3GPP SA WG1 Meeting #91-E
E-meeting, Aug 24-Sep. 2, 2020

S1-203180
Rev. of S1-20xxxx

to present slides 2, 3, 4, 5

New Study Proposal on 5G System Support for Service-Oriented Robots – Motivation Part I

- Motivation, Objective and UC Examples

Source: Ki-Dong Lee (kidong.lee(at)lge.com), LG Electronics
Agenda item: 4
Document for: Discussion

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Consideration Point#1

Highly efficient support of interactions with application layer:

- *Currently available robots (toys, assistive robots) have limited interactions b/w communication transport and its application functions*
- *Different types of Service robots: intended to be used in a wide range of social environments*
- *Service robots are basically equipped with control (typically powered by Reinforcement Learning-based models) and recognition capability (powered by various models, customized to voice, image and video, and 3D estimation, e.g., using various forms of neural nets)*
- A cloud robot platform typically requires more APIs (than a regular UE) for control and learning
- Way-forward: cognitive and programmable capabilities [NGMN 5G WP2] enable potentially **zero-touch** operation and maintenance of a network of robots through automation, delivering self-CHOP (Config, Healing, Optimization and Protection)
- transport –layer design consideration: necessity to study highly efficient support of interactions of communication transport with application layer
- service disruption should be less than human-recognizable limit

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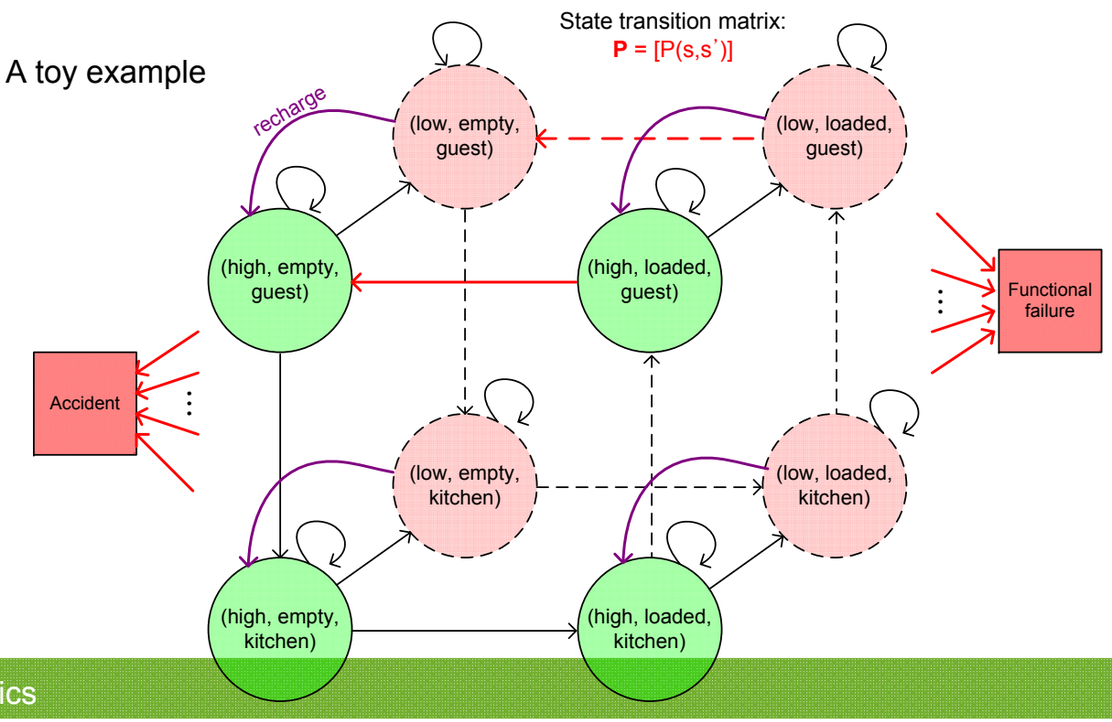
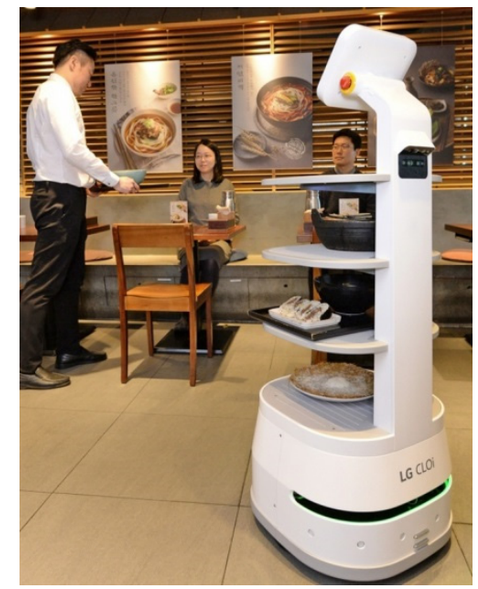
Consideration Point#1 (cont.)

