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ER-Agent Communication Languages and Protocol for Large-Scale Emergency Responses

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Abstract. In this paper, we introduce a new agent communication language (ER-ACL) and a corresponding protocol (ER-ACP) to be used in multi-agent systems (MAS) to assist large-scale emergency responses as a part of an Emergency Response Communication Framework. In the previous study of ACL, we found them lack the necessary richness to support communication during a large-scale disaster, inc. structure, semantics and user models. This inspired us to create a new ER-ACL to fulfil this gap. Four types of agents are supported in ER-ACL: victims, carers (medical & social workers), families & friends, and ER-rescuers & helpers (members of the public, NGOs, government agencies, etc.). The advantages of ER-ACL and ER-ACP are that they provide a well-defined foundation to connect victims with potential helpers, thereby enabling crowdsourcing via effective communication based on precise semantics. The ER-ACL represents a significant extension and specialisation of the FIPA ACL for applications in emergency response scenarios now that great technical advances have been made in telecommunication (including image and video reporting). We have also added many new message constructs from the Common Alerting Protocol. In today's uncertain world, we believe a well-managed and personalised communication system is vital to organise unstructured/opportunistic resources to save lives. Not having found one in existence to-date, we hope our efforts can help close this gap.

Keywords: Agent Communication Language and Protocol, Emergency Response, Mobile Agents, large-scale disaster rescue.

1 Introduction

Communication is key to effective emergency response, especially in large-scale disaster events. Effective communication allows volunteers and rescuers to find victims quickly and accurately, allowing them to plan and carry out rescue tasks using suitable methods in a timely fashion. Communication is essential to keep families, friends, rescuers and carers informed, thereby providing effective support ASAP [1].

Multi-agent systems [2][3] are distributed systems that encompass many autonomous self-directional and actionable agents. Such systems are ideally placed to model and support Emergency Response Scenarios. Engineering such a multi-agent system requires rigorous specification, homogenization, standardization and a suitable foundation to support a good level of richness in conversations in the communication language and interaction protocols among agents.

FIPA-ACL is a widely used standard Agent Communication Language [4]. One of the motivations behind the development of FIPA-ACL was the need to address the challenges faced by the Knowledge Query and Manipulation Language (KQML) [5]. However, in this research, we found significant gaps still exist in FIPA-ACL when we tried to apply it to support emergency response scenarios.

For example, there is a lack of richness in the different types of message, which are thereby unable to support specific different agent interaction models. Examples of these are announcements, live updates, broadcast appeals, forwarded appeals and complex collaboration and planning types of conversations. For instance, announcements and live updates do not normally require a reply, but a broadcast appeal does - planning and collaboration would require back-and-forth discussion and confirmation.

FIPA-ACL also lacks a mechanism for the storage of emergency-related information, e.g. the changing status of a disaster and its impact, event and victim locations, dynamic personal health statuses, including injury type, severity and urgency, and hospital capacity. Nor does it support modern mobile technology that would allow voice, image and video file attachments to communications. Also lacking is any means of defining groups of users in order to support group-specific communication more rigorously. To address all of the above gaps, this paper discusses the Emergency Response Agent Communication Language (ER-ACL) and its corresponding protocol (ER-ACP) that we have designed to support communication in large-scale disaster emergency response.

2 Motivating Scenario

The inherent complexity and dynamism of large-scale disasters make the implementation of timely, effective, well-informed and organised emergency responses a far from trivial task, made even more complex when a large number of victims are involved. In order for a response to be effective, a broad range of information needs to be readily available and directed to the right people regarding, for instance, the changing status of the disaster itself, of locations and conditions of survivors, up-to-date shelter logistics, and communication between victims and rescuers, carers, family and friends.

Search and rescue may be framed as an agent-based problem for which the development of a suitable Agent-based Communication Language (ACL) is urgently needed. This ACL will be used via a mobile communication mechanism, such as a mobile app, that can store personal information (sharable before the emergency event) and be personalised to suit individual users' needs and their ways of communicating with others according to a set of pre-defined user groups using well-defined protocols.

To address these aims, based on the existing FIPA-ACL we have developed a new Emergency Response Agent Communication Language (ER-ACL) and a corresponding protocol (ER-ACP) in a new mobile app, Mobile Kit Assistant (MKA). This allows different information sources created by different people in different places to be connected and used together in meaningful ways based on an ontological backbone that we have created in [1].

3 Agent Communication Language and Protocol Design

When developing ER-ACL and ER-ACP, several issues have been taken into account to ensure the language is appropriate and usable. The following were considered.

