

# Personalisable Ad-hoc Mobile Communication based on a Semantics-Rich Multi-Agent Framework for Large-Scale Emergency Responses –

Mobile Kit Disaster Assistant (MKDA)

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- In 2018, there were 281 climate-related and geophysical events recorded in the EM-DAT (International Disaster Database)
- 10,733 deaths, and over 60 million people affected worldwide.
- *In the 21st century, earthquakes and tsunamis have been the deadliest disasters, and this trend continued in 2018.”*

# BACKGROUND - 1

1. Sichuan, China earthquake in 2008 killed at least 69,000 people, injured more than 374,000, leaving 4.8 million homeless.



## BACKGROUND - 2

2. Haiti earthquake in January 2010, causing over 200,000 fatalities, 300,000 injuries and leaving over 1 million people homeless (Yates and Paquette, 2011)



# BACKGROUND - 3

3. Pacific Ocean earthquake and subsequent tsunami in Japan in March 2011 that cost the Japanese economy more than \$300 billion and caused unprecedented loss to the Japanese people, their environment, and the global economy



# BACKGROUND - 4

4. Kaohsiung, Tainan earthquake on February 2016. More than 100 people died and numerous buildings reportedly collapsed. A total of 34 historical buildings around Taiwan were damaged, in which 23 of them are located in Tainan.



# EARTHQUAKE FATALITIES 1990– 2014

Largest Earthquakes					Deadliest Earthquakes				
Year	Date	Magnitude	Fatalities	Region	Year	Date	Magnitude	Fatalities	Region
1990	16-Jul	7.7	1,621	Luzon, Philippine Islands	1990	20-Jun	7.4	50,000	Iran
1991	22-Apr	7.6	75	Costa Rica	1991	19-Oct	6.8	2,000	Northern India
1991	22-Dec	7.6	-	Kuril Islands	1991				
1992	12-Dec	7.8	2,519	Flores Region, Indonesia	1992	12-Dec	7.8	2,519	Flores Region, Indonesia
1993	08-Aug	7.8	-	South of Mariana Islands	1993	29-Sep	6.2	9,748	India
1994	04-Oct	8.3	11	Kuril Islands	1994	06-Jun	6.8	795	Colombia
1995	30-Jul	8	3	Near Coast of Northern Chile	1995	16-Jan	6.9	5,530	Kobe, Japan
1995	09-Oct	8	49	Near Coast of Jalisco Mexico	1995				
1996	17-Feb	8.2	166	Irian Jaya Region Indonesia	1996	03-Feb	6.6	322	Yunnan, China
1997	14-Oct	7.8	-	South of Fiji Islands	1997	10-May	7.3	1,572	Northern Iran
1997	05-Dec	7.8	-	Near East Coast of Kamchatka	1997				
1998	25-Mar	8.1		Balleny Islands Region	1998	30-May	6.6	4,000	Afghanistan-Tajikistan Border Region
1999	20-Sep	7.7	2,297	Taiwan	1999	17-Aug	7.6	17,118	Turkey
2000	16-Nov	8	2	New Ireland Region, P.N.G.	2000	04-Jun	7.9	103	Southern Sumatera, Indonesia

