Publishable Summary for 17IND02 SmartCom
Communication and validation of smart data in IoT-networks

Overview

The central mission of this project is to develop and provide the basis for a secure, unambiguous and unified exchange of data in all communication networks, where metrological data is used. The SmartCom project will develop, provide and distribute a formal framework for the transmission of metrology data based on the SI (International System of Units). The framework will be applicable to all metrology domains. Furthermore, a worldwide applicable concept, summarising minimum requirements for the use of digital calibration certificates (DCCs) will be available for the first time ever.

Need

An Internet of Things (IoT) network provides the capability of communicating data within the network and to data hubs. However, the value of the data depends on its ability to be interpreted correctly. For metrology data, effective use of the data is also only possible, if the unit and uncertainty associated with the numerical value, expressed in a standard format, are also available.

Current cloud storage and services provide state-of-the-art capabilities to store data, but on their own provide no information on the origin of the data or how to interpret it correctly. Therefore, an essential component of a digitally enabled metrology landscape for IoT that can meet the requirements of calibration, traceability and legal metrology is the automatic and secure communication of all relevant elements of the data and metadata. This should enable an unambiguous and correct interpretation of the data. The interoperability of metrology data is severely impaired if essential information is lost or corrupted and current protocols do not address this issue.

In general, the confusion, ambiguity and incorrect interpretation caused by missing metadata, diversity of units, etc., represent a significant risk for future investments in IoT technologies. If the IoT is to bring benefits to society, it must be based on well-engineered principles, including those derived from the metrological concepts of traceability, uncertainty and interoperability. In order to avoid future loss of information and consequent impact on decision-making and to make human lives and environment secure, the exchange of metrological information (measurement results and associated information) must be defined for all measurement tasks.

Objectives

The overall goal of the project is to provide the methodological and technical foundation for an unambiguous, universal, safe and uniform communication of metrological data in the IoT. The specific objectives of the project are:

1. To define the requirements for a uniform, unambiguous and safe exchange format for measurement data and metrological information in an IoT network. The exchange format shall be based on the definition of SI units and meet central requirements from standards, guidelines and legal metrology.
2. To develop and establish secure DCC. This should include exchange formats for administrative information, data transfer, cryptographic requirements, authentication and digital signatures.
3. To develop an online validation for services system for the types of data format as addressed under objectives 1 and 2.
4. To develop a reliable, easy to use, validated and secure online conformity assessment procedure designed for cloud system applications for legal metrology. The online conformity assessment procedure should also be applicable for calibration services and provide compliance with current international and European standards.
5. To build and validate demonstrators involving running applications from industrial stakeholders, to facilitate the take up of the technology and measurement infrastructure developed in the project by

the measurement supply chain, standards developing organisations and end users, and to work towards a European platform for metrological calibration services.

Progress beyond the state of the art

This project is intended to create the methodological and technical foundation for the unambiguous, universal, safe and uniform communication of metrological data in IoT and Industry 4.0 (i.e. the next step towards the digitization of our society and economy, in which objects and people are connected to each other).

The project will go beyond the state of the art by defining requirements for a uniform, unambiguous and safe exchange format for measurement data and metrological information in an IoT network. It will be based on the definition of a metrological domain-independent exchange format based on the internationally agreed SI-Units. The project has already initiated this by producing a publicly available brochure describing a new machine-readable data representation based on such metrological standards and regulations. Today measurement results can be communicated in SI, but also in domain-specific formats such as feet, rad, inch, weber, gallons, etc. A BIPM brochure gives advice on how to specify derived units in the SI. However, this system is not sufficient for the automated data processing required in IoT, where information must be understood unambiguously and worldwide. Here, a main goal of the SmartCom project is the definition of a data exchange format where the expression of measurement results in SI units is mandatory. Optional information such as domain specific or derived units will be covered as well as additional information.

Exchange of printed calibration certificates or encrypted PDF/A (standardised by the International Organization for Standardization (ISO)) is still state of the art. However, their use is not widespread in legal metrology. Automated processing of the information included is also not possible. Therefore, another important goal of SmartCom is to develop and provide the basis for machine readable calibration certificates, to be used in worldwide communication of calibration information.

Results

Objective 1: To define the requirements for a uniform, unambiguous and safe exchange format for measurement data and metrological information in an IoT network.

A brochure describing a new machine-readable data representation based on metrological standards and regulations like GUM, VIM or BIPM SI-brochure has been prepared "*SmartCom Digital System of Units (D-SI) Guide for the use of the metadata-format used in metrology for the easy-to-use, safe, harmonised and unambiguous digital transfer of metrological data*" and made publicly available https://doi.org/10.5281/zenodo.3522631. At the moment, this brochure covers real, complex and vectoral quantities as well as formats for fundamental constants and will be optimised successively in the course of the project. The description of the data format is accompanied by a realisation of it in Extensible Markup Language (XML) making it easily usable. In addition, a short and end-user focussed 'catchy' version of the digital SI format was developed an is provided as a digital brochure.