3.1 Design Philosophy

To added new message constructs from the Common Alerting Protocol [6], important considerations for designing the ER-ACL are: **Interoperability** – ER-

ACL should provide a well-define structure and semantics, so that messages can be understood correctly in different systems; **Completeness** – The ER-ACL should support all of the possible communication information and methods, e.g. (typical) communicated information and its formats, e.g. voice, images and video messages and an indication of their retrieval method. **Simple implementation** – The ACL should be as simple as possible to use and implement; **Flexibilities** –The constructs should remain sufficiently abstract, while being rich, to be adaptable and extendable to other coding schemes; **Multi-use format** – the same message format may be used by different message types issued by different user groups; **Familiarity** – The data elements and code values should be meaningful to originators and non-expert recipients alike; **Interdisciplinary and international utility** – The design should allow a broad range of applications in public safety and emergency management and allied applications and should be applicable worldwide.

3.2 Requirements for Design

The ER-ACL should (1) Provide a specification for a simple, extensible format for digital representation of warning messages and notifications; (2) Enable integration of diverse sensor, inc. multi-gesture signals on mobile phones; (3) Support multiple transmission systems, including Wi-Fi Direct Peer to Peer (P2P), this is needed, as standard telecommunication networks are often down or congested that alternative communication channels are much needed; (4) Provide a unique identifier (e.g., Message ID) for each warning message and for each message originator; (5) Support multiple message types and sender roles; (6) Support suitable pre-defined content (key words); (7) Referencing supplement information/files external to the message; (8) Following established standard data representation; (9) Can sustain real-world cross-platform testing and evaluation; (10) Support emergency response scenarios and promote public safety.

3.3 Emergence Response User Scenarios

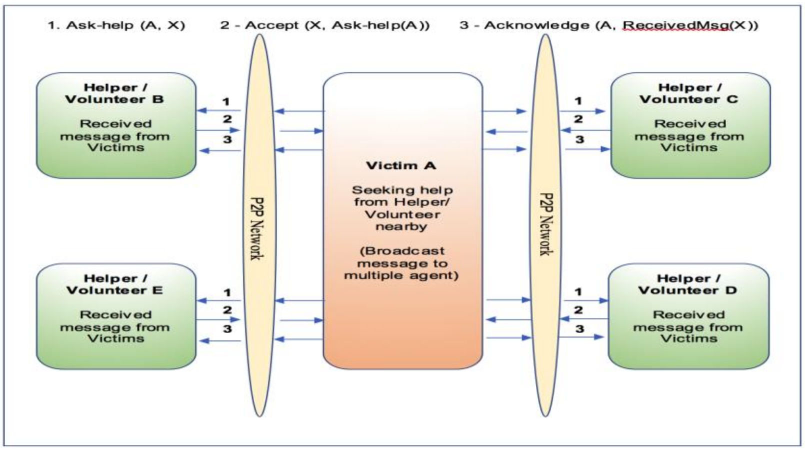

Fig. 1. Victim agent asking for help (broadcast mode)

In our study, there are several scenarios that can take place during and after large scale of disasters. We provide such an example in **Fig. 1** This situation indicates that the victim broadcasts an ask-help message to everyone near his location in the hope to find a volunteer/rescuer that is close to the victim. The literature showed [7] that the ideal distance for wireless connectivity for smart phones [8] is maximum 100 meters. Our focus is to alert nearby helpers and to reduce the congestion of telecommunication network, thus help the victims quickly after a large scale of disaster. The timing of how messages are sent is as follows: (1) Send Ask-help messages from victim to (nearby) volunteers; (2) Send Accept- message by volunteers to victims, if helping (refuse-messages are not send to reduce network congestion); (3) send Acknowledge-messages from victim to helpers.

3.4 Developing ER-ACL

Two documents have been used as main references to develop our ER-ACL and its protocol ER-ACP: the FIPA ACL [9] and Common Alerting Protocol [6]. These documents provide fundament concepts and structure. Here we present ER-ACL and the part of FIPA ACL performatives that we would normally use in emergency scenarios.

