DCCs. [9, 10]

4. Benefits of DCC in engineering applications

In precision engineering achieving tolerances requires precise manufacturing methods, which are based on precise measurements. Manufacturing of complex machine parts may involve measuring instruments with long calibration chains, which can lead to a loss of accuracy [11]. Having calibration data available in a standardized machine-readable format for each individual measurement instrument allows automatized assessment of production lines. This allows further optimization of assemblies when tolerances can be analysed more efficiently.

With the digital format, the data management of the certificates can be made more efficient when the amount of data that requires manual inputting to data management systems can be reduced. This also significantly improves data integrity as the likelihood of human errors in the process can be minimized. This would be most beneficial in legal metrology and other areas such as pharmaceutical industry where the use of metrological instruments is strictly regulated.

The calibration intervals for measurement instruments are defined in quality management standards or regulations such as the ISO 9000 [12]. These intervals are typically given as months or years regardless of what the actual need for recalibration of each individual instrument type is. With digitalized calibration data it is much easier to assess the behaviour of each instrument type over time e.g. to see if drifting or other similar phenomena occurs over time and at what point the precision of a measurement instrument is affected so much that it would have to be recalibrated. This would allow more efficient optimization of recalibration intervals based on the actual needs. Optimizing the calibration intervals can significantly reduce the calibration costs if it can be proven that longer intervals do not have remarkable effects on the product quality.

5. Conclusions

Since significant changes in the current practices in calibration and handling of metrological data are required, respectively a lot of work will be needed to achieve global standards. In this process, the co-operation between the NMIs, authorities and companies must be emphasized. EMPIR project SmartCom aims to define an XML based structure for machine readable and processable digital calibration certificates and establish a framework, which allows unambiguous and secure handling and transfer of metrological data in IoT and cloud applications.

The ongoing work in SmartCom, CIPM Working Groups and other research activities related to digitalization in the field are important steps towards globally standardized data formats and transfer for metrology. Currently a second EMPIR project is being proposed to continue the work done in SmartCom. With the supporting infrastructure in place DCCs will provide solid foundation for more digital applications for secure, traceable and authenticated metrological data, which offer significant benefits over the current practices. Validating the benefits and finding possible applications for DCCs offer topics for additional individual research. Demonstrators of DCC implementations will be developed in SmartCom and follow-up research projects.

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