Objective 2: To develop and establish secure DCC. This should include exchange formats for administrative information, data transfer, cryptographic requirements, authentication and digital signatures.

The SmartCom concept of a digital calibration certificate (DCC) is available and can be accessed via a GitLab repository by project stakeholders. In addition, the DCC concept has been presented on many occasions such as a PTB seminar on metrology, the APMP conference in 2018 or the MetMap conference in 2019. The DCC structure concept presented consists of administrative(core)-data, measurement-data, comments and a human readable part and has been shown to cover the needs from industry.

First machine-readable digital calibration certificates based on draft outcomes of SmartCom are currently being developed at PTB and Aalto, in cooperation with feedback from local project groups and selected industrial partners in the field of calibration.

Objective 3: To develop an online validation for services system for the types of data format as addressed under objectives 1 and 2.

Online validation is a tool used in metrology. For example, test data for the validation of Gaussian or Chebyshev calculations or the determination of the comparability of measurement results are available as part of the TraCIM ("Traceability for Computationally-Intensive Metrology") platform. TraCIM is a service run at PTB as an outcome of a previous EMRP project NEW06. The validation of software versions by use of check sums is well established and described for example in WELMEC (European Cooperation in legal metrology) Guide 7.2 Measuring Instruments Directive 2004/22/EC. By going beyond this, the SmartCom project will develop for the first-time modules for the validation of SI-based data formats and digital calibration certificates. These modules shall be implemented and made available to industry via the established TraCIM platform.

The TraCIM system will be able to validate data implemented in XML. The required XML implementations for the data formats are already available from the project in objectives 1 & 2: i.e. the general data exchange metadata format and the implementation of the DCC concept.

The concept of validating measurement results by using the established TraCIM system has been presented during project meetings, e.g. with NPL, technical meetings with industrial partners such as Zeiss or Sartorius, the first industrial workshop of the project GemiMeG (project on "secure and robust calibrated measurement systems for the digital transfer") and a PTB seminar on metrology. A wider discussion has been started on a publicly accessible server and interested parties can take part in tests following confirmation by the project consortium (smartcom@ptb.de).

Objective 4: To develop a reliable, easy to use, validated and secure online conformity assessment procedure designed for cloud system applications for legal metrology.

It is intended to produce a guideline on how to establish secure communication interfaces in legal metrology. This guideline will include a security concept and requirements for the transmission of metrological information as well as a concept and technical specifications for a universal terminal for the digitized communication of metrological data.

Objective 5: To build and validate demonstrators involving running applications from industrial stakeholders, to facilitate the take up of the technology and measurement infrastructure developed in the project.

It is intended to provide a client/server-based validation infrastructure ready to be implemented and used by the industrial stakeholders. The validation could be used e. g. for the automation of calibration processes. An additional aim is to develop a graphical user interface which can be used to extract and indicate the core data of DCCs.

Impact

So far, the project has attracted significiant interest from metrological organisations, academia and industry world-wide. A significant highlight is the promotion of SI units for digital communication of metrological data at the International Committee for Weights and Measures (CIPM) whose stakeholders are international standardisation bodies like ISO, IEC and legal metrology organisations like OIML. The promotion by PTB lead to the foundation of the CIPM Task Group "Digital-SI" which is pursuing the future harmonisation of SI units in digital applications.

Furthermore, contacts and dissemination of project outputs were established with stakeholders such as CECIP (the European Weighing Industry Association), EURAMET TC-IM 1448 (DCCs), EURAMET TC-L, VDMA (The Mechanical Engineering Industry Association of Germany), VDI (Association of German Engineers), British accreditation body UKAS, German accreditation body DAkkS, German groups in Research Data Management and many partners from other (EMPIR) projects.

First versions of the DCCs based on the SmartCom definitions are being prepared and tested by the project partners and at PTB by project GemiMeG. The project GemiMeG deals partly with secure and robust calibrated measurement systems for the digital transfer of information and focuses also on the secure distribution and usage of obtained data. Thus, the main link between GemiMeG and SmartCom will be the development of digital calibration certificates based on the SmartCom definitions.

Impact on industrial and other user communities

The most important impact so far is that SmartCom has initiated a worldwide discussion on how metrological information can be communicated in future IoT networks and these discussions are expected to intensify over the remaining life-time of the project.

The SmartCom concept of a uniform and globally available communication protocol is of great interest for industry and calibration services. The project was asked to present the ideas to relevant communities around the world. For example, presentations were held at the APMP conference in Singapore 2018 (a podium discussion), at the international metrology conference and fair CIM in Paris 2019 and at the MatMap 2019 conference (UK). The European weighing industry also invited SmartCom to their annual meeting in 2018 to get information on how to benefit from project results.

