3GPP SA WG1 Meeting #98e S1- 221027

Electronic Meeting, 9 May – 19 May 2022 (revision of S1- 220149r12)

 (CL\_01b.Nokia\_LG2 is up to date)

**Source: LG Electronics, LG Uplus, OPPO, KRRI, China Unicom, Kyonggi University, Institute for Information Industry (III), Kontron Transportation France, CATT, Orange, SK Telecom, Xiaomi, Sharp, Hyundai Motors, Verizon UK Ltd, Futurewei, Tencent, FirstNet, KT Corporation, Hansung University, Qualcomm, ITRI**

**Title: Study on Network of Service Robots with Ambient Intelligence**

**Document for: Approval**

**Agenda Item: 4**

3GPP™ Work Item Description

Information on Work Items can be found at <http://www.3gpp.org/Work-Items>
See also the [3GPP Working Procedures](http://www.3gpp.org/specifications-groups/working-procedures), article 39 and the TSG Working Methods in [3GPP TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm)

Title: Study on Network of Service Robots with Ambient Intelligence

Acronym: FS\_SOBOT

Unique identifier: tbd

Potential target Release: *{Rel-19}*

# 1 Impacts

{For Normative work, identify the anticipated impacts. For a Study, identify the scope of the study}

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Affects: | UICC apps | ME | AN | CN | Others (specify) |
| Yes |  | **X** | **X** | **X** | Applications Enablement Aspect |
| No |  |  |  |  |  |
| Don't know | **X** |  |  |  |  |

# 2 Classification of the Work Item and linked work items

## 2.1 Primary classification

### This work item is a …

|  |  |
| --- | --- |
|  | Feature |
|  | Building Block |
|  | *Work Task* |
| X | Study Item |

## 2.2 Parent Work Item

For a brand-new topic, use “N/A” in the table below. Otherwise indicate the parent Work Item.

|  |
| --- |
| Parent Work / Study Items  |
| Acronym | Working Group | Unique ID | Title (as in 3GPP Work Plan) |
|  |  |  |  |

### 2.3 Other related Work Items and dependencies

|  |
| --- |
| Other related Work /Study Items (if any) |
| Unique ID | Title | Nature of relationship |
| 800049 | 5G\_HYPOS | Normative work outcome summarized in 22.261 |
| 840041 | eCAV | Normative work outcome summarized in 22.261, 22.104 |
| 840039 | EAV | Normative work outcome on UAS in 22.125 |
| 840031 | VIAPA | Normative work outcome on CMED and A/V Service Production 22.263 |
| 860009 | FS\_AMMT | Prior study on AI/ML model transfer |
| 750003 | eV2X | Normative work outcome in 22.186  |
| 950003 | FS\_Sensing | Ongoing study in 22.837 |
| 950004 | FS\_AmbientIoT | Ongoing study in 22.840 |
| 950005 | FS\_Metaverse | Ongoing study in 22.856 |
| 950008 | FS\_AIML\_Ph2 | Ongoing study in 22.875 |
|  |  | {optional free text}  |

**Dependency on non-3GPP (draft) specification:**

# 3 Justification

The advancement of robotics application technology would bring more business opportunity in telecommunication market segments through interdisciplinary and cross-industry collaborations. Some critical communication aspect of industrial robots in the context of cyber-physical control systems has been studied so that important use cases, including those with human-machine interface (HMI), can properly be supported with a higher level of communication availability, reliability, clock synchronization and so on. As a result, the related requirements have been identified in three typical traffic classes or communication patterns in industrial environments (refer to 3GPP TS 22.104).

There is a growing demand in consumer electronics segments that expects a great deal of roles that service-oriented robots (or service robots; Reference: ISO 8373:2012) should play in order to improve the level/quality of a human user’s daily behaviours for, such as shopping, traveling and more to come upon us resulting from smart-living innovations. Some examples of service-oriented robots include:

1. *serving robot or delivery robot* that delivers an item to the customer, e.g., at Continuing Care Retirement Community (CCRC), hotels and airport lounges quickly and efficiently;
2. *hazardous control or underwater rescue robot* that helps worker/officer playing critical roles in dangerous and extreme situations de
3. *shopping assistant robot* that is designed to help customers get necessary information and get “hands free” while shopping (local operations) and to help shopping for a remote customer (remote operations)

The characteristics and required roles of service robots to play are similar to yet also different from those of industrial robots:

1. Application area: service robots are intended to assist humans in various settings (as described in ISO 8373:2012) whereas industrial robots are to replacing human workforce in structured settings, such as manufacturing
2. Interacting points: service robots have interactions with human, capable of understanding natural forms of human input (e.g., natural language, gestures, facial expressions) whereas industrial robots have more standardized and structured way of interactions with human workers in job site
3. Business opportunity: service robots are designed for different usage scenarios than industrial robots, such as shopping assistance, care-giving, and indoor and local outdoor delivery
4. Technology readiness: apart from some basic roles that service robots can play, there exist challenging and promising areas that technology will need to catch up, in order to improve the service quality that service robots can provide, such as AI-native operation, zero-touch operation so that ideally human customers do not need to anything even when disruption happens in service robot operations