Use case Examples (indoor delivery)

- Even if it is approx. decomposable, the state transition probability matrix (e.g. the probability of functional failure) still needs to be estimated/improved in a given job site (e.g. model-free control, deep learning) using **highly efficient interactions of transport with robot application layers**;
- Used for communication path reconfiguration (including heavy traffic)

A toy example





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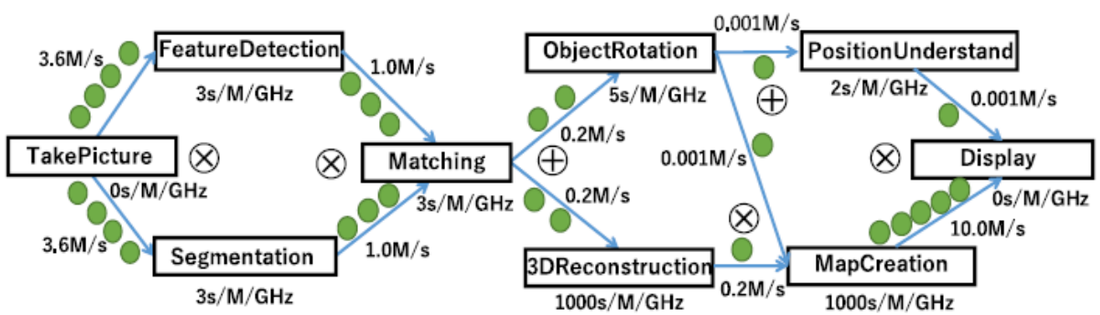
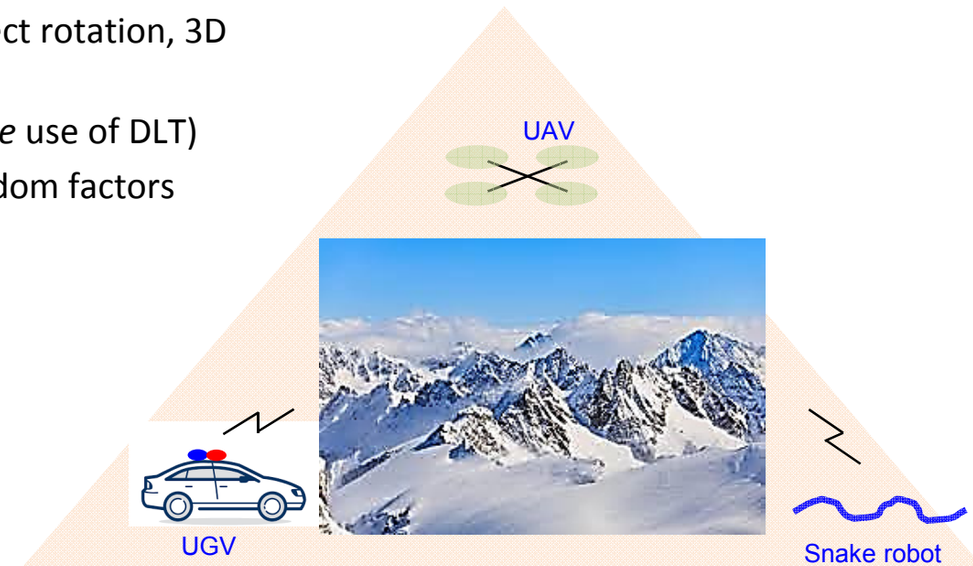
Consideration Point#1 (cont.)

Use case Examples (cont.)

- Search-and-rescue robot team operation: assist rescue officers
  - Snake robots
  - Unmanned ground vehicles (UGVs)
  - Unmanned aerial vehicles (UAVs)
  - Tasks: Feature detection, segmentation, matching, object rotation, 3D reconstruction, understanding position, **map creation**
  - Record of Task: observation, completion status, etc. (*see* use of DLT)
- **Transport/App layer interactions** to cope with Unknown/random factors
- Communication path: Uu, PC5 (including multihop)



(source: "Robotics cooperation…", Chen et al., IEEE Access, Vol 6, 2018; image from public domain)



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Consideration Point#2

- Operation support for a service robot authorized to serve multiple customers
  1. Different from smartphones (UEs), service-oriented robots will be used to service multiple customers at the same time.
  2. The Study will consider use cases related to 3GPP system's provisioning identifiability of different customers and collection of charging information for the respective customers that have received services via a robot (i.e., robot's communication transport).
     - The charging information is assumed to be provided to the subscriber of a robot. It is intended to provide necessary details (e.g. expense breakdown) for a subscriber.
     - If a subscriber has multiple robots which have provided service to multiple different customers, it would then be possible for the subscriber to be able to get the details (e.g., per customer, per robot).