Largest Earthquakes					Deadliest Earthquakes				
Year	Date	Magnitude	Fatalities	Region	Year	Date	Magnitude	Fatalities	Region
2001	23-Jun	8.4	138	Near Coast of Peru	2001	26-Jan	7.7	20,023	India
2002	03-Nov	7.9	-	Central Alaska	2002	25-Mar	6.1	1,000	Hindu Kush Region, Afghanistan
2003	25-Sep	8.3	-	Hokkaido, Japan Region	2003	26-Dec	6.6	31,000	Southeastern Iran
2004	26-Dec	9.1	227,898	Off West Coast of Northern Sumatra	2004	26-Dec	9.1	227,898	Off West Coast of Northern Sumatra
2005	28-Mar	8.6	1,313	Northern Sumatra, Indonesia	2005	08-Oct	7.6	80,361	Pakistan
2006	15-Nov	8.3	-	Kuril Islands	2006	26-May	6.3	5,749	Java, Indonesia
2007	12-Sep	8.5	25	Southern Sumatera, Indonesia	2007	15-Aug	8	514	Near the Coast of Central Peru
2008	12-May	7.9	87,587	Eastern Sichuan, China	2008	12-May	7.9	87,587	Eastern Sichuan, China
2009	29-Sep	8.1	192	Samoa Islands region	2009	30-Sep	7.5	1,117	Southern Sumatra, Indonesia
2010	27-Feb	8.8	507	Offshore Maule, Chile	2010	12-Jan	7	316,000	Haiti
2011	11-Mar	9	20,896	Near the East Coast of Honshu, Japan	2011	11-Mar	9	20,896	Near the East Coast of Honshu, Japan
2012	11-Apr	8.6	-	off the west coast of northern Sumatra	2012	06-Feb	6.7	113	Negros-Cebu region, Philippines
2013	24-May	8.3	-	Sea of Okhotsk	2013	24-Sep	7.7	825	61km NNE of Awaran, Pakistan
2014	01-Apr	8.2	6	NW of Iquique, Chile	2014	03-Aug	6.2	729	near Wenping, China



# Earthquake Magnitude Scale

<b>Magnitude</b>	<b>Earthquake Effects</b>	<b>Estimated Number Each Year</b>
2.5 or less	Usually not felt, but can be recorded by seismograph.	900,000
2.5 to 5.4	Often felt, but only causes minor damage.	30,000
5.5 to 6.0	Slight damage to buildings and other structures.	500
6.1 to 6.9	May cause a lot of damage in very populated areas.	100
7.0 to 7.9	Major earthquake. Serious damage.	20
8.0 or greater	Great earthquake. Can totally destroy communities near the epicenter.	One every 5 to 10 years

## Earthquake Magnitude Classes

Earthquakes are also classified in categories ranging from minor to great, depending on their magnitude.

<b>Class</b>	<b>Magnitude</b>
Great	8 or more
Major	7 - 7.9
Strong	6 - 6.9
Moderate	5 - 5.9
Light	4 - 4.9
Minor	3 - 3.9

# The communication problem

- Largest casualty in 2018 – in Papua New Guinea - left 181 dead, and affected over half a million people, many of whom **lived in remote highlands which were difficult to reach by aid and rescue operations.**
- Can local people help themselves?
- Can victims provide real-time, accurate information to helpers and organisations that can help them?
- Vital information to share
  - Location
  - Personal well-being
  - Critical needs
  - Capabilities to help

# EXISTING COMMUNICATION TOOLS

## 1. SEA-EAT blog (2004):

Pacific Ocean Earthquake

## 2. PeopleFinder (2005):

Hurricane Katrina

## 3. Nepal Earthquake Missing

People Facebook (2015)

## 4. Nepal Earthquake Missing

People Web Sites (2015)

The screenshot shows the homepage of the SEA-EAT blog. At the top, there is a navigation bar with a search box, a G+1 button, and a 'More' dropdown menu. Below this is the main header with the title 'The South-East Asia Earthquake and Tsunami Blog' and a subtitle 'a.k.a. the TsunamiHelp blog a.k.a. the SEA-EAT blog. News and information about resources, aid, donations and volunteer efforts.' A secondary navigation bar contains buttons for 'Tsunami Help Home', 'Enquiry', 'Missing Persons', 'News Updates', 'Help Needed', and 'Help Offered'. The main content area features a date stamp 'WEDNESDAY 11 APRIL 2012' and a headline 'Tsunami alert partly lifted after Aceh quake'. The article text states: 'A tsunami watch declared after two major earthquakes off the coast of Indonesia's Aceh province has now been partly lifted, the Pacific Tsunami Warning Center (PTWC) says. A quake with a magnitude of 8.6 triggered the initial warning, which was renewed after another quake a few hours later measuring 8.3. Alerts remain in place for Indonesia, India and the islands. There have been no immediate reports of damage or casualties. The region is regularly hit by earthquakes. The Indian Ocean tsunami of 2004 killed 170,000 people in Aceh alone and some 250,000 around the region. The US Geological Survey (USGS), which documents quakes worldwide, said the first Aceh quake was centred at a depth of 33km (20 miles), about 495km from Banda Aceh, the provincial capital. Source: BBC News'. On the right side, there is a sidebar with a search box, a 'Resource List' section with a link to 'The Tsunamihelp Wiki', a 'Contribute' section with links for 'Seek information', 'Share information', and 'How can we continue to help?', and a 'Contact' section with a link to 'Media' and contact information for Peter Griffin.

