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Context Information Management (CIM); Use Cases (UC)

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Foreword

This Group Report (GR) has been produced by ETSI Industry Specification Group (ISG) cross-cutting Context Information Management (CIM).

Modal verbs terminology

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1 Scope

The present document discusses the concepts which are foundational for Cross-Cutting Context Information Management (C3IM) and their application to a selection of Use Cases from the domains of Smart Cities, Smart Agrifood and Smart Industry. These areas of application, together with the general area of Internet of Things (IoT) technology and services, are expected to especially benefit from usage of cross-cutting (cross domain) context information, and from a set of specifications for the APIs supporting C3IM.

The present document covers the following:

- A definition of terms relevant to cross-cutting Context Information Management (C3IM).
- An introduction to the notions of C3IM and the potential role of C3IM in enabling services in cross-cutting inter-domain areas, for example Smart Cities, Smart Agrifood, and Smart Industry.
- A motivation for this project's key goal, i.e. defining an API for C3IM.
- A reference diagram illustrating possible architectures and functional entities involved in facilitating C3IM.
- A set of high level Use Cases which can potentially be supported using a C3IM system.
- A subset of detailed Use Cases (scenarios) illustrating potential information flows among functional entities.
- A summary of requirements extracted from the Use Case analysis.

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] INSPIRE Data Specifications Drafting Team, 2008-03-18: "Deliverable D2.3: Definition of Annex Themes and Scope".

NOTE: Available at http://inspire.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.3_Definition_of_Annex_Themes_and_scope_v3.0.pdf.

[i.2] INSPIRE: "European Data Portal -Training & Library - Use Cases".

NOTE: Available at https://www.europeandataportal.eu/en/training-library/library/training-materials.

[i.3] European Data Portal: "Re-using Open Data: A study on companies transforming Open Data into economic and societal value", CapGemini, 20170117.

NOTE: Available at https://www.europeandataportal.eu/sites/default/files/re-using_open_data.pdf.

[i.4] "DIGITALEUROPE's views on the Artificial Intelligence, Machine Learning and Robotics", Brussels, 10 May 2017 Published 20170510.

NOTE: Available at http://www.portugalglobal.pt/PT/Acoes/missoes/Documents/2017/belgica-2nd-innovation-sessions-digital-europe.pdf.

[i.5] Pohl, Klaus: "Requirements engineering: fundamentals, principles, and techniques". Springer Publishing Company, Incorporated, 2010.

[i.6] Library of Congress of USA: "PREMIS Data Dictionary for Preservation Metadata version 3.0".

NOTE: Available at http://www.loc.gov/standards/premis/v3/premis-3-0-datadictionary-only.pdf.

[i.7] W3C, PROV Model Primer. Working Group Note 30 April 2013.

NOTE: Available at http://www.w3.org/TR/2013/NOTE-prov-primer-20130430.

[i.8] ITS International: "Substantial savings from smarter street lighting", first published January 2015.

NOTE: Available at http://www.itsinternational.com/sections/general/features/substantial-savings-from-smarter-street-lighting/.

[i.9] ETSI GS CIM 004 (V1.1.1) (04-2018): "Context Information Management (CIM); Application Programming Interface (API)".

3 Definitions and abbreviations

3.1 Definitions

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

agent: system, software program or firmware that is a producer, consumer or manipulator of data in a use case

NOTE: That in some use cases, an agent may act on behalf of a human or legal stakeholder.

context: set of entities with which an entity has defined relationships, together with the categories (classes) and properties of these entities, their relationships and their properties

context information: informational representation of a context

cross-cutting context information: context information that spans multiple distinct application domains

(Cross Cutting) Context Information Management (C3IM): following services provided by a platform: context information registry, discovery, publication, mediation, modification or notification, and more generally mediation between context information sources and context information users

NOTE: The acronym C3IM is used only in the present document as a shortcut for, cross cutting context information management, rather than CIM to avoid confusion with acronyms uses by other SDOs (e.g. ISO/IEC Common Information Model).

entity: something existing in the real world such as a person, a place such as a building or street corner, an object such as a car or tree or refrigerator or any equipment or sensor, a document such as a book or legal document, which can be represented in a context information management platform

NOTE: This is different from the sense in which the oneM2M specification uses the word "entity".

information model: set of types and associated constraints that formally define the classes(categories) used for context information representation

NOTE: The information model constrains the specific representation of the structure, manipulation and integrity aspects of the data stored in data management systems such as graph databases, whereby generic cross-domain and specific domain-dependent terminologies/taxonomies are used for the information elements and their instantiations.