MiD/MuD, UIA aspects are removed from this SID proposal

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The Objective

- Use cases and the related potential service requirements for 5G system support for communications in support of service-oriented robots :
  1. Highly efficient support of interaction with application-layer to minimize service disruptions caused by functional failure of robots
  2. Operation support for a service robot authorized to serve multiple customers
  3. Transport-layer support for efficient distribution of task status information of multiple robots(e.g., when using distributed database such as DLT) [to be justified in 3181]

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References

Please use the link or hyperlink

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- Intel New Era AI Robotic Inc.
- Sony's Robot Dog Aibo, IEEE Spectrum, Feb. 2020
- Robots come in all shapes and sizes at London's Science Museum, 2017 12(2) IET Engineering & Tech

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Robots (as an embedded UE*)

- Types of Robots "with communication functions"
  - "Robots are already deployed in retail, hospitality, manufacturing, healthcare, emergency services, and other areas" [RoboticsTomorrow]
  - For extreme purposes: Military robots, inter-planet explorer robot
    - E.g. Mars Pathfinder (X band)
  - For industrial purposes: typically called "industrial machinery" or "industrial robot"
    - Manufacturing robots in smart factory settings

  - For service purposes:
    - Entertainment
    - Assistance: contactless delivery of various items (indoor, e.g., restaurant, library, CCRC, hospital) → robot mobility, multi-robot collaborations, planning / coordination / communication
    - Shopping

- "embedded UE": a UE attached to a machinery/robot specifically for providing communication features b/w the system and external entity.
- Image source: Robotic Vision and Control (P. Corke)

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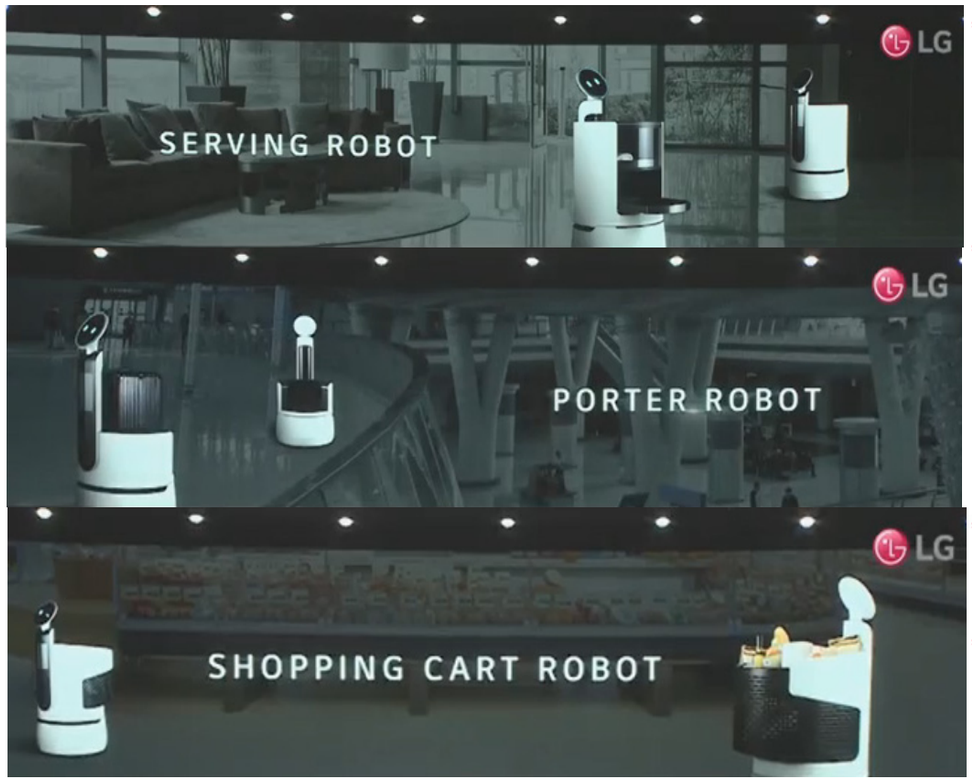
Annex

Examples of **Service-Oriented Robots**



- ***serving robots*** deliver food and beverage to residents of Continuing Care Retirement Community (CCRC), guests of hotels and visitors to airport lounges quickly and efficiently; assistive robots for quarantine officers; "contactless"
- ***porter robots*** help minimize inconvenience for travelers by reducing slow service and long wait times. This robot can also facilitate express check-in and check-out service by handling payment and delivering luggage to a waiting vehicle in a fraction of the time;
- ***shopping cart robots*** help customers get necessary information and get "hands free" while shopping
- ***(elderly) assistive robots:*** in-home environment, CCRC