# Missing People on Facebook

**Nepal Earthquake Missing People** shared **Bartaula's photo.**  
May 13 · Edited ·

#kathmandu, #earthquake, #langtang, #langtangvalley  
#nepalquake, #missingperson



**Niraj Bartaula**  
May 12 ·

This baby is crying and we can't locate his family in Norvic h  
share

**Nepal Earthquake Missing People** shared **Viljoen Gavala's photo.**  
May 9 ·

#holdontohope #langtang #missinginnepal



**Milena Viljoen Gavala** ▸ **Langtang Missing/Found People**  
May 3 ·

Edited, so sorry for the mistake in the last one!

**Nepal Earthquake Missing People** shared **Lola Foullaud's photo.**  
May 5 ·

#kathmandu, #earthquake, #langtang, #langtangvalley  
#nepalquake, #missingperson



**Lola Foullaud** ▸ **Nepal Earthquake Missing People**  
May 4 ·

Bonjour à vous ,  
je n'ai toujours pas de nouvelles de mon ami et bonne étoile

**Nepal Earthquake Missing People** shared **Ruth Gallo Alcalá's post.**  
May 4 ·

#kathmandu, #earthquake, #langtang, #langtangvalley, #nepalearthquake,  
#nepalquake, #missingperson



**Ruth Gallo Alcalá** ▸ **Langtang Missing/Found People**  
May 4 ·

They left Godatabela about 7 am , must be between the Langtang village and kianjin  
gomba, they are still missing...if you saw them in the trekking, hep us!!!

# Missing People Web Sites

**Nepal Earthquake Restoring Family Links**

Home | English

Restoring contact between people separated by the earthquake in Nepal

> English > नेपाली

**Search**

> [List of missing persons and persons who have reported that they are alive](#)

**Register**

> Online registration has been closed on 17.06.2015.

> If you are still looking for a family member, please contact the [Tracing Service of the National Red Cross or Red Crescent Society](#) in the country of your residence.

**Family Links Website**

This website belongs to [familylinks.icrc.org](http://familylinks.icrc.org). It is dedicated to the people missing in connection with conflicts, natural disasters or migration.

Share

✉️ Facebook Google+ Twitter

**Restoring family links in affected areas**

Do you want to know what has happened to a family member?

> [Search through the list of missing persons and people who have reported that they are alive](#)

The Nepal Red Cross Society and the ICRC are responding to the restoring family links needs in the areas affected by the earthquake in Nepal.

ICRC

This Site is managed by the International Committee of the Red Cross

in cooperation with National Red Cross and Red Crescent Societies

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## Search

MISSING

People who are still missing

I AM ALIVE

People who have announced that they are alive

Online registration of missing persons has been closed on 17.06.2015.

If you are still looking for a family member, please contact the [Tracing Service of the National Red Cross or Red Crescent Society](#) in the country of your residence.

Enter all or part of your or your missing relative's name to search within the list.

| [clear results](#)

