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Contents

Intellectual Property Rights 4
Foreword....4
Modal verbs terminology....4
1 Scope 5
2 References 5
2.1 Normative references 5
2.2 Informative references....5
3 Definitions and abbreviations....6
3.1 Definitions....6
3.2 Abbreviations 6
4 SAREF extension for the Smart Agriculture and Food Chain domain 7
5 Related initiatives....7
5.1 Introduction 7
5.2 Standardization initiatives and associations 7
5.2.1 AEF....7
5.2.2 AgGateway 8
5.2.3 AIOTI 8
5.3 Standards 8
5.4 Ontologies 8
5.5 European projects....8
5.5.1 IoF2020 (H2020 Large Scale Pilot)....8
5.5.2 DISAC project 9
5.5.3 DDINGS project 9
5.5.4 SDF project....9
5.6 ETSI initiatives....9
6 Use cases 10
6.1 Use case 1: On-farm precision farming....10
6.2 Use case 2: Smart irrigation 11
6.3 Use case 3: Agriculture or forestry equipment from the fields in the road....11
6.4 Additional use cases 12
6.4.1 Greenhouses....12
6.4.2 Food chain 12
7 Requirements....12
7.0 Introduction 12
7.1 Livestock farming....13
7.2 Smart Irrigation 14
7.3 Agricultural machines from the field on the road....15
8 Conclusions 15
Annex A: Bibliography 17
History 18

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Smart Machine-to-Machine communications (SmartM2M).

Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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1 Scope

The present document specifies the requirements for an initial semantic model for smart agriculture and food chain domain (AgriFood) based on a limited set of use cases and from available existing data models. The present document is developed in close collaboration with AIOTI, the H2020 Large Scale Pilots and with ETSI activities in the smart agriculture and food chain domain. Further extensions are envisaged in the future to cover entirely the smart agriculture and food chain domain. The associated ETSI TS 103 410-6 [i.13] will define the extension (i.e. the semantic model) for the smart agriculture and food chain domain based on the requirements and use cases specified in the present document.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] European Commission and TNO: "Smart Appliances REFerence ontology (SAREF)", April 2015.

NOTE: Available at http://ontology.tno.nl/saref.

[i.2] European Commission and TNO: "D-S4 Final Report - SMART 2013-0077 - Study on Semantic Assets for Smart Appliances Interoperability", March 2015.

NOTE: Available at https://sites.google.com/site/smartappliancesproject/documents.

[i.3] ETSI TS 103 264 (V1.1.1) (11-2015): "SmartM2M; Smart Appliances; Reference Ontology and oneM2M Mapping".

[i.4] ETSI TR 103 411 (V1.1.1) (02-2017): "SmartM2M; Smart Appliances; SAREF extension investigation".

[i.5] ETSI TS 103 410-1: "SmartM2M; Smart Appliances Extension to SAREF; Part 1: Energy Domain".

[i.6] ETSI TS 103 410-2: "SmartM2M; Smart Appliances Extension to SAREF; Part 2: Environment Domain".

[i.7] ETSI TS 103 410-3: "SmartM2M; Smart Appliances Extension to SAREF; Part 3: Building Domain".

[i.8] ETSI TR 103 545: "SmartM2M; Pilot test definition and guidelines for testing cooperation between oneM2M and Ag equipment standards".

[i.9] Brewster C: "The landscape of agrifood data standards: From ontologies to messages". EFITA WCCA 2017 conference, Montpellier, France, July 2017.

[i.10] Kempenaar C. et al.: "Big data analysis for smart farming. Results of TO2 project in theme food security".

NOTE: Available at http://edepot.wur.nl/391652.

[i.11] Verhoosel J. and Spek J.: "Applying Ontologies in the Dairy Farming Domain for Big Data Analysis". CEUR-WS Joint Proceedings of the 3rd Stream Reasoning (SR 2016) and the 1st Semantic Web Technologies for the Internet of Things (SWIT 2016) workshops, co-located with 15th International Semantic Web Conference (ISWC 2016), Kobe, Japan, October 2016.