3.5 Performatives in ER-ACL

Table 1. List of Performative (Bold are new performatives used in ER-ACL)

Performative	Description	Status
Ask-help	Used by sender (victim) to send help message to receiver (volunteer)	New
Ask-help-for-others	Used by sender (volunteer) to send help message to receiver (volunteer)	New
Offer-help	Used by sender (helper) to send offer of help message to receiver (victim)	New
Accept	Used to accept message (and reply with current situation of sender agent)	New
Forward-Message	Used to forward message from agent (victim) from sender to another receiver	New
Acknowledge	Used to acknowledge message received from sender	New
Send	Used to send normal messaging between or among agents	New
Reply-to	Used to reply in normal messaging between or among agents	New
Reply-with	Used to reply-with normal messaging between or among agents	New
Status-report	Used to report status between or among agents	New
Channel	The connection method used for data transferring	New
refuse	Used to refuse to perform a given action, explaining the reason for the refusal.	Existing

Table 1 shows the combination of Performances in our new ER-ACL and FIPA-ACL as in [10] (ER-ACL performatives are shown in bold) has been used in our study. With these extensions, we are able to support common emergency response scenarios.

4 ER-ACL Communication Protocol

Through different scenarios of **Fig. 1** what we may call two-way complex communication may exist among three main agents such as family/friend, volunteer 1 and volunteer 2. Fig. 2 shows communication taking place among agents after a large scale of disaster, beginning with the victim asking for help from family/friend and then they ask help from volunteer 1 (we assume they are nearby the victim).

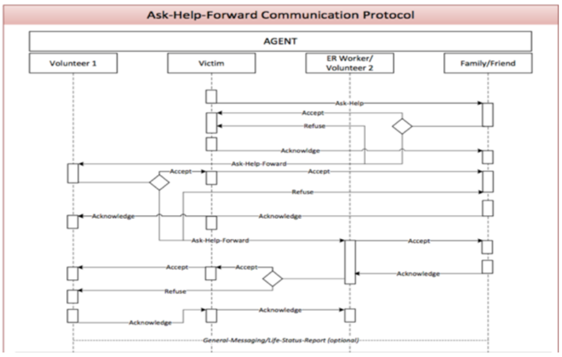

Fig. 2. Complex 3rd Party Ask-Help and Forward Communication Protocol in ER-ACL

However, the outcome is that volunteer 1 cannot help because they are managing another victim nearby. So volunteer 1 refuses the request, and then sends the information to another volunteer (volunteer 2). If volunteer 2 is able to help, they will accept the request and the 'accept' message will be sent to volunteer 1 and the family/friend, informing every one of the situation. The acknowledge message will be sent to the sender (family/friend) and Victim to ensure the information has been received, and the victim has only to wait for volunteer 2 to come.

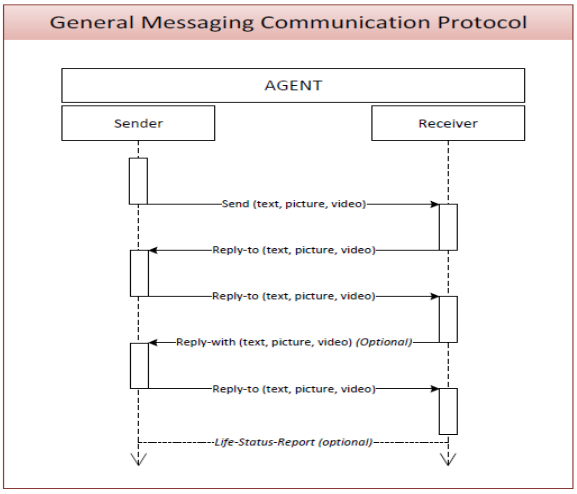

Fig. 3. Two Ways General Messaging Communication Protocol in ER-ACL

The situation shown in Fig. 3 is a protocol diagram for general messaging communication for situations that occur when two personal agents exchange information. Even the existing FIPA-ACL consist of reject-proposal, request, request-when and request-whenever performative, it is much difference with our propose performative in ER-ACL. The differences of those performative shown in Table 2 below:

Table 2. Performative Differences Between FIPA-ACL and ER-ACL

FIPA-ACL	ER-ACL
Reject-proposal	**Refuse**
The action of rejecting a proposal to perform some action during a negotiation.	The action of refusing to perform a given action and explaining the reason for the refusal.

FIPA-ACL	ER-ACL
Request The sender requests the receiver to perform some action. One important class of uses of the request act is to request the receiver to perform another communicative act. **Request-when** The sender wants the receiver to perform some action when some given proposition becomes true. **Request-whenever** The sender wants the receiver to perform some action as soon as some proposition becomes true and thereafter each time the proposition becomes true again. **Inform** The sender informs the receiver that a given proposition is true.	**Ask-Help** The action of sending information for getting help by victim (sender agent) to volunteer (receiver agent) or by family/friend (sender agent) to volunteer (receiver agent). There is no action perform needed by the receiver.

