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Fighting pandemic disease with Internet of Things (IoT)

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Contents

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Foreword

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

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**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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Executive summary

The present document defines properties and usage of IoT and M2M technology in Contact Tracing.

It introduces the method of Asynchronous Contact Tracing (ACT). ACT registers the presence of SARS-CoV-2 virus on IoT connected objects (waste water, or air conditioning filters, or dirty objects, or dirty cleaning tools, etc.) or connected locations (such as a shops, restaurants, corridors in a supermarket, sanitary facilities in a shopping mall, railway stations, airports terminals and gates, etc.) using Group Test (sometime called in the literature Pooling Test).

ACT identifies contacts with IoT connected objects that have been contaminated by the SARS-CoV-2 virus and works in synergy with solutions designed for manual and digital contact tracing to identify and alert people who may have been infected by the virus. In case the object is suspected to host or have hosted the SARS-CoV-2 virus, ACT allows users that have been in contact with the object or visited the connected location to be informed.

This shifts the paradigm from synchronously tracing the contacts of the people infected by COVID-19 to asynchronously tracing of contacts of materials (such as infected surfaces, waste-water, air-conditioning filters, etc.) that are hosting the SARS-CoV-2 virus.

This enables people who have come into contact asynchronously with those particular materials to be alerted of a potential COVID-19 contagion, and, at the same time, it signals that one or more persons have been in contact with the material which is now spreading the SARS-CoV-2 virus.

This methodology is particularly effective as the SARS-CoV-2 virus can survive for a significant time on objects that have been contaminated. The degree of contamination depends on the object (e.g. a surface), the concentration of the virus, the temperature, the humidity conditions, and the exposure to sun light. Viral contamination can be active for a few hours or last for several days.

The ACT method uses existing, ready-to-market IoT-based technology and well-established wireless network techniques. The methodology is not dependent on achieving a certain number of tests, or of people adopting it, in order for the results to be useful, but from the number of (grouping) tests performed. Moreover, it does not require the transmission of any personal information by the user, respecting both EU GDPR (General Data Protection Regulation) and people's sensibility to personal privacy.

The present document also shows a number of relevant case studies in many different areas.

The present document also defined requirements and the functionalities required to meet the requirements.

The present document specifies a solution for the ACT method using the oneM2M standard communication framework.

This process was inspired by Occam's Razor [i.5] or the *Law of Parsimony* (Latin: *Lex Parsimoniae*), that states that entities and theories useful to solve a problem should not be multiplied unless necessary. On the contrary, simpler entities and theories are preferable to more complex ones because they are easier to test and more likely to be true.

Introduction

"*C'est un projet qui répond à une crise historique sans laquelle il n'existerait pas et au-delà de laquelle il n'existera pas: l'épidémie de COVID-19*" [i.10].

Asynchronous Contact Tracing is a method (network protocol + appropriate IoT infrastructure based on SmartM2M/oneM2M + mobile and web applications) [i.15] conceived for regular, 'peace time' use, as opposed to (Synchronous) Contact Tracing methods [i.6], [i.7], [i.8] and [i.9] which tend to be employed when society is put on an urgent, war footing in reaction to an acute problem.

The ACT process is not only applicable to the current pandemic wave. The parameters can be adapted to any other virus in a future pandemic.

ACT is able to work alone or in coordination with all existing (Synchronous) Contact Tracing solutions. It has been designed as a service and a methodology that will be available for all pandemic, epidemic and other contagious illnesses, as well as for other applications intended for protecting and tracing users. ACT is not only applicable to the current wave of COVID-19. The parameters can be adapted to any other virus as required, and for testing and tracing of e.g. situations related to leaks of discomforting or dangerous gasses and liquids.

ACT is intended to be socially and economically acceptable to people who consider Asynchronous Contact Tracing to be a social-service (that is offered by, for example, a health or social security organization) and should not be perceived to be an obligatory requirement.

ACT will promote individual testing only in the unfortunate event of the user receiving official notifications that he/she may be potentially at risk. It can be applied to all the contexts where people share the same physical space, such as a supermarket, schools, restaurants, hotels, gyms, offices, working plants, hospitals, hospices, etc. It can also be applied to an object that is encountering people while it is in movement, such as a public transportation network.

ACT traces the contacts of objects with people and other objects and uses IoT technologies to react when a connected object may 'host' or 'has hosted' the virus and spread the virus to other people. It is intrinsically asynchronous because it does not require people to be in the same place at the same time, and, even stronger, it does not require the exchange of any information between people, as the virus will be tracked back, or uncovered by doing (group) testing on objects and not on people.

For many communities, this type of tracing will promote a quicker return to normal after, or avoiding lockdowns. This will benefit many social and industrial organizations, cities, tourism, education, commerce, and travel, etc.

ACT has been designed as a service and a methodology that will also be available for COVID-19 and future pandemic attacks.

ACT traces the contacts of objects with people and other objects and uses IoT technologies to react in the case that such connected object will 'host' the virus and widespread a pandemic virus with people.

The process is intrinsically asynchronous because it does not require people to be in the same place and at the same time, and, more importantly, it does not require any information exchange between humans, since the virus has been detected by Group Testing on materials and not on humans.

For many communities, this type of tracing will support an elaborate form of selective lockdown, i.e. the surgical closure of specific areas following a forecast announcing a new spike of infection. It is without doubt a process that will naturally benefit many social and industrial organizations, cities, tourism, education, commerce, and travel, etc.

1 Scope

The present document is structured as follows:

- Clauses 1 to 3 set the scene and provide references as well as definitions of terms, symbols and abbreviations, which are used in the present document.
- Clause 4 shortly describes contact tracing and testing techniques, with in particular Dorfman's Group testing [i.1], which contributes to of the ACT methodology.
- Clause 5 describes some use cases that are be useful to understand the usefulness of ACT method. These use cases provide some relevant examples (among all the potential ones in the areas of Tourism, Commerce, Transportations, Schools, Hospices, etc.) that are then used as reference for the specification development.
- Clause 6 specifies the solution for the ACT method using the oneM2M standard communication framework. It allocates the functionalities in the architectural framework of the solution and the related interfaces. It defines the oneM2M resources required to implement the functionalities. It specifies the ACT method in oneM2M, in terms of features, resources, parameters, API, considering modifications to the existing ones and/or definition of new ones.
- Clause 7 presents the ACT oneM2M communication framework.
- Annex A (normative) presents the ACT Messages Specification.
- Annex B (normative) presents some JSON messages examples.
- Annex C (informative) contains a Bibliography.
- Annex D (informative) contains the repsent document Change History.

2 References

2.1 Normative 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.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference.

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 necessary for the application of the present document.

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[4] ISO 6709: "Standard representation of geographic point location by coordinates".

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[6] ETSI TS 118 102: "oneM2M; Requirements (oneM2M TS-0002)".

[7] ETSI TS 118 104: "oneM2M; Service Layer Core Protocol Specification (oneM2M TS-0004)".

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[13] ETSI TS 118 112: "oneM2M; Base Ontology (oneM2M TS-0012)".

[14] ETSI TS 118 115: "oneM2M; Testing Framework (oneM2M TS-0015)".

[15] ETSI TS 118 113: "oneM2M; Interoperability Testing (oneM2M TS-0013)".

[16] ETSI TS 118 122: "oneM2M; Field Device Configuration (oneM2M TS-0022)".

[17] oneM2M TS-0016: "Secure Environment Abstraction".

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[19] ETSI TS 118 126: "3GPP Interworking (oneM2M TS-0026)".

[20] oneM2M TS-0030: "Ontology based Interworking".

[21] oneM2M TS-0031: "Feature Catalog".

[22] oneM2M TS-0033: "Interworking Framework".

[23] oneM2M TS-0034: "Semantics Support".

[24] ETSI TS 103 264: "SmartM2M; Smart Applications; Reference Ontology and oneM2M Mapping".

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.

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[i.8] MIT etal. PACT (Private Automated Contact Tracing).

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[i.9] Apple and Google: Privacy-Preserving Contact Tracing.

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[i.17] ETSI TR 118 525: "oneM2M; Application Developer Guide".

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[i.19] ETSI TR 118 545: " oneM2M; Developer Guide: Implementing Semantics (oneM2M TR-0045)".

3 Definition of terms, symbols and abbreviations

3.1 Terms

Void.

3.2 Symbols

Void.

3.3 Abbreviations

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

5G	Fifth generation technology standard for broadband cellular networks
ACT	Asynchronous Contact Tracing
AE	Application Entity (in oneM2M architecture)
AI	Artificial Intelligence
API	Application Programming Interface
ASN	Application Service Node
ATM	Automated Teller Machine

NOTE: In French: DAB Distributeur Automatique de Billets.

BSSID	Basic Service Set IDentifier
COVID-19	Coronavirus Disease 2019
CSE	Common Service Entity
CT	Contact Tracing
EU	European Union
GUI	Graphical User Interface
ICT	Information and Communication Technology
IPE	Interworking Proxy Entity
JSON	Java Script Object Notation
MAC	Media Access Control (physical address)
oneM2M	ETSI standards for M2M and the Internet of Things
PC	Personal Computer
RT-PCR	Reverse Transcription Polymerase Chain Reaction
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2
SCT	Synchronous Contact Tracing
SSID	Service Set Identifier
UX/UI	User Experience/User Interface
WiFi	IEEE 802.11 family of standards

NOTE: Based on the IEEE 802.11 [2] family of standards

WLAN	Wireless Local Area Network

4 Testing and Contact Tracing

4.1 Introduction

Lockdown

The main weapon against COVID-19 currently available is physical distancing and it requires full/partial/selective lockdown of cluster areas in the event of a high peak in the spread of the virus. This creates severe damage to an economy and to the personal life of its citizens. While people are all waiting for a vaccine, the other relevant tool to fight the virus is testing. Unfortunately, widespread testing of large populations in a very short time remains unpracticable. The single testing would require some million tests per week and about 60 weeks for a nation such as France. This is clearly an unworkable solution to the problems raised by the current pandemic and is common to many countries across the world.