The operational models of service robot(s) include: (1) in an individual operation model, a single service robot is used for certain task (2) in a group operation model, a group/family of service robots work together for certain task, often referred to as a multi-agent scenario/model. The group operation model (or multi-agent model) is more advanced than the former model and thus has challenging requirements, which is the main focus of this study. Within the group operation model where a family of service robots work together, there are two modes of collaboration: (1) when the communication channel/link condition is not good enough and, as a result, some service robots out of the family/group cannot share the necessary information in time, they should make decisions with limited information, which is labelled as competitive mode. Each service robot in the group/family should go for a game-theoretic decision making process (typically, zero-sum game). (2) When the communication channel/link condition is good enough (not only at a certain epoch but continuously during their operation), the group/family of service robots can share necessary information fully and they could make a better coordination in strategy planning and can be more productive or efficient than in the previous case. Each service robot should go for a game-theoretic decision making process but, different from the previous case, the group/family can achieve better performance (typically, positive-sum game in this cooperative mode, namely, via the communication, their own individual decisions get better). Therefore, it is critically important to provide sufficient level of communication availability in the group operation model; if not (temporarily or not), it is critically important to provide a predictive means from communications layer suitable for the group operational model of service robots so that the group/family of service robots can maintain high level of performance/productivity/efficiency by avoiding or minimizing disruption of service robot operations. .

Due to the nature of their roles of assisting human in some use case scenarios (e.g., delivery, hazardous control, underwater rescue), some event-related information (e.g., accident, robot/sensor breakdown that have potential to contribute to or have contributed to service disruption, and information that has to rather be sent out of such a problematic situation that is predicted to happen or has already happened) needs to be share with the robot operator/server and/or with participating robots within certain time interval whenever such an event is predicted or any precursory indication becomes available (time-bounded communication). Several prior studies have addressed similar concerns in the context of other use cases such as V2X and UAS and other system enhancements such as ProSe, Group Communications, positioning and ranging. Some of the resulting normative requirements (reference to TSs 22.186, 22.125, 22.261, 22.263) can be applicable to support of service robots working in close cooperation with humans. Additionally, several new Rel-19 studies are likely to introduce new potential requirements that can enhance support for service robots, including FS\_Sensing and FS\_Metaverse among others.

Given the interesting scenarios and diverse requirements involved, it is proposed to analyse and document the 3GPP 5G system support for a group of service robots in various usage scenarios.

Analysis of technical challenges/gaps:

1. Safety: Service robots are required to perform “motion planning” and are strictly required for collision avoidance between human and robot, and between robots even when they are heterogeneous in dimension.
2. Enhanced exposure and support of on-demand priority communications: Service robots are equipped with various advanced sensors for various purposes. When a disruption to service robot operation is predicted at the applications layer (via advanced sensors), this predicted information can be utilized for applications layer to indicate necessary changes in the communications layer in a very timely manner.
3. Enhanced support for time-bounded communication for information/data sharing: 3GPP system is expected to be enhanced to support such an event-triggered delivery of information/data in an ultra-timely.
4. For some of the above-mentioned service scenarios, service robot communications are likely to require dedicated media configurations for robot vision tasks such as object analysis.

# 4 Objective

The objective of this study is to identify use cases and the potential service requirements to support efficient communications service and cooperative operation for a group of service robots including:

* + exposure of information between application layer and communications layer (e.g., capability to handle on-demand high priority events)
	+ support of on-demand high priority communications, to help avoid or minimize disruptions of service robot operation
	+ support of time bounded communication to help timely delivery of information/data between multiple service robots (including KPIs related to access delay, communication re-establishment, etc.), especially for large-scale group operation scenarios, e.g., due to robot’s communication failures or other event triggers
	+ support of scalable and efficient use of radio resources needed for stable operation of multiple service robots especially when a large number of service robots are present
	+ requirements related to media applications specific for service robots (e.g. speech, haptics, multiple simultaneous media types)
	+ aspects related to security, privacy and charging.

In addition, this study aims at

* collecting the existing functional and performance requirements that are relevant to support particular use cases of service robots that have human-machine and machine-machine interactions
* identifying potential correlation with some of stage-1 studies, e.g., Sensing, Metaverse

Also, this study may consider high-level spectrum usage considerations based on specific use cases for implementation, deployment and operation of a group of service robots, which are relevant to external audience from robotics-related industry.

# 5 Expected Output and Time scale

|  |
| --- |
| New specifications {One line per specification. Create/delete lines as needed} |
| Type  | TS/TR number | Title | For info at TSG#  | For approval at TSG# | Rapporteur |
| " TR" | 22.9XX | Study on Network of Service Robots with Ambient Intelligence | TSG#96Dec. 2022 | TSG#97Mar. 2023 | LEE, Ki-Dong (kidong.lee@lge.com), LG Electronics  |
|  |  |  |  |  |  |

|  |
| --- |
| Impacted existing TS/TR {One line per specification. Create/delete lines as needed} |
| TS/TR No. | Description of change  | Target completion plenary# | Remarks |
|  |  |  |  |
|  |  |  |  |

# 6 Work item Rapporteur(s)

LEE, Ki-Dong, kidong.lee@lge.com, LG Electronics

# 7 Work item leadership

SA1

# 8 Aspects that involve other WGs

# 9 Supporting Individual Members

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| --- |
| Supporting IM name |
| LG Electronics |
| LG Uplus |
| OPPO  |
| Korea Railroad Research Institute (KRRI) |
| China Unicom |
| Kyonggi University |
| Institute for Information Industry (III) |
| Kontron Transportation France  |
| CATT |
| Orange |
| SK Telecom |
| Xiaomi |
| Sharp |
| Hyundai Motors |
| Verizon UK Ltd |
| Futurewei  |
| Tencent |
| FirstNet |
| KT Corporation |
| Hansung University  |
| Qualcomm |
| ITRI |