property: description instance which associates a literal characteristic (e.g. a value in a common data type). to either an Entity, a Relationship or another Property

relationship: description of a directed link between a subject which is either an Entity, a Property, or another Relationship on the one hand, and an object, which is an Entity, on the other hand; for example "isAdjacent to", "isContainedIn", "is ASubSystemOf", "isOwnedby", "isCreatedBy"

stakeholder: person, business or other legal entity who is involved in a service or process of a use case

situation: set of entities and services, and their dynamic states, interacting within a specific geo-temporal range

target domain: set of business activities (e.g. automobile traffic flow planning, energy distribution, etc.) within which traditional use cases are defined

NOTE: The entities of a target domain may be shared with others (e.g. streets as city entities are shared between traffic management and lighting management) and this is precisely where cross-cutting context information comes into play.

3.2 Abbreviations

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

ADSL	Asymmetric Digital Subscriber Line
AI	Artificial Intelligence
AIOTI	Alliance for the Internet of Things Innovation
ALPR	Automatic License Plate Recognition
API	Application Programming Interface
ATM	Automated Teller Machine
CAL	Climate Associates Limited
EC	European Commission
EGM	Easy Global Market
EU	European Union
EV	Electric Vehicle
GHG	Green House Gas
GPS	Global Positioning System
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
ICD	Implantable Cardioverter-Defibrillator
IoT	Internet of Things
ISG	Industry Specification Group
ISO	International Organization for Standardization
KPI	Key Performance Indicator
NEC	Nippon Electric Company
NGSI	Next Generation Service Interfaces
OWL	Ontology Web Language
RDF	Resource Description Format
SMS	Short Message Service
UI	User Interface

4 Introduction

4.1 Introduction to Context Information Management

As stated in the scope, the present document concerns the application of cross-cutting contextual information management to a selection of Use Cases from the domains of Smart Cities, Smart Agrifood and Smart Industry. These applications are expected to especially benefit from cross-cutting context information and from a set of specifications for the APIs supporting C3IM.

Cross-cutting Context Information Management (C3IM) is provided by a C3IM platform. A C3IM platform collects data from IoT devices, lower-level platforms managing such devices, crowdsourced devices, databases and other sources, and provides as consolidated context information to applications via an API (defined in later documents as NGSI-LD). The C3IM platform enables use-cases which link together disparate but related information. It is thought that IoT services will be enriched when applications have access to a full set of context information, as defined in clause 3. A C3IM system potentially enriches services by bringing together information from a wider set of service-relevant sources than would otherwise be available to a traditional vertically integrated IoT application.

This is illustrated in figure 4.1-1. In the first figure, an IoT information source such as a sensor provides data to an application. As an example, an IoT-enabled fitness tracker device reports heart rate and step counts to a user via a cloud-based "runner fitness" service. The user is simply able to access current values and past statistics for these measures. For best results and widest interoperability, the transfer of information from the sensor to the cloud application needs to be accompanied by the semantics and context of the information (i.e. the numbers sent are "heart rate", not "blood pressure" or some other measure).

The simple example makes clear that the protocol to exchange data should contain (or reference) all context information needed to correctly interpret that data for a given service (the cloud application) and that the protocol should be designed to function between widely different kinds of information sources and information "consumers". For widest interoperability, nothing should be assumed.

Figure 4.1-1: Exchange of (context) information between a source and an application

In figure 4.1-2, the first information source is supplemented by additional contextually relevant information from a variety of databases or other sources. The Application has access to a wider set of information and can provide a richer service. To continue the example, an enhanced runner fitness service uses GPS location (from the user's phone sensor), road inclination (from a municipal database), weather information (from a national government service web-API) and traffic conditions on the road (from a web API of a popular map application). These are tied together by the application. The user sees suggested running routes based upon his/her goals and local conditions, can track his/her progress and speed, and sees graphs of heart rate against estimated calorie burn, speed, or road inclination.