It is also clear that many people are unwilling to be COVID-19 tested for social reasons, such as job restriction, economic consequences, violation of private life, or even fear of quarantine. It is now well understood that without widespread testing of the population, the only weapon against COVID-19 is lockdown and subsequent severe economic and social disruption.

Contact Tracing

Contact Tracing (CT) has been actively used in Europe since the 16th century to contain epidemic disease. The principles remain the same today whether carried out by phone, mail or personal contact. The aim is to identify the origin of the infection and to where, or to whom, it has been transferred. If receipt of this information is followed immediately by isolation, treatment and aggressive decontamination, it can lead to containment and the gradual elimination of the disease itself.

The year 2020 has seen an explosive demand for information about COVID-19. It rapidly focused on the possible use of new technology, and particularly on the capabilities of the mobile phone to automate the process of 'track and trace', producing more accurate and timely information flows - to the advantage of public health, governments and the patient and their personal contacts. The potential of 5G and AI seemed to beckon to a future where silent, rapid transmission of data would protect us all from an unseen virus that observes no political or social boundaries.

There was an immediate counter reaction - this degree of protection might also be intrusive. It threatened the security of our private lives, our right to move freely and our right to confidentiality, particularly in the medical field. There have been many public statements asserting that current practice of CT observes Human Rights as expressed by the EU, but the resulting focus on the individual subject of CT has led to much confusion as to the purpose and direction of the resulting data collection.

Who Needs to Know? And What do they Need to Know?

These are questions that initially were considered to have obvious answers. Design of ICT systems for CT would follow the traditional, manual methodology but should make it faster, more accurate, more useful. Solutions were found to protect the individuals' personal rights and freedoms, but little attention was paid to the 'back-end' - the ultimate destination of the data and the use to which it would be put.

Put simply, it has always been true that security and transparency share a trade-off. One threatens the other. If the potential patient, the user of the 'track and trace' enabled phone is to be fully protected then the program should not store their name or contact details in any way that could lead to their identification.

This debate has distracted attention from an important issue. Track and trace exercises in the past have been used principally to support government and public health initiatives not just to inform the individual as to their potential risk. Common modern focus on the rights of the individual threatens the management of track and trace data, which could seriously minimize its usefulness to central authorities which all people hold responsible for containing the infection.

Testing for the SARS-CoV-2 virus

Testing is essential to the fight against the SARS-CoV-2 virus and it should be accurate. At the present moment, there are different products based on two methodologies, namely virologic tests (e.g. RT-PCR) and antibodies tests. Unfortunately, the accuracy of the tests is not absolute, and this lead to test repetitions and especially to interpret inconsistent results, e.g. VIRAL=POSITIVE and ANTIBODY=NEGATIVE.

There is a further problem caused by the number of commercial products available with varying standards of accuracy as well as the high cost of some testing kits. e.g. see [i.11].

There is a plethora of test solutions. This "abundance" is neither helpful nor economically sustainable. Some of the tests require access to specific processing equipment and/or skilled laboratory technician which may be expensive or not generally available in local hospitals or laboratories.

The last frontier is the Rapid Antibody Test (< 30 minutes) intended for the use as an aid in identifying individuals with an adaptive immune response to SARS-CoV-2 virus, indicating prior infection. This rapid lateral flow test is intended for the professional use in laboratory and near patient-testing environment and qualitatively detects antibodies specific to SARS-CoV-2 virus in serum, plasma, and whole blood.

4.2 Tracing and testing problems encountered during this COVID-19 pandemic

For various reasons people are not tracing and testing enough persons and fast enough. Without wider test information public health authorities are limited in their decision-making capacity and current SCT alone cannot fill the gap.

People may be sceptical about using and installing current Contact Tracing applications for various reasons. It is also clear that many people are unwilling to be COVID-19 tested for social reasons, such as job restriction, economic consequences, violation of private life, or even fear of quarantine. For example, front-line health workers may be reluctant to go risk going into lockdown, which will stop them working in hospitals and care homes where they know that they are needed, and possibly losing their job. They will only take this decision on very clear and verifiable advice.

The synchronicity rules (typically 15 minutes and the distance typically from 1 to 2 meters) are sometimes considered too stringent, resulting in the same limited number of proximity events as would result from manual CT, and not resulting in the recording of many more potentially contagious contacts that do actually occur.

In addition to tracing, the other relevant tool to fight the virus spreading is testing. Unfortunately, widespread testing of large populations in a very short space of time still remains impracticable. And it can be argued that massive testing is required when large number so people are getting contaminated, but equally when one wants to contain the spreading of the virus when the number of positive cases is low but not zero, and herd immunity has by far not been reached.

It has been calculated that the repeated testing of a population every 14 days (i.e. the safe envelop corresponding to COVID-19 contamination) with some million tests per week would require about 60 weeks per test round for a nation of 60 million people, such as in France. This is clearly an unworkable solution to the problems raised by the current pandemic and has been noted in many countries across the world.

4.3 Dorfman's group testing methodology

During the 2nd World War Professor Dorfman invented a group testing method to screen for syphilis amongst American soldiers. The testing process people aim to use is inspired by the principle of Dorfman's Group Testing described in his seminal paper, "*The detection of defective members of large population*" [i.1]. The rationale of Group Testing is simple. A sample of blood is taken from, say, five people. These samples are mixed together and one test for the virus is made on the combined fluids. If this test result is negative then all five individual samples are considered to be negative, thus saving four test kits. If the result is positive, then the original five samples should be tested individually.

The testing methodology applied in the ACT process is a subset of the Dorfman Group Testing, namely, people are interested only in the presence or absence of the SARS-CoV-2 virus in order to make the ACT process work; the reason for this is trivial because people cannot identify the 'infectors' of waste-water, or air-filtering or other materials: the waste-water or the air-filtering act like an *hash-function*, i.e. it would be computationally impossible to come back to the infectors. Note that infector here is used to denote either humans or things hosting the virus.

Use of this sub-kind of group testing (sometimes called *pooling testing*), in combination with modern digital IoT technology, may provide a new and effective 'forecast' for the introduction of 'selective lockdown'; this means that whenever people test an infected location, the ACT technique will communicate to the population a precise geographical area which can be defined immediately as safe or unsafe.

5 Use Cases and Scenarios to running ACT

5.1 ACT in a nutshell

5.1.0 Foreword

Today, Synchronous Contact Tracing (SCT) [i.6], [i.7], [i.8] and [i.9] protocols are all being designed to exploit the following digital information; namely, physical and spatial proximity, whilst preserving personal anonymity, in order to track the chain of transmission of the virus.

Asynchronous Contact Tracing (ACT) removes the time and space limitation of SCT; rather than just the persons potentially infected and involved in a possible infection transfer, ACT traces objects and surfaces or locations that have been contaminated by the virus.

The SARS-CoV-2 virus is known to stay contagious for some time in an aerosol, or on an object or a hard surface, depending on the nature of the surface, the virus concentration, temperature, humidity conditions, exposition to sun light. This time can vary from few hours to several days; some examples are 2-3 hours on paper, 4 hours on copper, 3-4 days on plastic and steel, 7 days on face masks, and even more in specific climate conditions [i.2], [i.3], [i.4], [i.13] and [i.14].

In addition to the formation and lifetime of aerosols, typical hard surfaces at risk include items such as a plastic drink bottle, a can of beer, a milk carton, a water tap or hand dryer in a public toilet, a park bench, a metro train's doors, seats, buttons, handrails, ATM machines etc. In reality this may include everything around us. ACT can be tuned on the kind of surface.

ACT is a process that exploits the following digital information:

- The possibility of testing material (waste-water / air-conditioning filters / hard surfaces) using standard, reliable, testing techniques and producing results in reasonable time (See annex C). By results here people mean the percentage of SARS-CoV-2 virus on that material without adding information about who infected it. The accent is therefore on the infected object and not on the person. This is an interesting application of Dorfman's Group Testing techniques. Note that people are not interested to go further in the investigation of who (as a person) really is infected: here the focus is on the fact that a given material or location is infected and, as such, it need to be closed to the public and people whose visited those locations or touched those material should be informed and suggested to go fast for a RT-PCR test.

- The results of testing materials are first interpreted by the National Public Health authorities into a precise forecast, which is geo-localized and then widely communicated to the population using WiFi and well-established Web techniques. Access to the forecast may be achieved by a mobile application or by querying a Web-accessible data-base.

In case presence of a virus is detected, the following actions will be undertaken:

- **Fast detection:** in case there is a short time, in minutes, between taking a sample and obtaining the result:
  - Initiate an action to close access to the object or location for the public, and get the location disinfected before reopening for the public;
  - Broadcast an alert, that allows the public to receive a warning to avoid the specific infected location till it has been serviced;
  - Initiate actions that allow possibly exposed persons, that have been close to, used or visited the object or location, to take the appropriate actions: timely isolate and get RT-PCR tested when the development of the virus and contagion can be tested.