NOTE: Available at http://ceur-ws.org/Vol-1783/.

[i.12] Abendroth L. J., Elmore R. W., Boyer M. J. & Marlay S. K.: "Corn growth and development", 2011.

[i.13] ETSI TS 103 410-6: "SmartM2M; Extension to SAREF; Part 6: Smart Agriculture and Food Chain Domain".

[i.14] ISO 11783 series: "Tractors and machinery for agriculture and forestry -- Serial control and communications data network".

[i.15] ETSI TS 103 410 series: "SmartM2M; Smart Appliances Extension to SAREF".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

ontology: formal specification of a conceptualization, used to explicit capture the semantics of a certain reality

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AEF	Agricultural industry Electronics Foundation
AIOTI	Alliance for the Internet of Things Innovation
EPCIS	Electronic Product Code Information Services
FAO	Food and Agriculture Organization
GPS	Global Positioning System
GTIN	Global Trade Item Number
HTTP	HyperText Transfer Protocol
ICT	Information and Communications Technology
IoT	Internet of Things
ISOBUS	International Standard Organization Binary Unit System
NDVI	Normalized Difference Vegetation Index
RDF	Resource Description Framework
RFID	Radio-Frequency IDentification
RPM	Revolutions Per Minute
RTK	Real-Time Kinematic
SAREF	Smart Appliances REFerence ontology
SAREF4AGRI	SAREF extension for the AgriFood domain
SDF	Smart Dairy Farming
SKOS	Simple Knowledge Organization System
SKOS-XL	SKOS eXtension for Labels
STF	Specialists Task Force
TNO	Netherlands Organization for Applied Scientific Research
TR	Technical Report
TS	Technical Specification
XML	Extensible Markup Language

4 SAREF extension for the Smart Agriculture and Food Chain domain

SAREF [i.1] is a reference ontology for IoT created in close interaction with the industry during a study requested by the European Commission in 2015 [i.2] and subsequently transferred into an ETSI TS 103 264 [i.3].

SAREF contains core concepts that are common to several IoT domains and, to be able to handle specific data elements for a certain domain, dedicated extensions of SAREF can be created. Each domain can have one or more extensions, depending on the complexity of the domain. As a reference ontology, SAREF serves as the means to connect the extensions in different domains. The earlier document ETSI TR 103 411 [i.4] specifies the rationale and methodology used to create, publish and maintain the SAREF extensions.

The present document specifies the requirements for an initial SAREF extension for the Smart Agriculture and Food Chain domains based on a limited set of use cases and from available existing data models. The present document has been developed in the context of the STF 534 (https://portal.etsi.org/STF/STFs/STFHomePages/STF534.aspx), which was established with the goal to create SAREF extensions for the domains of Smart Cities, Smart Industry & Manufacturing, and Smart AgriFood. The STF 534 follows the outcomes of the earlier STF 513, which developed an updated the SAREF specification ETSI TS 103 264 [i.3], and the first extensions of SAREF in the energy [i.5], environment [i.6] and building [i.7] domains.

The STF 534 consists of the following two main tasks:

1) gather requirements, collect use cases and identify existing sources (e.g. standards, data models, ontologies, etc.) from the domains of interest (i.e. Smart Cities, Smart Industry & Manufacturing, and Smart AgriFood); and

2) produce extensions of SAREF for each domain based on these requirements.

The present document focuses on the extension of SAREF for the Smart Agriculture and Food Chain domain, which will result in a new ontology, called SAREF4AGRI, to be published in the companion ETSI TS 103 410-6 [i.13] as part of the SAREF extensions series ETSI TS 103 410 [i.15].

5 Related initiatives

5.1 Introduction

In this clause, some of the main related initiatives in terms of modelling and standardization in the Smart Agriculture and Food Chain domain are reviewed. Existing efforts range from national or international standardization initiatives to specific European or national projects related to these standardization initiatives. The potential stakeholders identified for the SAREF4AGRI extension can be classified as: farmers, industry vendors (e.g. suppliers of agriculture equipment and machinery, farm management systems, climate control systems for greenhouses, etc.), associations related to Internet of Things and Smart AgriFood, European projects, research community, platforms for IoT data processing, and standardization bodies. An overview of the landscape of agrifood standards including those for crop research, farming, food supply chain and food retail purposes is provided by Brewster 2017 [i.9] (for additional links to related literature, portals and repositories, see also http://aims.fao.org/activity/blog/agrovoc-and-other-community-agreements-agrifood-related-sectors).