Source: LG Global YouTub https://www.youtube.com/watch?v=umKVtkT-wvA

(source: "Social robotics service…", Kamei et al., IEEE Ubiq. Robotics and Ambient Intelligent 2017)

Annex

Different Roles and their Implications

	Service-Oriented Robots	Industrial Robots
Application	*Assisting human*	*Replacing human as possible*
	Confrontation of customers Responsive to human request, emotion, unexpected changes	No confrontation Acting according to defined rules, programmed tasks
Interacting point	*Customer*	*Workers (authorized personnel)*
	Request/HMI	Control/Command/KPI
Target customers	*Customer/human interaction*	*Manufacturer/enterprise*
	Shopping, traveling; elderly (CCRC); quarantine officers; Diverse/regional/cultural	Industry standards
technology	*Need more evolution*	*Relatively matured*
	Need to evolve/learn as human continues to change/evolve	Acting according to defined rules, programmed tasks

Service-Oriented Robots

Assisting Human

- Independent roles

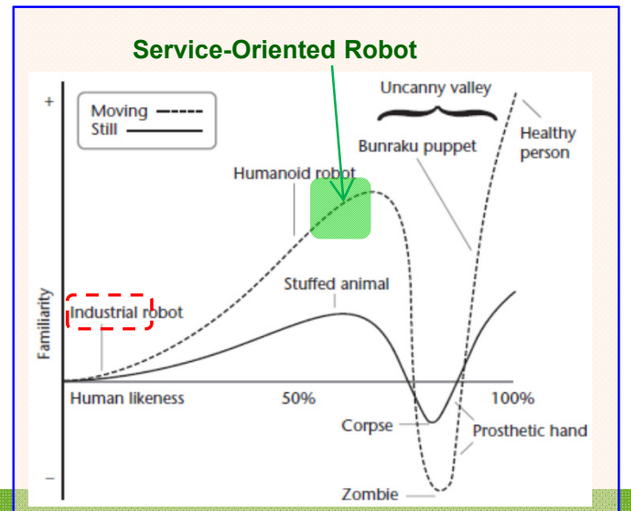
unknown
- Timely Response to Unknown/Unpredictable Factors: anything in direct confrontation of human customers

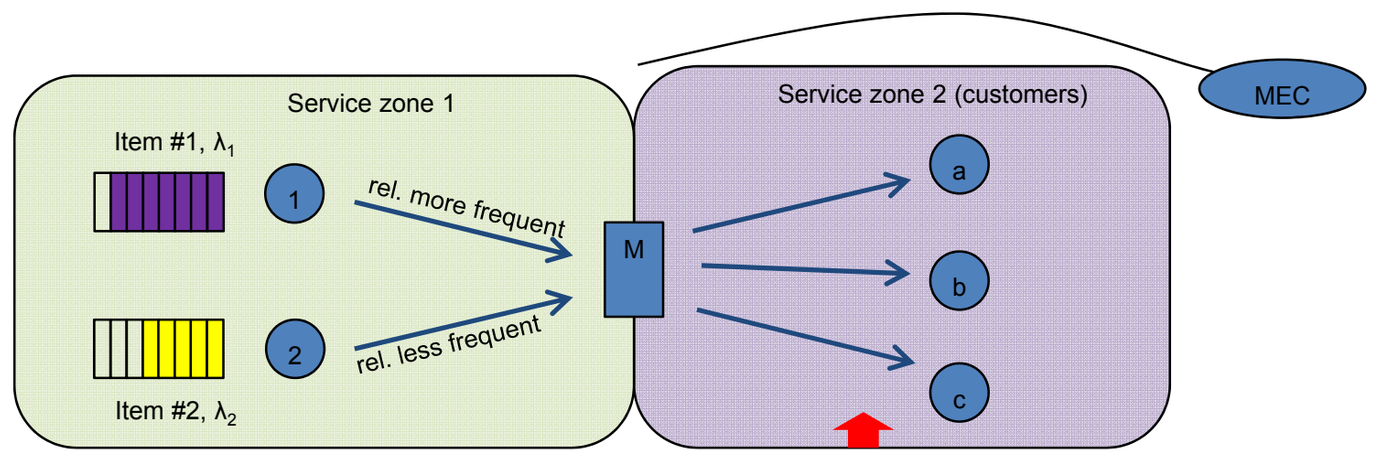
random
- Random Factors : Customer's requests are not always formalized; in nature, they make scheduling more difficult as unexpected outcome/delay will *in turn cause* a 2nd delay to happen in the following array of work tasks;

- Collaborative roles in a group of robots

multi-party
- A group of robots may have different roles in different service zones: different zones have different task arrivals, queue lengths, waiting times, etc.

collaboration
- Collaboration, coordination is needed





Different event rates (caused by customers, also affected by failures)

(source: M. Mori, IEEE)

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