- **Next day detection:** in case samples have to be send to a test lab and obtaining the result may be next day:

  - Initiate actions that allow possibly exposed persons, that have been close to, used or visited the object or location, to take the appropriate actions: timely isolate and get RT-PCR tested when the development of the virus and contagion can be tested.

NOTE: People assume that in this case the regular cleaning and disinfection of e.g. sanitary facilities ensures the safety to the public; in such a case sampling should be linked to cleaning and disinfection, so that a sample always corresponds to the status just before the cleaning and disinfection action.

- **No detection:** in absence of detection or the possibility for detection:

  - Initiate actions that allow persons, that have been close to, used or visited an object or location, to take the appropriate actions in case they would receive a warning that another person that has been close to, used or visited this object or location has been tested positive within a time frame that could have created exposure;

  - Possibly exposed persons would: timely isolate and get RT-PCR tested when the development of the virus and contagion can be tested.

It is understood that warning persons for possible exposure is subject to authorization by the local health authorities and is implemented by an entity of, for or authorized to operate by the local health authorities.

Note that the user does not need to communicate his/her position, identity or pseudonyms, but has just to listen to the broadcast alerts and query a Web-accessible data-base, and to download and evaluate lists of objects detected infected with the associated time window. This is why people consider ACT to be intrinsically *'asynchronous'*.

To resume, the main objectives of ACT are:

- To record the proximity of users to objects and locations, and provide the mechanisms that allows them to be warned as soon as a possible infection is detected or suspected.

- To, whenever possible, detect the presence of virus traces at objects and locations:

  - with results after a short delay, allowing immediate actions by both users and facility managers;

  - with results next day, still allowing users to take preventative actions avoiding spreading of the disease.

- To trace the IoT that "hosts" the SARS-CoV-2 virus instead of the people that got infected by the SARS-CoV-2 virus.

- To contribute to supporting the overall avoid - test - trace - action policies of local, regional, national, and where possible multi-national, authorities and health authorities, and thereby contribute to avoiding constraining and costly measures including lockdowns.

- To inform National (and Inter-National) Health Authorities so that they can establish common Policies and local, selective, surgical lockdown in a timely and effective manner, and avoid the severe economic, social and psychological disadvantages of full generic lockdown.

- To forecast for the public information on the clinical status of areas which may be infected and new clusters where the virus is spreading.

5.1.1 ACT in action

ACT performs tests on all materials. If the test is positive, then the following actions could be performed:

- Immediate publishing of the test result on a Public Web-accessible Database with consequent immediate publishing of the isolation/closure of the potentially infected location on a Public Web-accessible Database.

The tasks performed by the smart application associated with ACT are:

- To listen and record all the Peripheral Service and memorize their identifier.

- To match all of the identifiers sent by the National Control Service, each of one associated with a precise forecast, with the one he/she has recorded, and, in case of non-empty intersection, notify immediately a potential contamination to the owner of the smartphone. At that point he/she may decide (or not) to go to a laboratory for an individual test.

- To ask its National Control Service to be informed about the forecast by other foreign Inter-National Control Services.

The tasks performed by the PC application associated to ACT are to:

- To access the forecast produced by the National Control Service.

- To access with a simple GUI, a precise forecast relative to the local area, denoted via suitable geographical coordinates e.g. latitude, longitude, and radius.

5.1.2 ACT recap

To resume the main contribution of ACT is to use a sub-kind of group testing, in combination with modern digital IoT technology, to provide a new and effective *'forecast'* for the introduction of '*selective lockdown'*; this means that whenever people test an infected location, the ACT technique will communicate to the population a precise geographical area which can be defined immediately as safe or unsafe. People are interested only in the presence or absence of the SARS-CoV-2 virus in order to make the ACT process work; the reason for this is trivial because people cannot identify the 'infectors' of waste-water, or air-filtering or other materials. Note that infector here is used to denote either humans or things hosting the virus.

5.2 A Simple Use Case for Asynchronous Contact Tracing

If Alice is infected without knowing and goes shopping at the supermarket at 10:15 am; she touches some items or sneezes or coughs on them or just breathes close to some items. She then leaves the supermarket. The corridors that Alice walked, its caddy and the goods that Alice touched are surely infected by SARS-CoV-2 virus.

Now if Bob, who is not infected at all, visit the same supermarket corridors, (unfortunately take the same caddy) and touches those same items at 11:00 am, unfortunately and involuntarily infecting him by SARS-CoV-2 virus.

The following considerations are now in play:

- Synchronous Contact Tracing Protocols [i.6], [i.7], [i.8] and [i.9] cannot allow the exchange between Alice and Bob of pseudonyms, because their respective mobile phones and contact tracing apps were not present and active at the same place (around 1 meter) and at the same time (for at least around 15 minutes).

- If Alice is later tested COVID-19 positive, then there are no means by which Bob will ever be informed and yet this is a likely to be a common means of transmission of the virus.

- It is not necessary to test Alice to inform Bob that he was potentially infected: it would suffice to test the items that Alice touched and the corridors that Alice walked, because Bob did probably the same.

- It is not even necessary for Alice to exist as a physical person, because the virus could transfer on to a surface as a result of coming into contact with other contaminated surfaces, such as articles being sent from an infected region.

- If Alice was infected in the same conditions as Bob but *two days before* in another supermarket, and if Alice had been informed about the potential risk of infection, then she probably would have done a unitary RT-PCR test and, if positive, she would not then touch the items in the supermarket because she would have stayed at home, and probably not infecting Bob.

5.3 ACT in Tourism

An hotel chain or apartment rental company may adopt the ACT protocol for their rooms and apartment rentals, incorporating it as part of their brand. As a result they will be able to offer accommodation that can be certified ‘100 % COVID-19 free.’ Before each arrival of new guests, the cleaning crew working for the company performs a deep clean

with a final "pooling test" of the resulting waste-water and air-conditioning filters. If the testing of the area is POSITIVE, then the following actions can be performed:

a) Declaring quarantine as appropriate, for all the hotel rooms or apartments on the same corridor, or if deemed necessary, the complete closure of the hotel or the building where the unit is located;

b) the cancelation of all future reservations for that space for a period of 14 days (minimum);

c) the relocation of the cancelled reservation to other accommodation owned by the same company.

In the event (out of the scope of the present protocol) of linkage with a Synchronous Contact Tracing (SCT) protocol, if the pooling testing of the accommodation is positive, in addition to the previous actions, the guest that just visited the premises will be notified by the SCT protocol that the hotel and apartment chain have found traces of COVID-19 and will be strongly recommended to have a RT-PCR test. If the laboratory performing the pooling test is able to produce the results before the arrival of new visitors, it follows that the latter will be relocated immediately by the hotel / accommodation management.

5.4 ACT in Commerce

Alice buys chocolate from the supermarket in Paris. The outer packaging is contaminated and she may receive a dose of the virus. That same day, Bob buys the same chocolate in Lyon, from the same supermarket chain as does Marie in Antibes and Mario in Turin the day after. The supermarket chain has adopted the ACT protocol. It follows that all four supermarket corridors selling chocolate are measured positive with the SARS-CoV-2 virus during the cleaning that takes place every two hours in those supermarkets. The consequences of those four measures are as follows:

- Isolate the fours corridors and stop sales of chocolate items in the four supermarkets.
- Verify and warn factory, country of origin and logistics.

In conclusion, ACT can be a practical *virus-tracing* tool, following the *supply chain* related to chocolate in that supermarket chain.

5.5 ACT and its relation with Time

Common assumptions for the 3 scenarios

This description follows these 2 persons:

- Carrie, a young woman that is asymptomatic or unnoticed very lightly symptomatic, and is exposing unintentionally others to the COVID-19 virus.
- Alice, a second young woman that so far has been free of COVID-19, and therefore can be infected.

Both Carrie and Alice have the Synchronous Contact Tracing (SCT) application ACT application installed and active on their respective smartphones.

The Crossroads supermarket has installed and operational COVID-19 sampling of waste-water and dirty cleaning water, as well as ACT enabled broadcasting stations near the entrance, at the sanitary facilities and at several reference points in the supermarket.

Carrie goes shopping at the Crossroads supermarket at about 13:00; she touches some items and unintentionally sneezes and coughs on some products, she breathes and leaves a temporary aerosol trace where she walks. She makes use of the sanitary facilities of the Crossroads supermarket. After about half an hour, she pays and leaves the supermarket at 13:35.

Carrie has potentially left a trace of SARS-CoV-2 virus on the caddy she has used, the products she has touched, in the corridors she walked through, in the sanitary facilities, etc.

At about 13:45, Alice enters the Crossroads supermarket; she makes use of the sanitary facilities before 14:00, then goes about her shopping, and leaves the supermarket at about 14:45; on the way out, she buys flowers from the flower shop at the supermarket entrance.

By coincidence, Alice takes the same caddy as Carrie, she walks through some of the corridors that also Carrie has used, and she buys a product that Carrie has touched.

The following scenarios can be then identified.

Scenario 1: ACT with fast facilities detection

The cleaning service takes a sample of the waste-water in the sanitary facilities every hour, at the hour, that is processed in local sample testing equipment that gives a test result in less than 30 minutes; the test result of the sample taken at 14:00 is available at 14:30: Alice is still in the supermarket; Carrie has left the supermarket well before the result becomes available (at 13:35).