5.2 Standardization initiatives and associations

5.2.1 AEF

The Agricultural Industry Electronics Foundation (AEF) (http://www.aef-online.org) is an independent organization founded on October 2008 by seven international agricultural equipment manufacturers and two associations. Currently, eight manufacturers and three associations work as core members of the AEF together with 200 general members. Their work aims at improving cross-manufacturer compatibility of electronic and electric components in agricultural equipment and to establish transparency about compatibility issues. Implementing international electronic standards is therefore a cornerstone of the AEF work.

While the AEF's intention is to enable mutually beneficial links between companies, the effort is first and foremost directed at their farming customers, i.e. to make work easier for them and to provide them with economic benefits. The AEF promotes compatibility across manufacturers or brands using standards, which is increasingly considered as a competitive advantage, as opposed to the idea of customers buying all their machinery from one manufacturer. Moreover, it aims to establish transparency about compatibility and to provide customers with relevant information prior to a purchase of agricultural machinery.

5.2.2 AgGateway

AgGateway (http://www.aggateway.org/) is a non-profit consortium of businesses serving the agriculture industry. AgGateway manages standardization through the agriculture value chain (horizontal). Their mission is to promote and enable the industry's transition to digital agriculture and expand the use of information to maximize efficiency and productivity. AgGateway counts more than 230 member companies working within the following eight major segments: Ag Retail, Allied Providers (systems & software developers and service providers), Crop Nutrition, Crop Protection, Grain & Feed, Precision Agriculture, Seed, Specialty Chemical. Each segment forms a council that operates autonomously within the overall guidelines of AgGateway.

5.2.3 AIOTI

The Alliance for Internet of Things Innovation (https://aioti.eu/), founded by the European Commission in 2015, consists on thirteen working groups. The WG03 on IoT standardization is a horizontal working group that addresses, amongst other, the issue of semantic interoperability in the IoT that is especially relevant to SAREF. The WG06 on Smart Farming and Food Security is a vertical working group dedicated to IoT scenarios/use cases that allow monitoring and control of the plant and animal products life cycle ("from farm to fork").

5.3 Standards

The most relevant standard for this work is ISOBUS, a communication protocol for the agriculture industry promoted by AEF. ISOBUS is based on the ISO 11783 standard series, parts 1 to 14 [i.14] and AEF works to coordinate enhanced certification tests for the ISO 11783 standard [i.14]. In the past, every manufacturer used their own proprietary solutions, which required special adaption for every combination of tractor and implementations. In contrast, ISOBUS promotes a plug and play solution based on international standards that increase the safety, effectiveness, precision and efficiency of agricultural equipment, regardless of the manufacturer. All signals, such as speed, position of the lower links, power take-off RPM, etc. are available in a standardized form. The communication between the implement and the farm management system is also standardized and simplified through the use of ISO-XML.

5.4 Ontologies

The most relevant ontology for this work is AGROVOC (http://aims.fao.org/vest-registry/vocabularies/agrovoc-multilingual-agricultural-thesaurus), a controlled vocabulary developed by the Food and Agriculture Organization of the United Nations (FAO) that contains over 34 000 concepts available in 29 languages including food, nutrition, agriculture, fisheries, forestry, environment, etc. It is maintained by an international community of experts and institutions active in the area of agriculture and related domains. It is available as an SKOS-XL concept scheme and is also published as a linked data set.