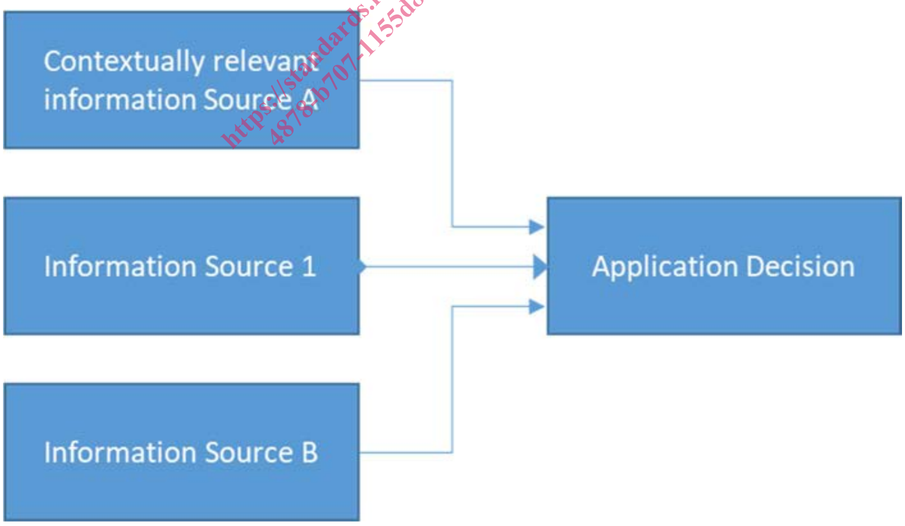

Figure 4.1-2: Merging of several contextual information sources to enhance an application

Access to relevant context information from multiple target domains enables "cross-cutting" applications to present a richer service to the user. To summarize, a C3IM system may utilize information of the following characteristics:

- information about or from one or more entities;
- static or dynamic information;
- information from database including open data;

- different sources leading to similar information (for example, in some cases temperature may be reported by a user, in other cases temperature may be reported from a sensor).

The C3IM system is expected to make it easier for applications to access this heterogeneous information by standardizing the APIs between applications, data aggregation platforms, and entities.

4.2 Information Sources

The purpose of the present document is to help clarify interoperability requirements for transmission and management of information between different information sources which have been developed under different sets of assumptions and definitions, particularly for:

a) various kinds of Internet-of-Things sensor/actuator frameworks;

b) various kinds of databases created and maintained for processes within municipalities and governments;

c) various kinds of internet/mobile applications promoting interaction of end users with the digital world, etc.

Everyone talks about the new digital society, digital transformation or fourth industrial revolution, etc. but building it will require unprecedented trading (not just "sharing") of information in forms which remain correctly interterpretable at all stages.

It is assumed in the present document that there are actually five broad sources of information about the real world, made available in the digital world and managed within a context information management platform:

a) **IoT Platforms:** they mediate raw data originating mostly from various sensors within the target environment. (e.g. a Smart City, an industrial compound, etc.). This mediation takes place through a two-sided platform that acquires, aggregates, references and maintains this data as consolidated information in order to make it available to applications or higher-level platforms operating within this environment.

b) **Managed Database Platforms:** containing aggregated, consolidated, filtered, etc. information, by stakeholders such as government agencies, commercial businesses, or subordinate lower-level database platforms, network servers, gateways, or third-party information services. Typical examples are statistics for crime, for traffic flow, for environmental pollution, for delays in scheduled public transport, or catalogues of information such as catalogues of products, of government requests for tender, of properties available for sale.

c) **Application Data Platforms:** applications delivering extremely varied kinds of data, usually from a multitude of end users. The kinds of data could be e.g. user-generated gps tracks of cars (input into a traffic flow database), user-identified locations of dangerous damage to streets (input into a municipal map for roadworks planning), etc.

NOTE: The difference to a Managed Database Platform is that the application services are not strictly filtered/managed by a uniform registration process and/or a single organization, and include many single-user sources of information, often with short validity period e.g. the time immediately after sending a SMS.

d) **Data Analytic Platforms:** consist of context information which has been derived from any and all other available information, including models and simulations, by specialized software. The provenance of such information needs to be very carefully tracked and taken into account when reaching conclusions (by humans or machines).

e) **Usage Data:** based upon roles and permissions for (re)use of the above data sources, accounting and provenance data accompanying access, logical extrapolations from all such data and *usages of that data.* Judging by commercial efforts to develop artificial intelligence platforms, commercial platforms for information retrieval and commercial platforms for sharing of information between friends and friends-of-friends, the set of networks of users of specific types of information will itself be a factor in the digital environment (and economy) for all users, in particular for services involving advertising and/or billing.

4.3 Motivation for developing a Context Information Management System

It is the goal of ETSI ISG CIM to facilitate consolidation and re-use of the different kinds of data and information sources, and multiple instances of any of the sources, into a federative platform. Cross-Cutting Contextual Information Management corresponds to the cross-fertilization and federated use of multiple sources of information, such that the original meaning and context (definition and provenance) of such information is not lost during transfer.