When at 14:30 the test result of the sample taken at 14:00 is available and indicates contamination with COVID-19, the supermarket initiates the following actions:

- sets an alarm for the sanitary facility;
- requests an intervention of the cleaning services;
- notifies the relevant health entities, local, regional, national;
- sets a web-accessible alarm;
- broadcasts a 'current alert' in the supermarket;
- till the sanitary facility is disinfected, a web accessible alarm includes a warning for users to avoid the infected location, till disinfection has taken place and the facility is again safe for users.

Alice, who is still in the supermarket, receives the broadcasted alert, checks the web alarm information, and the ACT application warns her of possible exposure, and advices her to consult specific ACT COVID-19 information on the actions to be taken.

Carrie has left the supermarket; the ACT Smartphone application automatically downloads later that day a list with possible infected locations. The ACT application discovers a match between Carrie's presence at the sanitary facilities and the possible infection, and advices her to consult specific ACT COVID-19 information for the actions to be taken.

NOTE 1: Carrie receives a notification of a possible exposure; in this case the exposure may be from herself, but Carrie cannot know that, nor does the ACT system know.

NOTE 2: The necessary sampling and testing equipment for ACT with fast facilities detection needs to be developed and tested.

Scenario 2: ACT with next-day facilities detection

The cleaning service takes samples from the waste-water every three hours (e.g. at 10:00, 13:00, 16:00, 19:00, 22:00), and after closing time, at 22:30 samples of the dirty cleaning water from cleaning different areas of the supermarket.

The samples are sent overnight to a bio-chemical lab for detection and measurement. The next day at about 15:00 the test results are made available. Carrie and Alice have left the supermarket well before the results become available (the previous day).

When the next day at about 15:00 test results of the samples sent overnight to a bio-chemical lab for detection and measurement become available and indicates contamination with SARS-CoV-2 virus.

The supermarket initiates the following actions:

- notifies the relevant health entities, local, regional, national;
- sets a web accessible alarm;
- broadcasts a 'late alert' in the supermarket.

Both Carrie and Alice have left the supermarket; the ACT Smartphone applications automatically download later that day a list with possible infected locations. The ACT application discovers a match between Carrie's at the infected locations in the supermarket and the possible infection the previous day, and advices them to consult specific ACT COVID-19 information for the actions to be taken. A similar match at the infected locations in the supermarket is communicated to Alice.

NOTE 3: Carrie receives a notification of a possible exposure; in this case, the exposure may be from herself, but Carrie cannot know that, nor does the ACT system know.

NOTE 4: The necessary sampling equipment for ACT with next day facilities detection needs to be developed and tested; this is considered requiring mainly limited hydraulic and sanitary engineering and testing.

Scenario 3: ACT without detection

Due to strike action by the cleaning personnel at the Crossroads supermarket, no samples are taken from waste-water or dirty cleaning water. However, the ACT broadcasting equipment is in normal operation.

Carrie and Alice visit the supermarket, but they are not protected at all by the ACT systems, as the required samples, produced by the cleaning personnel are missing.

Carrie has unintentionally infected some milk containers that day, and unknowingly Alice selects and buys one of these.

Alice develops light symptoms by day 6 after her visit to the supermarket, gets tested day 8, and the following day receives a positive result for COVID-19.

Alice receives authorization for her ACT application to release the recorded ACT events to the respective back-end server.

Carrie's ACT application on her smartphone automatically downloads later that day a list with possible infected locations. The ACT application reveals a match between Carrie's presence at the Crossroads supermarket within the calculated timeframe for exposure, and advises her to consult specific ACT COVID-19 information for action to be taken.

NOTE 5: Carrie receives a notification of a possible exposure; in this case, the exposure may be from herself, but Carrie cannot know that, nor does the ACT system know.

6 ACT Method Architecture and Solutions

6.1 ACT Method Architecture and Functionalities

The architecture and the entities required to support the ACT method are described in clause 6.1. The identified interfaces are specified in clause 6.2. Clauses 6.3 and 6.4 specify their implementation by means of the oneM2M standard framework.

The ACT architecture is depicted in figure 6.1-1.

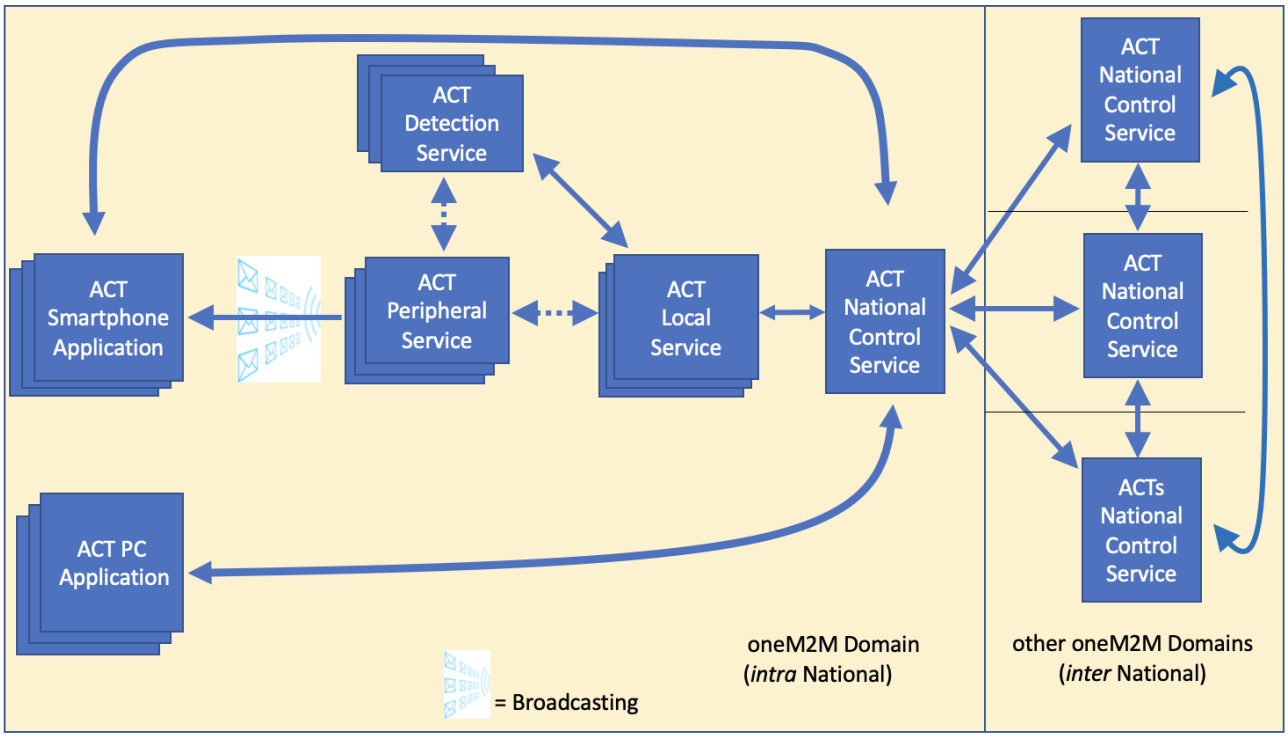

Figure 6.1-1: ACT Architecture

Table 6.1-1 clarify the numerosity relation between the ACT architectural elements.

Table 6.1-1: ACT elements numerosity relations

	ACT Smartphone Application	ACT PC Application	ACT Peripheral Service	ACT Detection Service	ACT Local Service	ACT National Service
ACT Smartphone Application			N←N (Based on broadcasted SSID and BSSID)			N←→1
ACT PC Application						N←→1
ACT Peripheral Service				N←→1 (No interface: the correlation is based on configuration)	N←→1 (The interface is based on commercial management configuration of the WiFi Access Points)	
ACT Detection Service					N←→1	
ACT Local Service						N←→1
ACT National Service						N←→N

In the following, the ACT services are described.

ACT Peripheral Service:

- A Peripheral Service, placed in a specific location, such as a supermarket corridor, a public toilet, a metro station, a fitness room etc. has the capability to transmit, using WiFi technology, the following information such as its unique identifier (also known as the MAC identifier BSSID).

The scope of this entity is to provide frequently with a configurable periodicity the BSSID identifier that permits the human to record the passage in a determined correlated area (e.g. a corridor, a metro car, a restroom, an open garden, an office, etc.).

It shall broadcast periodically its BSSID (with a timestamp) in order to allow the human handheld devices to record it, and by comparison, to discover the risk of having been infected by staying in its proximity area. It shall be also capable to broadcast information about the status of infection around its proximity and its adjacent areas ("the forecast").

It shall be associated with a unique **ACT Detection Service** to allow the correlation of the detection of the contamination with the proximity area where the **ACT Peripheral Service** is deployed.

It shall communicate with the one or more **ACT Local Services** to receive the SARS-CoV-2 virus (or any other virus) forecast information to configure the Access Point.

ACT Detection Service:

- A Detection Service informs the one or many Local Services about the detection of the contamination in one of the proximity areas associated to one or many Peripheral Service. The chemical process and the kind of test used to check the material for contamination (e.g. air-filter, waste-water filter, dirty cleaning tools and water, etc.) are stricto sensu not pertinent to ACT Technical Specification. Each Detection Service can be associated with one or many Peripheral Services and it shall communicate with the one or many Local Services the detection of a contamination. It will exchange its monitoring and configuration information with one or many Local Services, including means to exchange the information necessary to the management of the Detection Service.

The scope of this entity is to inform the **ACT Local Service** about the detection of the contamination in one of the proximity areas associated to one of the **ACT Peripheral Service** that belongs to it.