1 - 30 >

Status	Full name	Gender	Age	Place of birth	Father's name	Source
I AM ALIVE	A. Michelle Page	Female	50	USA	unknown	Online Registration
I AM ALIVE	Aagat Awasthi	Male	27	Kathmandu	Lava Deo Awasthi	Online Registration
MISSING	aashis karki	Male	27	damak	indra karki	Online Registration
I AM ALIVE	Abhinav Kant Mainali	Male	21	Kathmandu	Utsav Kant Mainali	Online Registration
MISSING	Abhisekh Thapa	Male	8	Selang, Sindhupalchok	Bijaya Thapa	Online Registration
I AM ALIVE	abhishek kakri	Male	19	damak	indra karki'	Online Registration
MISSING	Achyut Dhimal	Male	34	Bhaktapur	Shran	Online Registration
MISSING	Adad mishel chaul martinez	Male	33	Torreón, coahuila MEXICO	Pablo antonio chaul chamut	Online Registration
I AM ALIVE	Adam Jay Murphy	Male	27	Toowong	Kenneth Murphy	Online Registration
I AM ALIVE	Adam Robert Cleaver	Male	31	Davenport	Gary Cleaver	Online Registration

# GAPS IN EXISTING TOOLS

- Web based
  - must have access to Internet browser in time of needs; UI not suitable for on-the-go mobile devices
- Informal information - natural language based
  - information can not be easily transformed or summarised, and given to all relevant rescue workers to act upon in a timely fashion
- Un-verified and monitored information, e.g.
  - May mistaken victim's ID
  - Lost track of victims
- Focused on reporting missing people, limited help in rescue coordination
- No real-time feedback/communication/monitoring of victims, e.g.
  - Missing victims' live well-being information: e.g. alive, dead, injured, in critical conditions, resources needed, location, mental states, etc.

# PROBLEMS WITH DISASTER RESCUE

- **Effective communication and assist coordination is needed** – to support victims, communities, rescuers and organizations who are involved directly or indirectly during and just after an earthquake, thereby providing speedier recovery and relief to the victims as possible
- Formal help may be delayed
  - Set t up of temporary rescue organisations can take time or delayed
  - Available resources may not be utilised efficiently - people nearby can help themselves by better coordination and working together
- Rich and diversified data needed for rescue
  - Data from different organisations - technical/specialised - how to share for public use?
  - Data are stored in different format – uniform use?
- Live monitoring from victims, inc. multi-communication channels from victims
- Live monitoring of resources, e.g. availabilities of hospital beds
- Live monitoring of impact of disasters