In addition, PTB was invited to disseminate the SmartCom concepts and results at strategic meetings of the German Mechanical Engineering Industry Association (VDMA) and the Association of German Engineers (VDI), where the DCC has been identified as an essential part of future metrological infrastructures.

Furthermore, the cooperation between SmartCom and the German project GemiMeG is very promising. GemiMeG is trying to establish a technical infrastructure, supporting software and application examples in the field of digital calibration certification for German industry. SmartCom is involved in discussions with industry, calibration labs and German accreditation body DAkkS. A GemiMeG-workshop addressing the needs of German industry was held in June 2019, where SmartCom was closely involved. In November 2019 a stakeholder workshop was organised at NPL where the need for SmartCom's results was clearly expressed by stakeholders.

Impact on the metrology and scientific communities

The project will enable new services based on mobile communication devices. Electronic-documentation, quality management and assurance will be supported and facilitated. Automatic processing and provision of DCC will be possible as well as automatic reading of calibration values. The project will also support the future new services based on mobile communication devices. The activities of this project will enable NMIs to take a leading role in providing quality assured metrology information to support a well-engineered Industry 4.0 and IoT ecosystem.

In addition to the promotion at CIPM, the project ideas have been presented to regional metrology organisations such as Euro-asian cooperation of national metrological institutions (COOMET), Inter-American Metrology System (SIM) and Asia Pacific Metrology Programme (APMP). The EMPIR Technical Committee IM 1448 "Development of digital calibration certificates" is being coordinated by SmartCom representatives. Outcomes of the project are also being exploited in national German communities for digitalisation in Research Data Management (NFDI4phys & NFDI4ing).

A close cooperation with the EMPIR project 17IND12 Metrology for the factory of the future (Met4FoF) – has resulted in defining joint demonstrators – one regarding the use of the OPC UA communication standard and one to demonstrate the use in MEMS testing. This work will be continued and finalised in the second half of the projects.

Impact on relevant standards

The results of the project can be added to any standard in metrology dealing with certification or exchange of metrological data. The representatives of the consortium are active members in national and international standardisation bodies and committees and have fundamental knowledge in IT and IT-infrastructure. This expertise enables the formulation of end-user friendly interfaces considering the essential context of the SI system and related standards and regulations. The framework of the project will be presented to a broad group of experts at an early stage of the project to enable them to design their software interfaces according to the IoT guidelines defined in this project.

Through connection with the CIPM Task Group on the Digital SI, the related SmartCom results will be installed at the highest level of metrology and will become mandatory for metrological standardisation. In addition, the

SmartCom project has been presented to the Open Platform Communications United Architecture OPC-UA working group and to the Director of Technology of the OPC foundation, and German platform industry 4.0.

Longer-term economic, social and environmental impacts

A significant economic benefit for all future markets involved in IoT will be realised by the adoption of uniform communication specifications, as developed by this project. This will result in shorter timespans from product to market, reduced downtimes, fewer rejected parts, improvements in quality control, better organised maintenance, better conservation of energy and resources and better business.

Another major impact of the project will be that organisations will be able to exchange measurement information digitally, safe in the knowledge that all necessary metadata relating to units and uncertainties have also been exchanged using validated protocols. The benefit of this unambiguous communication of metrological data will be the elimination of financial and societal risks resulting from the misinterpretation of data.

Impact is also expected in the health-sector where a project will be launched in Germany in 2020 working on a secure exchange of medical measurement data between smart devices and emergency-services (ISAN). The outputs of the SmartCom project in combination with national developments from the GemiMeG project are important enablers of the ISAN project.

<table>
<tr><td colspan="2">Project start date and duration:</td><td>June 2018, 36 months</td></tr>
<tr><td colspan="3">Coordinator:
Thomas Wiedenhoefer, PTB, Tel: +49 531 592 9020 E-mail: smartcom@ptb.de
Project website address: https://www.ptb.de/empir2018/smartcom/home/</td></tr>
<tr><td>Internal Funded Partners:
1 PTB, Germany
2 CMI, Czech Republic
3 NPL, United Kingdom
4 UM, Slovenia</td><td>External Funded Partners:
5 Aalto, Finland
6 Ostfalia HAW, Germany
7 TUT, Estonia
8 UNICAS, Italy</td><td>Unfunded Partners:
9 Hexagon, Germany
10 KRISS, Korea, Republic of
11 Mitutoyo, Germany
12 NIM, China
13 Sartorius, Germany
14 Zeiss, Germany</td></tr>
<tr><td colspan="3">RMG 1 - UM, Republic of Slovenia (Employing organisation); PTB, Germany (Guestworking organisation)</td></tr>
</table>