The means of the object to be checked against contamination (e.g. climatization air filter, waste-water filter, dirty cleaning tools and water, etc.) are non-pertinent to this Technical Specification: nevertheless the exchange of specific configuration/monitoring information related to the detection tools are supported.

It shall be associated with one or more **ACT Peripheral Services**.

It shall communicate the detection of a contamination to the one or more **ACT Local Services.**

It shall exchange its monitoring and configuration information with the **ACT Local Service**, including means to exchange the information necessary to the management of the specific detection tool.

ACT Local Service:

- A Local Service receives the information from one or many Detection Services belonging to it and propagates this information to the National Control Service. It receives the necessary indications, in order to behave according to the National Authorities policies for the one or many Peripheral Services configuration (e.g. for the broadcast frequency of the identifier or for the emission of the forecast information). It will also transmit to the National Control Service the identifiers of the one or many Peripheral Services involved in a positive detection, together with their location and the approximate range of the detection. Finally, it will exchange monitoring and configuration information with the National Control Service.

The scope of this entity is to receive the information from the **ACT Detection Services** belonging to it and to propagate this information to the **ACT National Service** and receive the necessary indications, in order to behave according to the National Authorities policies for the **ACT Peripheral Services** configuration (e.g. the broadcast interval of the BSSID identifier and the emission of the forecast information).

It shall transmit to the **ACT National Service** the BSSID identifier of the **ACT Peripheral Services** involved in a positive detection, together with their location and the approximate range of the detection.

It shall exchange its monitoring and configuration information with the **ACT National Service**.

ACT National Control Service:

- A National Control Service will receive the information from the one or many Local Services related to contamination and will provide to it information according to the Public Health Authorities policies on the one or many Peripheral Services configuration (e.g. for the broadcast frequency of the identifier or for the emission of the forecast information). The National Control Service also represents a point of interaction with the users. It provides, on request, the identifier of the one or several Peripheral Services announcing contamination to the Smartphone applications and additional information about indications and suggestions according to the Public Health policies (e.g. the suggestion of avoiding certain areas or to perform a human test verification if certain conditions of exposure are met, according to the detection of the virus in the areas covered by one or many Peripheral Services). The National Control Service will exchange its monitoring and configuration information with the one or many Local Service and with the many Smartphone applications. It will also coordinate and communicate the information about the areas of detection of the virus with one or many Peripheral Services in other Nations or Regions. Finally, the National Control Service will be in contact with others National Control Services in order to exchanges forecast, common Policies so informing users of different Nations, Regions or Municipalities, etc., when they are traveling from home. This enables ACT to be a genuine, international forecast tool.

The scope of this entity is to receive the information form the **ACT Local Services** related to contaminations and to provide to it indications according to the national authorities policies about the **ACT Peripheral Services** configuration (e.g. for the broadcast frequency of the identifier or for the emission of the forecast information).

It also represents the point of interaction with the users. It provides, under request, the identifier of the contaminated **ACT Peripheral Services** to the **ACT Smartphone applications** and additional information about indications and suggestions according to the national Authorities policies (e.g. the suggestion of avoiding certain areas of to perform a verification if certain conditions of exposure are met according to the detection of the virus in the areas covered by certain **ACT Peripheral Services**.

It shall exchange its monitoring and configuration information with the **ACT Local Service** and with the **ACT Smartphone applications** and devices **ACT PC applications**.

It shall also coordinate and communicate the information about the areas of detection of the virus with other **ACT Peripheral Services** in other nations/regions.

ACT Smartphone application:

- A Smartphone application is the digital tool available to the user to monitor the level of contamination. It collects the identifier from the one or many Peripheral Services and periodically compares it with the identifier-related forecast published by the National Control Services, with an associated time and forecast, and about potential contaminated areas. It also receives the local forecast when approaching one or many Peripheral Services and will periodically warn the user according to the Public Health Policies received by means of the one or many National Control Service. The Smartphone application also offers the opportunity to request and receive forecast about other Peripheral Services (not necessary the one he/she was close) information always without communicating its user's location (this is a requirement). The periodicity of the request will be configurable by the Smartphone application.

The scope of this entity is to represents the application on the smartphones of the users. It collects the identifiers form the **ACT Peripheral Services** and periodically compares this information with the ones from the **ACT National Services** about the contaminated areas. It also receives the forecast when approaching the **ACT Peripheral Services** and will warn the user according to the National Authorities policies received by means of the **ACT National Services**.

ACT PC application:

- A PC application is an user connected device (tablet, personal computer, smart tv, etc.) that communicate with the National Control Services to query and receive feedback about the status of the situation in specific geographical areas. By delegation, it can also query other Inter-National Control Services. It basically supports the user about the discovery of its own risk according to the past visited areas and/or to plan his movement and behaviours in advance. The purpose of the PC application is similar to the Smartphone application, namely be informed about the forecast of the virus, but its UX/UI is rather different. However, the only difference is that the PC and SmartTV might not receive the WiFi signal from the Peripheral Service.

The scope of this entity is to represents an application on a user connected device (smartphone, tablet, personal computer, smart tv, etc.) that communicate with the **ACT National Services** to query and receive back information about the status of the situation in specific geographical areas. It basically supports the user about the discover of its own risk according to the past visited areas and/or to plan his movement and behaviour in advance.

6.2 ACT messages

6.2.1 Service Identifiers

The identifiers of the Detection Service, the Local Service, the National Control Service (respectively the DETECTION-SERVICE-ID, the LOCAL-SERVICE-ID, the NATIONAL-CONTROL-SERVICE-ID) shall map to the corresponding AE-ID of the oneM2M communication services and adopt their format. These identifiers do not need to be explicitly transmitted as part of the ACT protocol because are already part of the ACT communication framework. The mapping of the Detection Service and Local Service with the ACT communication framework is specified in clauses 6.2 and 6.4 of the present document.

The PERIPHERAL-SERVICE-ID is defined in clause 6.2.2 of the present document.

The NATIONAL-CONTROL-SERVICE-ID is defined in clause 6.2.6 of the present document.

6.2.2 Messages broadcasted by Peripheral Service (and listened by Smartphone application)

The Peripheral Service shall broadcast the information specified in the following table 6.2.2-1.

Table 6.2.2-1

Parameter name	Type	Description
PERIPHERAL-SERVICE-ID	String	The identifier depends on the communication technology used. The identifier of the supported technology is defined in this clause below the table.

The transmission technology supported by the Peripheral Service is WLAN (WiFi) according to IEEE 802.11 [2]. The Peripheral Service is broadcasted by a commercial WiFi Access Point, and the string of the PERIPHERAL-SERVICE-ID shall be the BSSID [2], i.e. the string corresponding to the MAC address of the WiFi Access Point of the Peripheral Services. In this case, the SSID [2] of the Access Point configured by the Local Service shall contain the prefix "ACT-", and it shall be composed by the concatenation of the string ACT- with a string set according to the deployment needs. This allows the Smartphone application to decide which BSSID would be memorized among the ones of the different WiFi Access Points detected.

Other technologies would be potentially included in future versions of the present document.

6.2.3 Messages between Detection Service and Local Service

The Detection Service shall transmit to the Local Service the information specified in the following table 6.2.3-1.

Table 6.2.3-1

Parameter name	Type	Description
STATUS	It is defined by one of the following String values: ACTIVE SLEEPING OUT-OF-SERVICE RESTARTING MAINTENANCE-REQUESTED FAULT	This parameter shall be mapped according to the following: ACTIVE: the Detection Service is operative; SLEEPING: the Detection Service has the energy saving status activated (*e.g.* when the associated shop is currently closed); OUT-OF-SERVICE: the Detection Service is still connected but it cannot become operative (e.g. it is subject to a maintenance procedure); RESTARTING: the Detection Service is in the process of becoming operative; MAINTENANCE-REQUESTED: the Detection Service require a maintenance (e.g. for the refilling of the test reagents, for the calibration, or for other tuning reasons); FAULT: the Detection Service has found itself to be faulty.
TEST-TIME	Time as defined in ISO 8601 [3]	The time of the collection of the test sample shall be reported in the TEST-TIME parameter. This parameter is absent if the Detection Service answers to a STATUS command and there is no TEST-RESULT to be reported.
TEST-RESULT	It is defined by one of the following Natural values: 0 to 10	This parameter shall be mapped according to the following: 0: No Virus detected; 1 to 10: Virus detected with an indication of the level of contamination of the sample. This parameter may be absent when the Detection Service answers to a STATUS command and there are not TEST-RESULTS to be reported.

The Local Service shall transmit to the Detection Service the information specified in the following table 6.2.3-2.

Table 6.2.3-2

Parameter name	Type	Description
COMMAND	It is defined by one of the following String values: RESTART SHUTDOWN SLEEP STATUS-REQUEST TEST-START TEST-STOP	This parameter shall be mapped according to the following: RESTART: the Detection Service shall restart; SHUTDOWN: the Detection Service shall shutdown; SLEEP: the Detection Service shall activate the energy saving status; STATUS-REQUEST: The detection service shall respond providing the STATUS Parameter; TEST-START: the Detection Service shall initiate performing the tests, according to the given TESTINTERVAL indication; TEST-STOP: the Detection Service shall stop performing the tests.
TEST-INTERVAL	Natural	This parameter shall be mapped according to the following: 0: the test shall be executed continuously; 1 to N: time interval, expressed in seconds, from the time of the last test if available; in case the time from the last test is not available, the test shall be executed immediately.