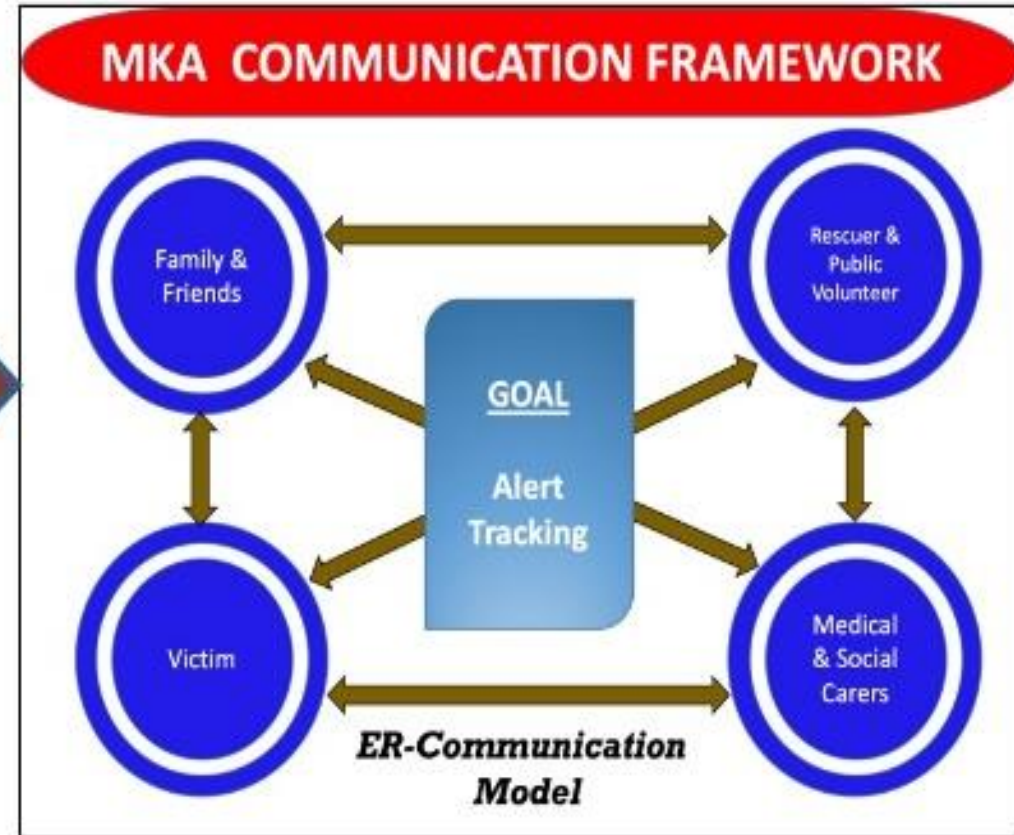




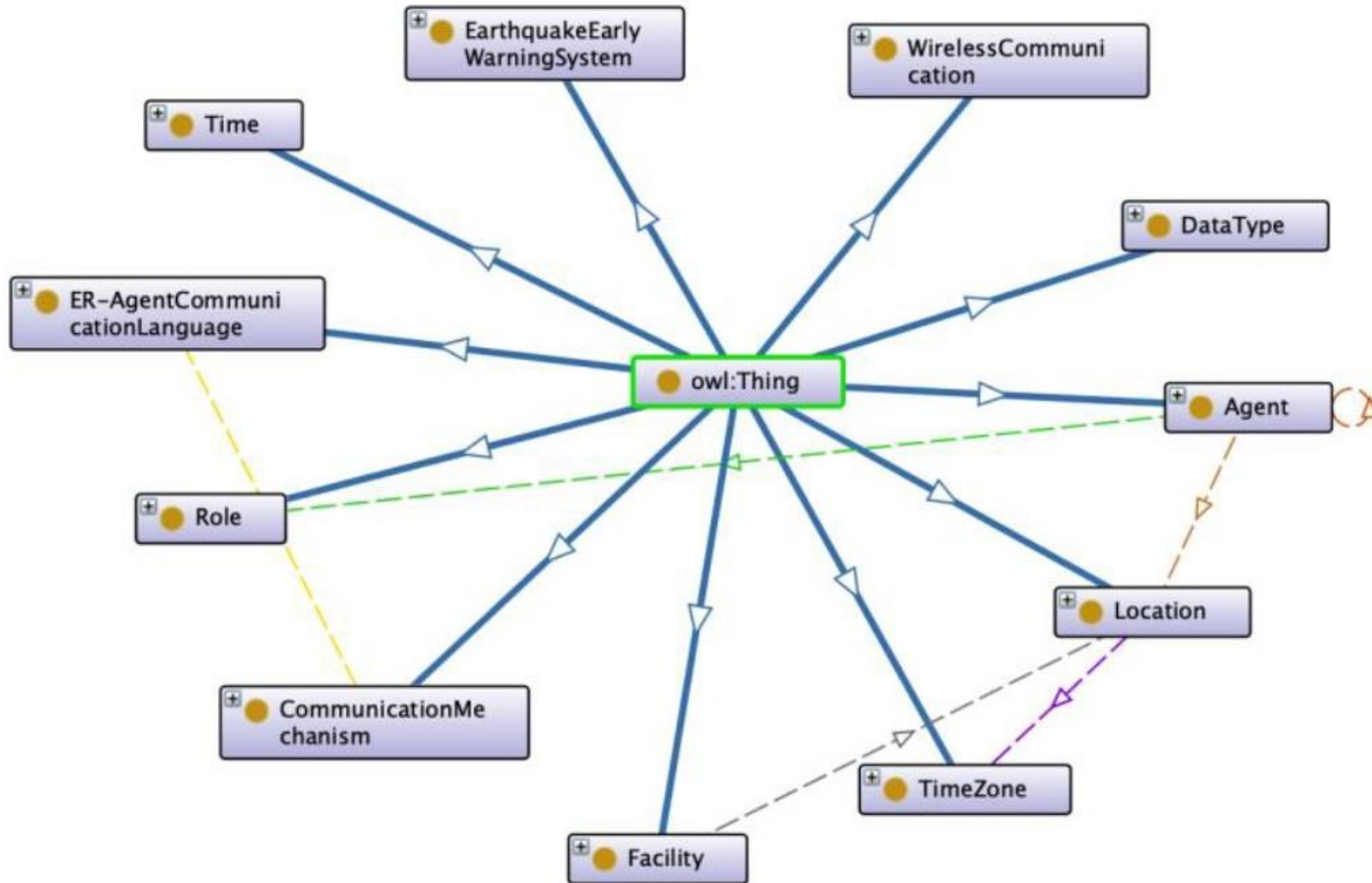
# SOLUTION

- Person-oriented (not organisation) communication – information feed available for aids and rescue teams
- Ontology based
- Mobile Communication framework for Emergency Response Agent based approach
  - ER Agent based Communication Language – ER-ACL
  - ER Agent based Communication Protocol – ER-ACP
- Communication during network breakout – P2P
- Energy saving solutions for smart phones