5.5 European projects

5.5.1 IoF2020 (H2020 Large Scale Pilot)

The Internet of Food and Farm 2020 (IoF2020) project is the H2020 Large Scale Pilot that explores the potential of IoT-technologies for the European food and farming industry (https://www.iof2020.eu/). The goal is to leverage IoT technologies to make precision farming a reality and to take a vital step towards a more sustainable food value chain, drop the use of pesticide and fertilizer, optimize the overall efficiency, but also enable better traceability of food, leading to increased food safety. IoF2020 aims to build a lasting innovation ecosystem that fosters the uptake of IoT technologies by involving stakeholders along the food value chain together with technology service providers, software companies and academic research institutions.

Nineteen use-cases organized around five sectors (arable, dairy, fruits, meat and vegetables) develop, test and demonstrate IoT technologies in an operational farm environment all over Europe.

The full list of use cases is available at https://iof2020.eu/trials. The IoF2020 project can provide the environment of stakeholders and use cases to validate the SAREF4AGRI extension.

5.5.2 DISAC project

The Data Intensive Smart Agrifood Chains (DISAC) programme is a public-private partnership between twenty industrial parties and four knowledge institutes in the Netherlands (https://subsites.wur.nl/en/plb/PL-Projects/DISAC.htm). The focus is on arable farming and more precisely on precision farming for agricultural fields. Aim of the programme is to develop a communication infrastructure between sensors and agricultural machinery, which will enable site-specific and real-time adjustments to crop treatment, harvesting and grazing schemes. The programme consists of the following three different subprojects:

1) the electronic potato, which tries to use sensors to monitor and control the potato growing process in the field;

2) the N-sensor, which tries to improve the measurement of nitrates in the field; and

3) connectivity on the field for grassland management and weed control.

The latter subproject uses standards for information exchange between machines in the field and the Farm Management Information System, such as AEF ISO-XML and the AgGateway ADAPT framework (https://adaptframework.org/). The relation between these standards and SAREF4AGRI can be further investigated.

5.5.3 DDINGS project

The Data-Driven Integrated Growing Systems (DDINGS) project is a Dutch national project that is targeted on data sharing and exchange for the improvement of greenhouse management. The project involves a large consortium of greenhouse equipment suppliers that provide appliances to monitor and control housing, windows, screen and climate of the greenhouse. The goal of the project is to combine data from the greenhouse appliances, as well as data from other external data sources, in order to perform meaningful data analysis. The ISOBUS standard is currently used in this area, but SAREF4AGRI could become especially relevant when alignment is needed in the information exchange between different appliances in the greenhouse.

5.5.4 SDF project

The Smart Dairy Farming project (http://www.smartdairyfarming.nl) is a Dutch national project that involved the main dairy industry organizations in the Netherlands. The goal of the project was to measure the improvement of the quality of life of the animals and use the results to better cater the individual needs of the cows, and to be able to detect symptoms of illness of the animal, making a positive impact on their wellbeing. Sensor equipment was used to monitor 300 cows at 7 dairy farms. A large amount of sensor data was generated on grazing activity, feed intake, weight, temperature and milk production of individual cows. Semantic alignment of similar concepts (but with different meaning) in various data sources was necessary for improved decision support and historical analysis. The generated data was used for decision support for the dairy farmers on feed efficiency in relation to milk production, by answering complex questions such as "How much food did an individual cow consume in a certain time period at a specific grassland parcel and how does this relate to the milk production in that period?". More details on the SDF project results can be found in the literature [i.10].

5.6 ETSI initiatives

The STF 542 is an ETSI Specialist Task Force (STF) dedicated to specify a pilot test plan for interfacing the oneM2M platform with agriculture machines and standards (https://portal.etsi.org/STF/STFs/STFHomePages/STF542.aspx). By making use of the oneM2M standards, the STF 542 produced ETSI TR 103 545 [i.8] to be used as input (parameters and measurement methods) for a pilot Plugtests™ event to validate the possible cooperation between the ETSI oneM2M standards and AEF ISOBUS standards implemented for communication inside and between agriculture and forestry machines.

The main scenario envisioned for the pilot Plugtests™ event consists in the dissemination of a warning message to vehicles passing-by as soon as an agriculture or forestry equipment from the fields has been detected to exit on the road. The coordination between the detection of this event and the sending of the notification message is envisioned using an oneM2M gateway in the tractor.