6.2.4 Messages between Local Service and Peripheral Service

The Peripheral Service is based on the WiFi technology with a commercial WiFi Access Point. The BSSID and the SSID identifiers of the Access Point as described in clause 6.2.2 of the present document and its broadcast interval are configured by the Local Service.

Other technologies would be potentially included in future versions of the present document.

6.2.5 Messages between Local Service and National Control Service

The Local Service shall transmit to the National Control Service the information specified in the following table 6.2.5-1.

Table 6.2.5-1

Parameter name	Type	Description
PERIPHERAL-SERVICE-ID	Defined in clause 6.2.2	Defined in clause 6.2.2
LOCATION	(DOUBLE, DOUBLE)	It shall contain the "geographical coordinates", represented by two doubles denoting latitude and longitude of the place where the sample reported in the provided TEST-RESULT has been collected plus the altitude indicated in meter
RANGE	Natural	It shall contain the range in meters correlated to the place of the collected sample
TEST-RESULT	Defined in clause 6.2.3	Defined in clause 6.2.3
TEST-TIME	Defined in clause 6.2.3	Defined in clause 6.2.3
NOTE: The LOCATION parameter may also denote the altitude where the PERIPHERAL-SERVICE-ID has been installed by using the type (DOUBLE, DOUBLE, DOUBLE).		

6.2.6 Messages between Smartphone application and National Control Service

The Smartphone application shall periodically send a query the National Control Service for providing the information specified in the following table 6.2.6-1. The periodicity of the request is can be configured in the Smartphone application, and can be modified by the National Control Service, as in "push notification". The location of the smartphone shall not be transmitted to the National Control Service.

The NATIONAL-CONTROL-SERVICE-ID are Web address that are hard coded in the Smartphone application: many NATIONAL-CONTROL-SERVICE-IDs can be then stored in the Smartphone application; this allow to the Smartphone application to perform a "late-binding" of the National Control Service relative to a given EU country he/she is currently depending in. For example, the usual Network Roaming will help ACT to communicate to the Smartphone application always the more pertinent NATIONAL-CONTROL-SERVICE-ID (i.e. the one related to the country where the Smartphone is currently operating, so therefore take full advantages of the ACT protocol all around EU in a seamless way.

Table 6.2.6-1

Parameter name	Type	Description
QUERY	It is defined by one of the following list of values: NATIONAL-CONTROL-SERVICE-ID (DOUBLE, DOUBLE, DOUBLE)	This parameter shall be mapped according to the following: NATIONAL-CONTROL-SERVICE-ID: interested in the geographical area managed by the *current* National Control Service, i.e. the one related with the network localization of the Smartphone, and, as such, strictly related with its geographical localization; (DOUBLE, DOUBLE, DOUBLE): interested in the geographical area represented by three doubles denoting a "circle" expressed by a point (expressed in latitude and longitude) and a radius. This represent the position of the closest regional department.

The National Control Service shall respond to the Smartphone application with a list of elements specified in the following table 6.2.6-2. Each element corresponds to the Peripheral Service of the query associated to a positive virus detection.

The relevance of the contamination is assessed by the National Control Services according to National Authorities policies, only RED and YELLOW cases are reported (other "safe" colours are not transmitted to save messages and energy).

Table 6.2.6-2

Parameter name	Type	Description
REPLY	PERIPHERAL-SERVICE-ID	PERIPHERAL-SERVICE-ID: as defined in clause 6.2.2. Note that in case the QUERY is (DOUBLE, DOUBLE, DOUBLE), the PERIPHERAL-SERVICE-ID will geographically belongs unequivocally to the "circle" expressed by a point (expressed in latitude and longitude) and a radius.
FORECAST	It is defined by one of the following list of String values: YELLOW RED	This parameter shall be mapped according to the following: YELLOW: <chosen by the National Control Service> RED: <chosen by the National Control Service>
FORECAST-TIME	Time as defined in ISO 8601 [3]	The time of the forecast it refers to.

Optionally, the following parameters can be added to the list as specified in the following table 6.2.6-3.

Table 6.2.6-3

Parameter name	Type	Description
MESSAGE	String	Used by the National Control Service to provide information and guidance to the users of the Smartphone application to be shown on the Smartphone.

6.2.7 Messages between PC application and National Control Service

The web-based PC Application (personal computer, tablet, smart tv, etc.) sends a query to the National Control Service for providing information. The parameters are specified in the following table 6.2.7-1.

Table 6.2.7-1

Parameter name	Type	Description
QUERY	(DOUBLE, DOUBLE, DOUBLE)	Interested in the geographical area represented by three doubles denoting a "circle" expressed by a point (expressed in latitude and longitude) and a radius.
FORECAST-FRAME	(Time, Time) as defined in ISO 8601 [3]	It shall contain two Times, i.e. the time-interval for which a forecast is queried. Note that both Times determine a time-interval that can be in the past, in the present, or in the future.

The National Control Service shall respond to the PC application with a list of elements as specified in the following table 6.2.7-2. Each element corresponds to the area of the query defined by latitude, longitude and radius.

The relevance of the contamination is assessed by the National Control Services according to National Authorities policies.

Table 6.2.7-2

Parameter name	Type	Description
REPLY	PERIPHERAL-SERVICE-ID	PERIPHERAL-SERVICE-ID: as defined in clause 6.2.2. Note that in case the QUERY is (DOUBLE, DOUBLE, DOUBLE), the PERIPHERAL-SERVICE-ID will geographically belong unequivocally to the "circle" expressed by a point (expressed in latitude and longitude) and a radius.
FORECAST	It is defined by one of the following String values: GREY GREEN YELLOW RED	This parameter shall be mapped according to the following: GREY: <chosen by the National Control Service> GREEN: < chosen by the National Control Service> YELLOW: < chosen by the National Control Service> RED: < chosen by the National Control Service>
FORECAST-TIME	Time as defined in ISO 8601 [3]	The time of the forecast it refers to. Note that the FORECAST-TIME shall be contained in the FORECAST-FRAME.

The UX/UI of the PC application may be able to draw some "animation" of the evolving situation between the required time frame. Optionally, the following parameter may be added to the list, as specified in the following table 6.2.7-3.

Table 6.2.7-3

Parameter name	Type	Description
MESSAGE	String	Used by the National Control Service to provide information and guidance to the users of the Smartphone application. This parameter may be absent, when present, the string shall be communicated also to the Local Service.

6.2.8 Messages between different National Control Services

The National Control Services should be able to communicate critical situations that would be useful if National and inter National Health Authorities may exchange data with eachothers to cross data each others. Broadcasting all messages of YELLOW and RED forecast seems to be a plausible solution that would not be so expensive, if people consider that all National Control Services are usually implemented as ordinary servers fully connected to Internet.

As such, the following messages are notified and broadcasted to all National Control Services. Note that they are exactly the same messages that all National Control Services forwards to Smartphone applications, as specified in the following table 6.2.8-1.

Table 6.2.8-1

Parameter name	Type	Description
NOTIFY-ALL	PERIPHERAL-SERVICE-ID	PERIPHERAL-SERVICE-ID: as defined in clause 6.2.2.
FORECAST	It is defined by one of the following list of String values: YELLOW RED	This parameter shall be mapped according to the following: YELLOW: <Chosen by the National Control Service> RED: <Chosen by the National Control Service>
FORECAST-TIME	Time as defined in ISO 8601 [3]	The time of the forecast it refers to.

Optionally, the following parameters may be added to the list, as specified in the following table 6.2.8-2.

Table 6.2.8-2

Parameter name	Type	Description
MESSAGE	String	Used by the National Control Service to provide information and guidance to the users of the Smartphone application. This parameter may be absent, when present, the string shall be communicated also to the Local Service.

6.3 oneM2M Resources to implement the ACT Services

The element of the ACT make use of oneM2M specification to support communication and interoperability. oneM2M specification are formally and normatively referenced in clause 7, while more information and tutorials are available on the oneM2M website www.oneM2M.org. For a correct understanding of the oneM2M use in the contest of the present documents, it is recommended to start becoming familiar with the oneM2M architecture and following oneM2M concepts:

- Nodes: ADN, ASN, IN
- Entities: AE, CSE, IPE
- Reference points/API: Mca, Mcc, Mcc'

Figure 6.3-1 below provide an example of association between ACT elements and the oneM2M Entities with the oneM2M relevant reference points.