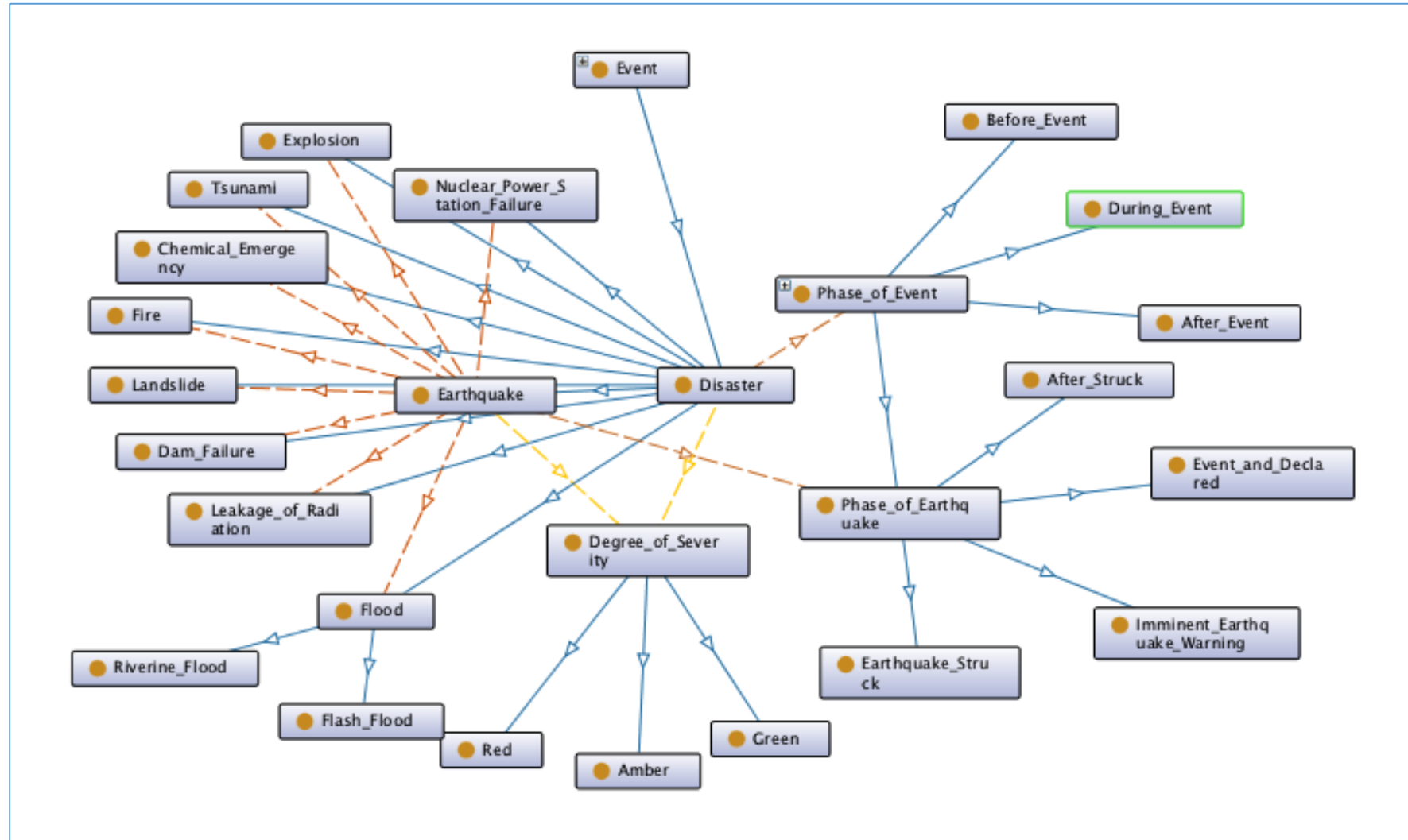
# Emergency Response Framework



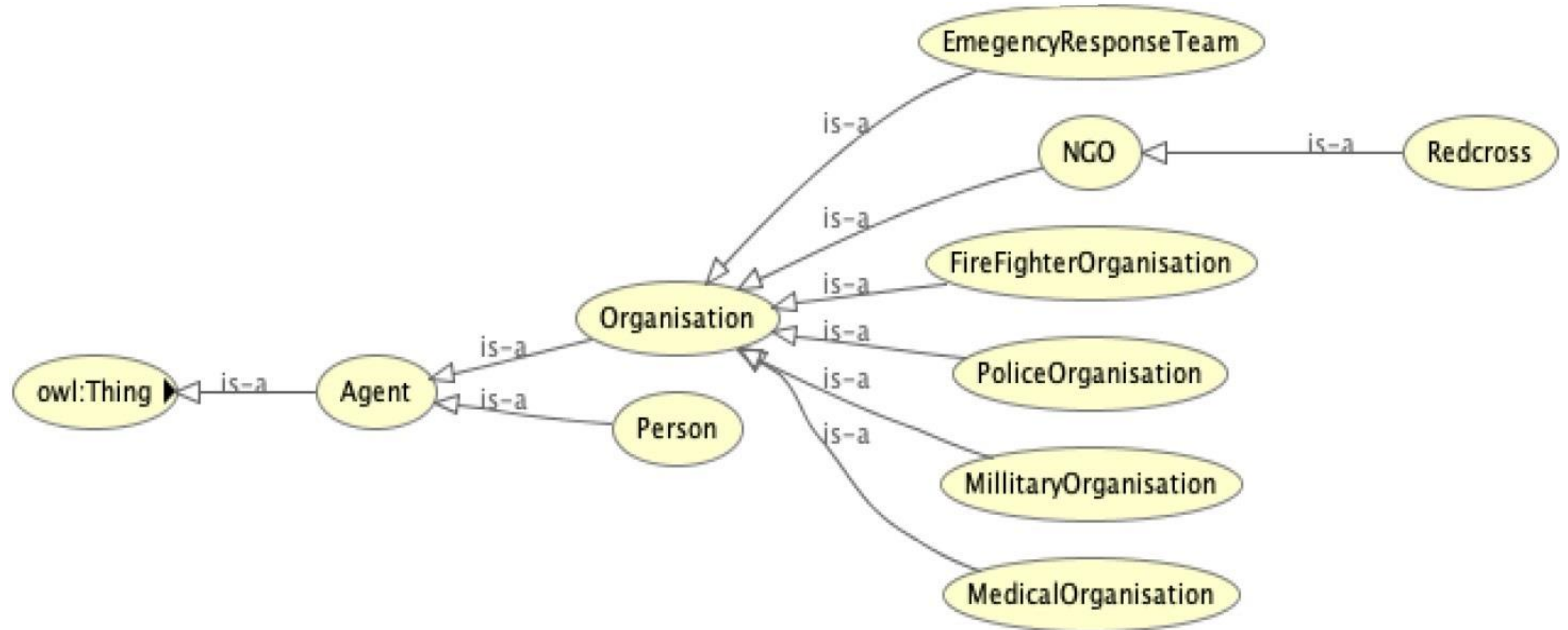