The term "context information" has a broad definition within the present document, including in principle all additional information about a bare recorded "fact" which would be needed to interpret that fact unambiguously under all circumstances. Usually, however, the term "context information" is pragmatically used in the sense of "additional information which explains the definition of the type of observation and the conditions affecting its observed value within a specific (set of) situation". This is more practical but also more limited and leads to situations where "one man's definition of context is another man's definition of irrelevant blather".

What is the meaning of the term "cross cutting" in connection with context information? The term emphasizes that information from one context may be highly useful in another, particularly if (a) the two contexts belong to disparate target domains, but also for (b) two very similar or even identical contexts where the information modelling of the entities, services or roles has developed in a non-identical way. An example of (a) is exchange of information between a bus timetable planning system and a weather prediction system. An example of (b) is exchange of information between police departments in two adjacent cities in different nations (example Saarbrueken).

The emphasis on "independent target domains" in C3IM clarifies the term "cross-cutting", indicating that information is combined from sources which may have only partial overlap - or even conflict - of explicit or implicit information models. These conflicts may occur even within the same target domain (e.g. the smart home) if description of data (meaning, provenance, etc.) is ambiguous, changes over time, or changes according to the person/system responsible for the sourcing of information.

It should be emphasized that the meaning of "context" nowadays (and in the present document) has changed markedly from the formerly prevailing definition of context originating from the "first wave" of context-awareness that dominated research in the years 2000-2010, as taken up within the broader "ambient intelligence" research agenda at that time. Context was then defined in a mostly end-user-centric way, which implicitly assumed that there existed a primary information source called "content" (typically audiovisual media or multimedia interpersonal communication), and "context" was defined relative to this user-centric content as anything that provided ancillary information. Typically, the aim was to enable the user to better "consume" the content, or in general to improve the content with regards to various criteria.

That end-user-centric view and the context vs content distinction have no relevance in the broader domain of IoT platforms and Database Platforms that is targeted here, because what is primary content for one application is context to another, and the C3IM platform is intended to serve all applications irrespective of the primary content they request. The C3IM platform should thus manage information at a level that makes it possible to consolidate all sources of potential content and context information jointly.

The above explanation motivates the key criterion in selecting use cases for the present document: they should demonstrate the benefits of mixing information from different sources, each of which corresponds to a source of "primary" information dedicated to one application, showing that jointly the combination can be richer, more reliable or more adaptable.

The barriers for successful cross-cutting context information management are still so high, that a CapGemini survey [i.3] published in 2017 of companies active in the field found that across 14 categories the correlation matrix of re-use of open data from two independent domains was only above 50 % for four pairs of categories:

a) Transport with Cities.

b) Environment with Cities.

c) Population and Society with Cities.

d) Population and Society with Environment.

Some examples of cross-domain use cases which require access to information from different domains, that is normally held separate, are:

- Smart Lighting and Smart Parking so that lighting is only provided when car parking is booked and used in order to save energy.
- Smart Buildings and Smart Mobility to ensure that power is available to charge electric vehicles when required (in order to reduce GHG emissions and improve air quality in a neighbourhood).
- Smart Parking and e-Health to ensure that parking spaces are available for health professionals when required.
- Smart Energy and Smart Buildings to improve the buildings environment and energy management based on information collected on the indoor and outdoor environment including energy consumption and production.
- E-Health and Smart Appliances to monitor appliances to check if they have been 'left on' by the user (detection of abnormal events).

Various H2020 research projects provide different practical examples of the above types:

- Management of Networked IoT Wearables - Very Large Scale Demonstration of Cultural and Security Applications - www.monica-project.eu.
- ACTivating InnoVative IoT smart living environments for AGEing well - www.activageproject.eu.
- AUTOmated driving Progressed by Internet of Things - www.autopilot-project.eu.
- Internet of Food and Farm 2020 - www.iof2020.eu.
- Delivering an IoT enabled Digital Single Market for Europe and Beyond - www.synchronicity-iot.eu.
- User Engagement for Large Scale Pilots in the Internet of Things - www.u4iot.eu.
- CRoss FErtilisation through AlignmenT, Synchronization and Exchanges for IoT - www.create-iot.eu.
- VICINITY - www.vicinity2020.eu.
- Wise-IoT - http://wise-iot.eu.

5 Methodology

5.1 Approach to Documenting Use Cases

5.1.1 Purpose

The main purposes of writing down C3IM Use Cases document are:

- to provide examples of services which require the use of a C3IM platform;
- to understand the requirements for an appropriate API and Information Model.

The list of Use Cases presented is not meant to be exhaustive, but to provide example services in the Smart City and other topic areas.