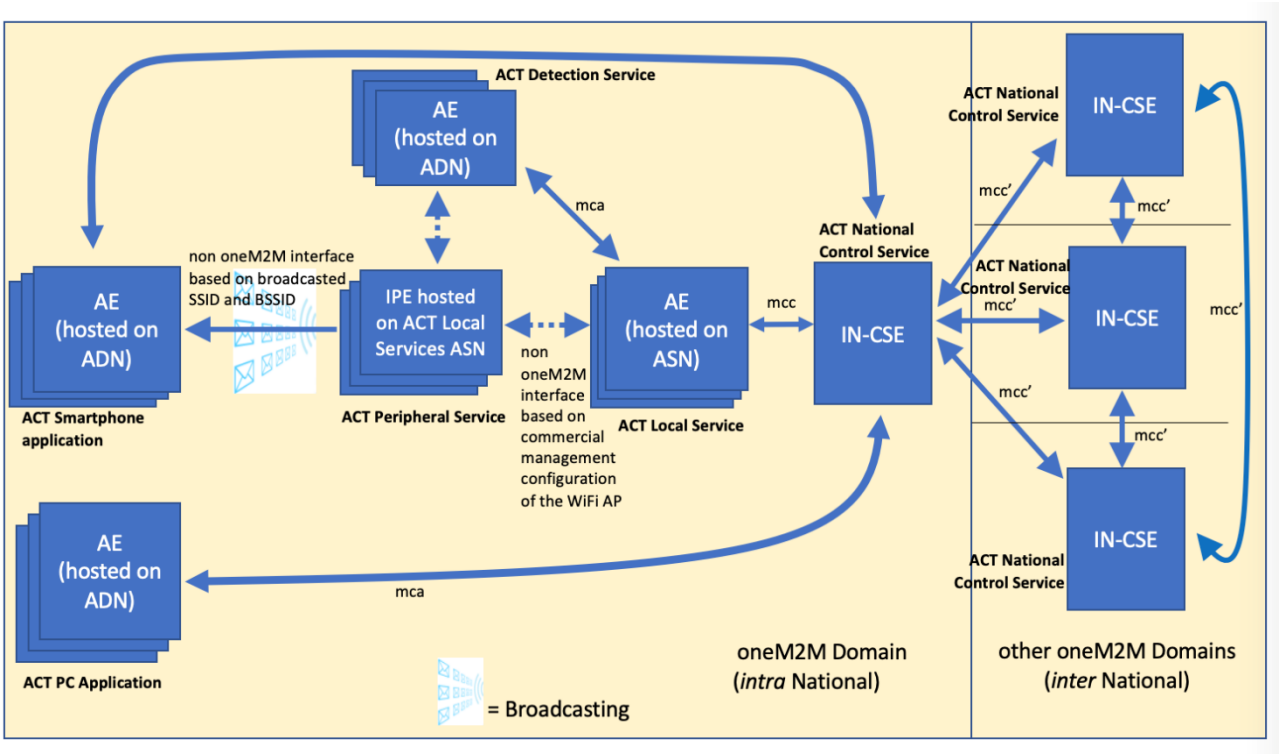

Figure 6.3-1: Mapping of the ACT Architecture in the common oneM2M Framework

The ACT elements shall comply to the mappings identified in the following table 6.3-1.

Table 6.3-1: Mapping of ACT on oneM2M elements and reference points

	ACT Smartphone Application	ACT PC Application	ACT Peripheral Service	ACT Detection service	ACT Local Service	ACT National Service
ACT Smartphone Application Mapped on: oneM2M AE (hosted on ADN)			Non oneM2M interface (Based on broadcasted SSID and BSSID)			Mca
ACT PC Application Mapped on: oneM2M AE (hosted on ADN)						Mca
ACT Peripheral Service Not a oneM2M node, It is mapped by an IPE hosted on ACT Local Services ASN					Non oneM2M interface (The interface is based on commercial management configuration of the WIFI Access Points)	
ACT Detection service Mapped on: oneM2M AE (hosted on ADN)					Mca	
ACT Local Service Mapped on: oneM2M AE (hosted on ASN)						Mcc
ACT National Service IN-CSE						Mcc'

6.4 Security, privacy and cybersecurity support

The security of the Asynchronous Contact Tracing architecture is assured by the communication framework (the oneM2M system) referenced in clause 7. The oneM2M system provide a complete solution for modular security (communication, identification, etc.) and flexible granularity of data access control (access control via identifiers, roles, tokens, etc.). Please refer to the oneM2M system specifications, in particular [4] (ETSI TS 118 103 [8]: oneM2M; Security solutions).

These capabilities empower the Asynchronous Contact Tracing with the ability to satisfy privacy and cybersecurity needs from the market and from the regulation authorities.

6.5 Management support

The management of the components of the Asynchronous Contact Tracing architecture, in particular the remoted components at the edges of the systems, is assured by the communication framework (the oneM2M system) referenced in clause 7. The oneM2M system provide a flexible solution for management including function such as security configuration and Software updates. Refer to the oneM2M system specifications.

7 Asynchronous Contact Tracing oneM2M Communication framework

7.1 Introduction

The oneM2M specifications define a framework for the communication and sharing of information. The major paradigm can be referred to as "store & share". De facto any object and information is mapped to resources that can be shared, discovered and accessed via a resource-oriented architecture and its related protocols.

IP protocols and URI formats are at the basis of the communication and identification, making the solution Internet of Things friendly, so the oneM2M system is a component of IoT.

The following three aspects most characterize the oneM2M solution in the context of ACT:

- The mentioned store & share mechanism allows information sharing among multiple services, without consuming the data or explicitly addressing the interested applications. In fact, the use of a communication that allows the storage of the information (on devices, gateways and servers) and its retrieval using application identities, removes the need for end to end routing of the information.
- A clear separation between security and privacy, where security is based on existing security mechanisms, while privacy is enforced by the system flexibly determined by the service application. The service application may decide to which applications/applications sets and under which conditions they choose to share the information.
- Transparency with respect to the application semantics. Data is stored and retrieved transparently from the point of view of the communication framework, which knows very little or nothing about the nature of the data contained and its format. This implies that to provide a full communication interoperability at the application level the service application needs to share a semantic model or to interwork with a common semantic model. In the case of ACT the common semantics are defined in ETSI TS 103 264 [24].

Everything is then integrated with the required communication feature: among others, security, device management, group managements, location management, communication scheduling, etc., are all part of the oneM2M solution. An intelligent independence from the underlying network: multiple IP based networks can be used, and the M2M System is used to hide (or abstract) the data with respect to the applications. This tries to make conscious & efficient use of the available connectivity means, with the possibility of reusing underlying network functionality where available.

Additionally, the oneM2M Communication Framework allows a flexible deployment. It is designed as a distributed system, where the functionalities and information can be distributed on devices, gateways and centralized servers, according to the specific service needs and optimizations.

7.2 Asynchronous Contact Tracing Communication Framework

The Communication Framework for ACT shall comply with the following specifications:

NOTE: For oneM2M specifications for which the transposition process by ETSI is still ongoing at the date of the present document, only the oneM2M number is provided.

- ETSI TS 118 111 (oneM2M TS-0011) [5].
- ETSI TS 118 102 (oneM2M TS-0002) [6].
- ETSI TS 118 101 (oneM2M TS-0001) [1].
- ETSI TS 118 104 (oneM2M TS-0004) [7].
- ETSI TS 118 103 (oneM2M TS-0003) [8].
- ETSI TS 118 105 (oneM2M TS-0005) [9].
- ETSI TS 118 106 (oneM2M TS-0006) [10].
- ETSI TS 118 109 (oneM2M TS-0009) [11].
- ETSI TS 118 120 (oneM2M TS-0020) [12].
- ETSI TS 118 112 (oneM2M TS-0012) [13].
- ETSI TS 118 115 (oneM2M TS-0015) [14].
- ETSI TS 118 113 (oneM2M TS-0013) [15].
- ETSI TS 118 122 (oneM2M TS-0022 [16]).
- oneM2M TS-0016 [17].
- ETSI TS 118 132 (oneM2M TS-0032) [18].
- ETSI TS 118 126 (oneM2M TS-0026) [19].
- oneM2M TS-0030 [20].
- oneM2M TS-0031 [21].
- oneM2M TS-0033 [22].
- oneM2M TS-0034 [23].

The communication framework security may be omitted when reusing an underlying network security (*e.g.* when the communication is performed on a secure cellular network).

Any proprietary addition/extension to the protocols on Mca, Mcc and Mcc' shall not be included (i.e. no proprietary parameter or resource is admitted on these interfaces). Proprietary extensions may be included by means of specialized applications that operate by associating semantic means to the standard resources (typically application and containers as defined in ETSI TS 118 101 [1]). This acts as plug in on the communication framework without impacting the communication framework interoperability.

These specifications apply to all the entities in the Asynchronous Contact Tracing Communication Framework including the Asynchronous Contact Tracing themselves.

Additional guideline and information are included in ETSI TR 118 501 [i.16], ETSI TR 118 525 [i.17], ETSI TR 118 535 [i.18] and ETSI TR 118 545 [i.19].

Annex A (normative): ACT Messages Specification

A.1 Messages between Detection Service and Local Service

```
DetectionToLocalServiceMessage:
      type: object
      required: [status, test-time, test-result]
      properties:
        status:
          type: string
          enum:
            - active
            - sleeping
            - out-of-service
            - restarting
            - maintenance-requested
            - fault
        test-time:
          type: string
          format: date-time
          description: "ISO 8601 time format"
          example: "2020-12-16T17:06:37+02:00"
        test-result:
          type: integer
          minimum: 0
          maximum: 10
          example: 3

LocalToDetectionServiceMessage:
      type: object
      required: [command, test-interval]
      properties:
        command:
          type: string
          enum:
            - restart
            - shutdown
            - sleep
            - status-request
            - test-start
            - test-stop
        test-interval:
          type: integer
          description: "test interval in seconds"
          minimum: 0
          example: "3"
```

A.2 Messages between Local Service and Peripheral Service

```
PeripheralServiceMessage:
      type: object
      properties:
        peripheral-service-id:
          type: string
          example: "C8:60:00:4C:27:A5"
          description: "The identifier depends on the communication technology used"
```

A.3 Messages between Local Service and National Control Service

```
LocalToNCServiceMessage:
      type: object
      required:
        - peripheral-service-id
        - location
        - range
        - test-time
        - test-result
      properties:
        peripheral-service-id:
          type: string
          example: "C8:60:00:4C:27:A5"
          description: "The identifier depends on the communication technology used"
        location:
          type: object
          required: [latitude, longitude]
          properties:
            latitude:
              type: number
              format: double
              example: 43.61599949832314
            longitude:
              type: number
              format: double
              example: 7.068412184709874
        range:
          type: integer
          minimum: 0
          description: range in meters
          example: 3
        test-time:
          type: string
          format: date-time
          description: "ISO 8601 time format"
          example: "2020-12-16T17:06:37+02:00"
        test-result:
          type: integer
          minimum: 0
          maximum: 10
          example: 3
```

A.4 Messages between Smartphone application and National Control Service

Mobile query message structure.

```
MobileQueryMessage:
      type: object
      required:
        - query
      properties:
        query:
          $ref: '#/components/schemas/Query'
```

Mobile query message response.