5 ER-ACL Conversation Tree

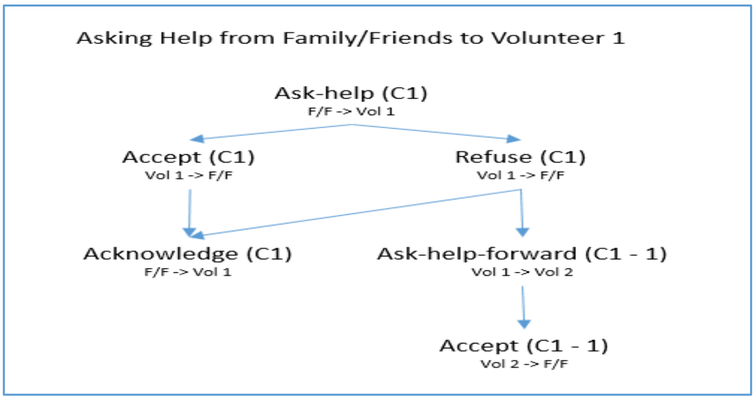

Fig. 4. Asking Help from Family and Friends to Volunteer

Fig. 4 shows a conversation tree where a family/friend asked for help on-behalf of the victim. Ask-help (C1) is the help request message sent by the family/friend to a volunteer 1. The second level applies whether volunteer 1 accepts or refuses the request. If volunteer 1 refuses to help, he/she may choose to forward the request in a new Ask-help-forward request (C1-1) to another volunteer 2 (and ride of the responsibility). An Accept message is sent to the family/friend by volunteer 2, only if help is offered by volunteer 2. The message ID, C1-1, records the trail of forwarded message of C1. This helps one to eliminate duplicated messages, if receives more than once.

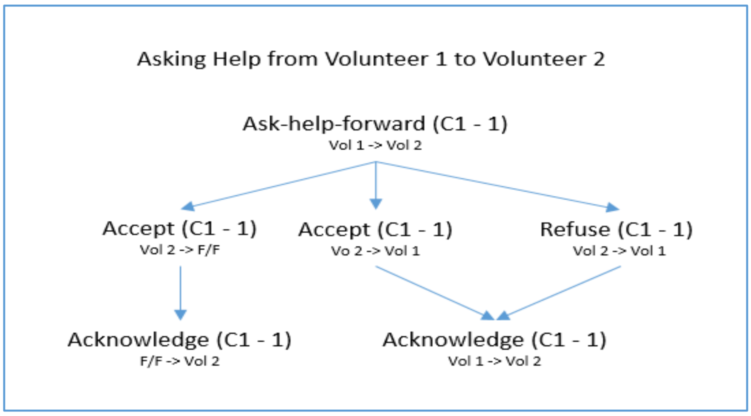

Fig. 5. Asking Help from Family and Volunteer to Volunteer

Fig. 5, above, shows the ask-help message that is sent by volunteer 1 to volunteer 2. The difference between ask-help and ask-help-forward, as shown above, is that a message sent via ask-help-forward will include the initial family/friend message sent to volunteer 1. This will help volunteer 2 glean important information such as location, time and message content, which is needed to help the victim.

6 ER-ACL Interaction Model

In this section, we describe two of our communication trees as in Fig. 4 and Fig. 5. From this communication tree, we, therefore, develop an interaction model in Table 3 and Table 4. The models have explained the use of ER-ACL performative and parameters per the ACL document as follows:

Performative <parameters>

6.1 Complex two ways communication Model Set

Table 3. Complex Two Ways Ask and Reply Communication Model

Performative	Parameter
Ask-Help	AH = <Mid, TS, S, R, Ec, Et, Se, Ed, Rm, Cm {Cid, Tm, LS, Um, Pid, VDid, VCid}, LL, CL, Bs, Ms, Cn, Po, Om >
Ask-Help-for-Others	AHF = <Mid, TS, S, R, Ec, Et, Se, Ed, Rm, Cm {Cid, Tm, {Fm}, LS, Um, Pid, VDid, VCid}, LL, CL, Bs, Ms, Cn, Po, Om >
Accept	A = <Mid, TS, S, R, Rm, Cm {Cid, Tm, LS, Um, Pid, VDid, VCid}, LL, CL, Bs, Ms, Cn, Po, Om >
Refuse	Re = <Mid, TS, S, R, Rm, Cm {Cid, Tm, {Fm}}, Ms, Cn, Po, Om >
Acknowledge	ACK = <Mid, TS, S, R, Cm {Cid, Tm}, Ms, Cn, Po, Om >