QueryResponse:

```
type: object
required: [reply, forecast, forecast-time]
properties:
  reply:
    type: string
    example: "C8:60:00:4C:27:A5"
    description: "The identifier depends on the communication technology used"
  forecast:
    type: string
    enum: ["yellow", "red"]
    description: "contamination level"
    example: "yellow"
  forecast-time:
    type: string
    format: date-time
    description: "ISO 8601 time format"
    example: "2020-12-16T17:06:37+02:00"
  message:
    type: string
    description: "Used by the National Control Service to provide
                  informations and guidance to the users"
```

A.5 Messages between PC application and National Control Service

Query message.

ForecastFrameQueryMessage:

```
type: object
required: [query, forecast-frame]
properties:
  query:
    $ref: '#/components/schemas/LocationQuery'
  forecast-frame:
    type: object
    required: [frame-start, frame-end]
    properties:
      frame-start:
        type: string
        format: date-time
        description: "Time frame start"
        example: "2020-12-16T17:06:37+02:00"
      frame-end:
        type: string
        format: date-time
        description: "Time frame start"
        example: "2020-12-16T17:06:37+02:00"
```

Query response.

ForecastFrameQueryResponse:

```
type: object
required: [reply, forecast, forecast-time]
properties:
  reply:
    type: string
    example: "C8:60:00:4C:27:A5"
    description: "The identifier depends on the communication technology used"
  forecast:
    type: string
    enum: ["green", "grey", "yellow", "red"]
    description: "contamination level"
    example: "yellow"
  forecast-time:
    type: string
    format: date-time
    description: "ISO 8601 time format"
    example: "2020-12-16T17:06:37+02:00"
  message:
    type: string
    description: "Used by the National Control Service to provide informations
              and guidance to the users"
```

A.6 Messages between different National Control Services

NCServiceMessage:

```
type: object
required: [notify-all, forecast, forecast-time]
properties:
  notify-all:
    type: string
    example: "C8:60:00:4C:27:A5"
    description: "The identifier depends on the communication technology used"
  forecast:
    type: string
    enum: ["yellow", "red"]
    description: "contamination level"
    example: "yellow"
  forecast-time:
    type: string
    format: date-time
    description: "ISO 8601 time format"
    example: "2020-12-16T17:06:37+02:00"
  message:
    type: string
    description: "Used by the National Control Service to provide informations
              and guidance to the users"
```

Annex B (normative): JSON messages examples

B.1 Messages between Detection Service and Local Service

From Detection Service to Local Service.

```
{
  "status": "active",
  "test-time": "2020-12-16T17:06:37+02:00",
  "test-result": 3
}
```

From Local Service to Detection Service.

```
{
  "command": "restart",
  "test-interval": "3"
}
```

B.2 Messages between Local Service and Peripheral Service

```
{
  "peripheral-service-id": "C8:60:00:4C:27:A5"
}
```

B.3 Messages between Local Service and National Control Service

```
{
  "peripheral-service-id": "C8:60:00:4C:27:A5",
  "location": {
    "latitude": 43.61599949832314,
    "longitude": 7.068412184709874
  },
  "range": 3,
  "test-time": "2020-12-16T17:06:37+02:00",
  "test-result": 3
}
```

B.4 Messages between Smartphone application and National Control Service

Mobile query message. Both structures are possible.

```
{
  "query": {
    "latitude": 43.61599949832314,
    "longitude": 7.068412184709874,
    "radius": 0.05
  }
}

{
  "query": {
    "peripheral-service-id": "C8:60:00:4C:27:A5"
  }
}
```

Mobile query message response.

```
{
  "reply": "C8:60:00:4C:27:A5",
  "forecast": "yellow",
  "forecast-time": "2020-12-16T17:06:37+02:00",
  "message": "string"
}
```

B.5 Messages between PC application and National Control Service

Query message.

```
{
  "query": {
    "latitude": 43.61599949832314,
    "longitude": 7.068412184709874,
    "radius": 0.05
  },
  "forecast-frame": {
    "frame-start": "2020-12-16T17:06:37+02:00",
    "frame-end": "2020-12-16T17:06:37+02:00"
  }
}
```

Query response.

```
{
  "reply": "C8:60:00:4C:27:A5",
  "forecast": "yellow",
  "forecast-time": "2020-12-16T17:06:37+02:00",
  "message": "string"
}
```

B.6 Messages between different National Control Services

```
{
  "notify-all": "C8:60:00:4C:27:A5",
  "forecast": "yellow",
  "forecast-time": "2020-12-16T17:06:37+02:00",
  "message": "string"
}
```

Annex C (informative): Bibliography

List of spare links about how extracting group testing from waste-water and air-conditioning:

About waste-water:

- https://www.bbc.com/news/uk-scotland-53109139.
- https://www.cbc.ca/news/health/covid-19-wastewater-1.5590882.
- https://www.nature.com/articles/d41586-020-00973-x.
- https://www.theguardian.com/world/2020/may/13/sewage-and-wastewater-the-key-to-finding-hidden-clusters-of-coronavirus.
- https://www.ft.com/content/e6ad8aa0-47ad-4ac1-b7f5-3375ab7d7ea6.
- https://www.santelog.com/actualites/covid-19-detecter-sa-propagation-dans-les-eaux-usees.
- https://www.kwrwater.nl/en/actueel/covid-19-publicaties/.
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- https://www.mathematica.org/services/covid19/covid19-wastewater-testing.

About air-conditioning:

- https://www.ashrae.org/about/news/2020/ashrae-issues-statements-on-relationship-between-covid-19-and-hvac-in-buildings.
- https://www.nafahq.org/covid-19-corona-virus-and-air-filtration-frequently-asked-questions-faqs/.
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Other useful references not used in the present document:

- oneM2M TS-0001: "Functional Architecture", version 4.7.0, Release 5.
- Édouard Philippe, Discours prononcé à l'Assemblée nationale, 28 April 2020, Assemblée Nationale, Paris, France.

NOTE: Available at https://www.gouvernement.fr/sites/default/files/document/document/2020/04/discours_de_m._edouard_philippe_premier_ministre_-_presentation_de_la_strategie_nationale_de_deconfinement_-_assemblee_nationale_-_28.04.2020.pdf.

- EitDigital: "Anonymous COVID-19 contact tracing using physical tokens".

NOTE: Available at https://www.eitdigital.eu/newsroom/news/article/anonymous-covid-19-contact-tracing-using-physical-tokens/.

Annex D (informative): Change History

Date	Version	Information about changes
09/2020	V0.0.1	Early Draft by LL
09/2020	V0.0.2	changed TOC and added references by LL
09/2020	V0.0.3	added some contents by LL
09/2020	V0.0.4	few modifications by LL
09/2020	V0.0.5	UK pass by Suno Wood
09/2020	V0.0.6	few modifications by LL
10/2020	V0.0.7	Services and Flows V1.0 by LL & ES
10/2020	V0.0.8	Protocol V0.1 by LL
10/2020	V0.0.9	Protocol V0.2 by LL
10/2020	V0.1.0	Protocol V0.3 by LL + UK pass by CL + changed TOC
10/2020	V0.2.0	Protocol V0.4 by LL + ES
10/2020	V0.2.1	Intro pass by CL
11/2020	V0.2.2	Protocol V0.5 by LL
11/2020	V0.2.3	Protocol V0.6 by LL + intro by SW
11/2020	V0.3.0	Protocol V0.7 by LL + ES
11/2020	V0.3.1	Protocol V0.7.1 by LL + ES
11/2020	V0.3.2	Draft reviewed by Technical Officer PG to better comply with ETSI TS Skeleton and ready to be shared in PDF format (with Disclaimer in front page) in the Open Area
11/2020	V0.3.3	Protocol V0.8. by LL. Better prose in Executive Summary, Introduction and Examples in clause 5 and clause 7 by LL + SW
12/2020	V0.3.4	Protocol V0.9 by LL. Add examples by CL: general pass of prose
12/2020	V0.3.5	Comments by TK
12/2020	V0.3.7	Polish and adjust by LL and ES
12/2020	V0.4.0	Protocol V1.0beta by LL. Response to questions asked during the 14/12 meeting + Polish examples + New TOC+ Add by LL + ES and O. Kramoff
12/2020	V0.4.1	Two tables added and amended two figures by Enrico Scarrone
12/2020	V1.1.1	Final Draft Approved by 15-18 December 2020 SmartM2M#56 Plenary reviewed by Technical Officer (from a fresh empty TS Skeleton) and submitted to EditHelp for Publication in URGENT mode
01/2021	V1.1.2	Editorial Modification clause 5.3 (ACT in Tourism) and [i.12] bookmark suppressed by LL on the express request of ETSI Technical Officer supported by TC SmartM2M Officials

History

Document history		
V1.1.1	December 2020	Publication
V1.1.2	January 2021	Publication