To see a more detailed structure, i.e. parameters used for complex two-way communication situations, we list all of the performative parameters used in Table 3. The acronyms of them are as follows:

AH – Ask Help	Mid – Message Id	AHF – Ask Help Forward
TS – Time Stamp	A – Accept	S – Sender
R_e – Refuse	R – Receiver	ACL – Acknowledge
R_m - Myrole	Cid – Content Id	T_m – Text Message
LF – Life Status	U_m – Urgency	PM – Picture Message
VM – Video Message	LL – Last Location	CL – Current Location
B_s – Battery Status	M_s – Message Status	P_o - Protocol
O_m – Ontology	F_m – Forward Message	E_c – Event Category
E_t – Event Type	S_e – Severity	E_d – Expiration Date

C_n – Channel VD_{id} – Video Message VC_{id} – Voice Message

6.2 Two Ways General Messaging Model Set

Table 4. Two Ways General Communication Model

Performative	Parameter
Send	Sn = <Mid, TS, S, R, Cm {Cid, Tm, Pid, VDid, VCid}, Ms, Cn, Po, Om >
Reply-to	Rt = <Mid, TS, S, R, Cm {Cid, Tm, Pid, VDid, VCid}, Ms, Cn, Po, Om >
Reply-with	Rw = <Mid, TS, S, R, Cm {Cid, Tm, Pid, VDid, VCid}, Ms, Cn, Po, Om >

The other communication possibility during the disaster as we name it Two Ways General Messaging Model which less complexity. This model is a direct communication between sender and receiver to exchange information.

Table 4 gives performative parameters used for two-way general messages. The new acronyms for this above list are:

- S_n – Send;
- R_w – Reply With; and
- R_t – Reply To.

7 Conclusion and Future Work

This paper explains how important it is to improve the existing FIPA-ACL to suit emergency response needs. We have therefore created ER-ACL as a foundation for mobile app developers. To explain what information is needed and when communication between the victim and the rescuer should occur, we also built ER-ACP, and have provided the corresponding syntax, conversation tree and interaction models. However, the new ER-ACL has not been implemented and tested in any real emergency response system. For future work, we plan to build a distributed multi-agent communication and tracking mobile apps based on ER-ACL, ER-ACP and their underlying ontologies to understand usability issues as the mobile apps are developed. Testing and evaluation of the usability, simulations and trials of the system involving real users will be carried out based on real-world emergency response scenarios to test the robustness and effectiveness of our proposed solution. We trust that this will improve protocols as well as similar apps in the future.

References

1. M. K. A. Hassan and Y.-H. Chen-Burger, 'Communication and Tracking Ontology Development for Civilians Earthquake Disaster Assistance', Proc. ISCRAM 2016 Conf. – Rio Janeiro, Brazil, May 2016 Tapia, no. May, 2016.

2. Z. Sharmeen, A. M. Martinez-Enriquez, M. Aslam, A. Z. Syed, and T. Waheed, 'Multi Agent System Based Interface for Natural Disaster', Lect. Notes Comput. Sci., vol. 8610, pp. 299–310, 2014.

3. B. Costin, M. Scafes, S. Ilie, A. Badica, and A. Muscar, 'Dynamic Negotiations in Multi-Agent Systems', ICT Educ. Res., 2011.

4. D. Juneja, A. Jagga, and A. Singh, 'A Review of FIPA Standardized Agent Communication Language and Interaction Protocols', J. Netw. Commun. Emerg. Technol., vol. 5, no. 2, pp. 179–191, 2015.

5. A. Chopra and M. P. Singh, 'Agent Communication', Multiagent Syst. A Mod. Approach to Distrib. Artif. Intell., pp. 101–141, 2013.

6. J. Westfall, 'Common Alerting Protocol Version 1.2', no. July, pp. 1–47, 2010.

7. H. Nishiyama, M. Ito, and N. Kato, 'Relay-by-smartphone: Realizing multihop device-to-device communications', IEEE Commun. Mag., vol. 52, no. 4, pp. 56–65, 2014.

8. A. A. Sheikh, P. T. Ganai, N. A. Malik, and K. A. Dar, 'Smartphone : Android Vs IOS', SIJ Trans. Comput. Sci. Eng. its Appl., vol. 1, no. 4, pp. 141–148, 2013.

9. Foundation for Intelligent Physical Agents, 'FIPA ACL Message Structure Specification', IEEE Comput. Soceity, p. 1, 2002.

10. Agent Communication, http://jmvidal.cse.sc.edu/talks/agentcommunication/.