# Top Level Ontology



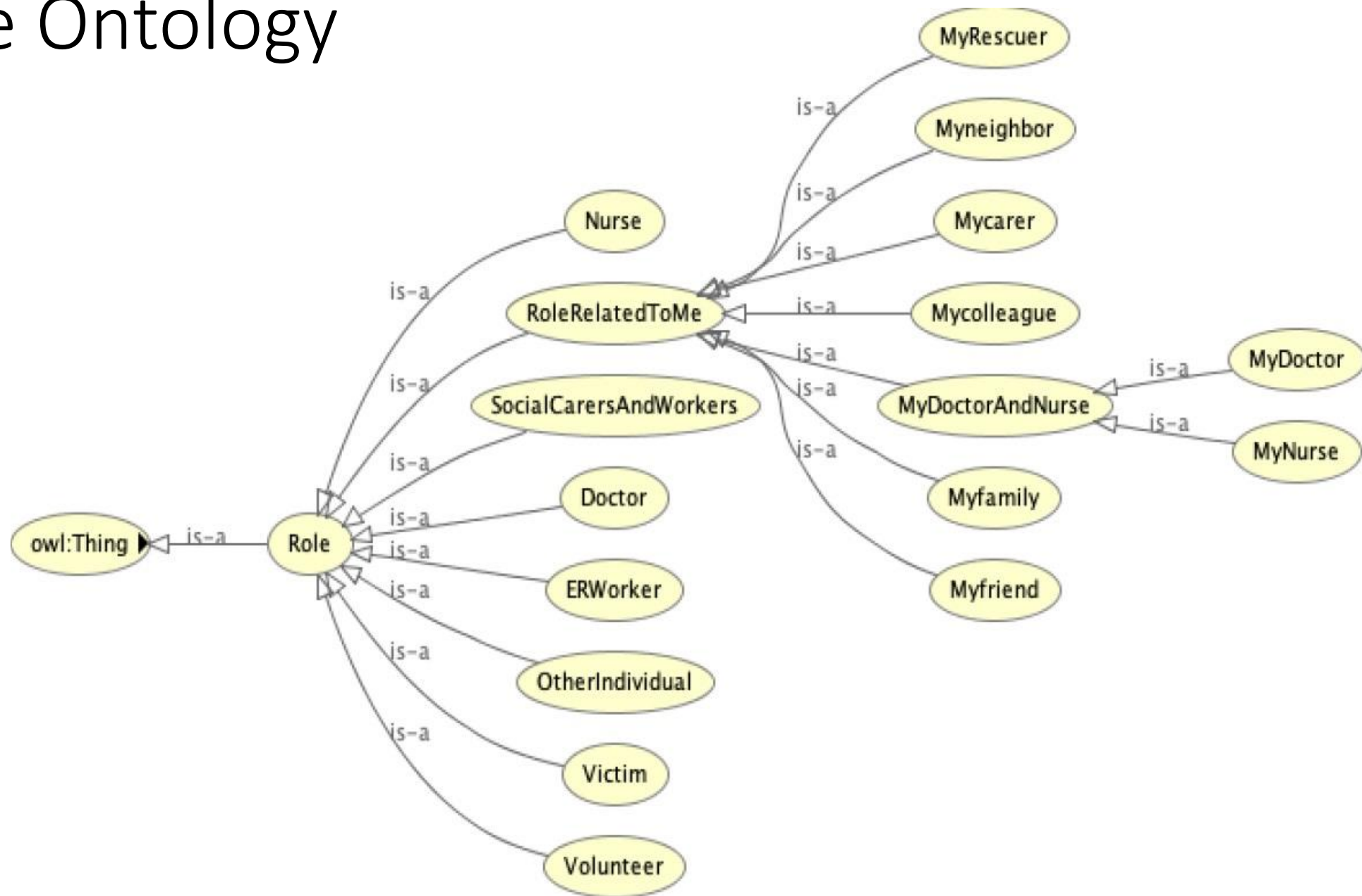
# The Event Ontology



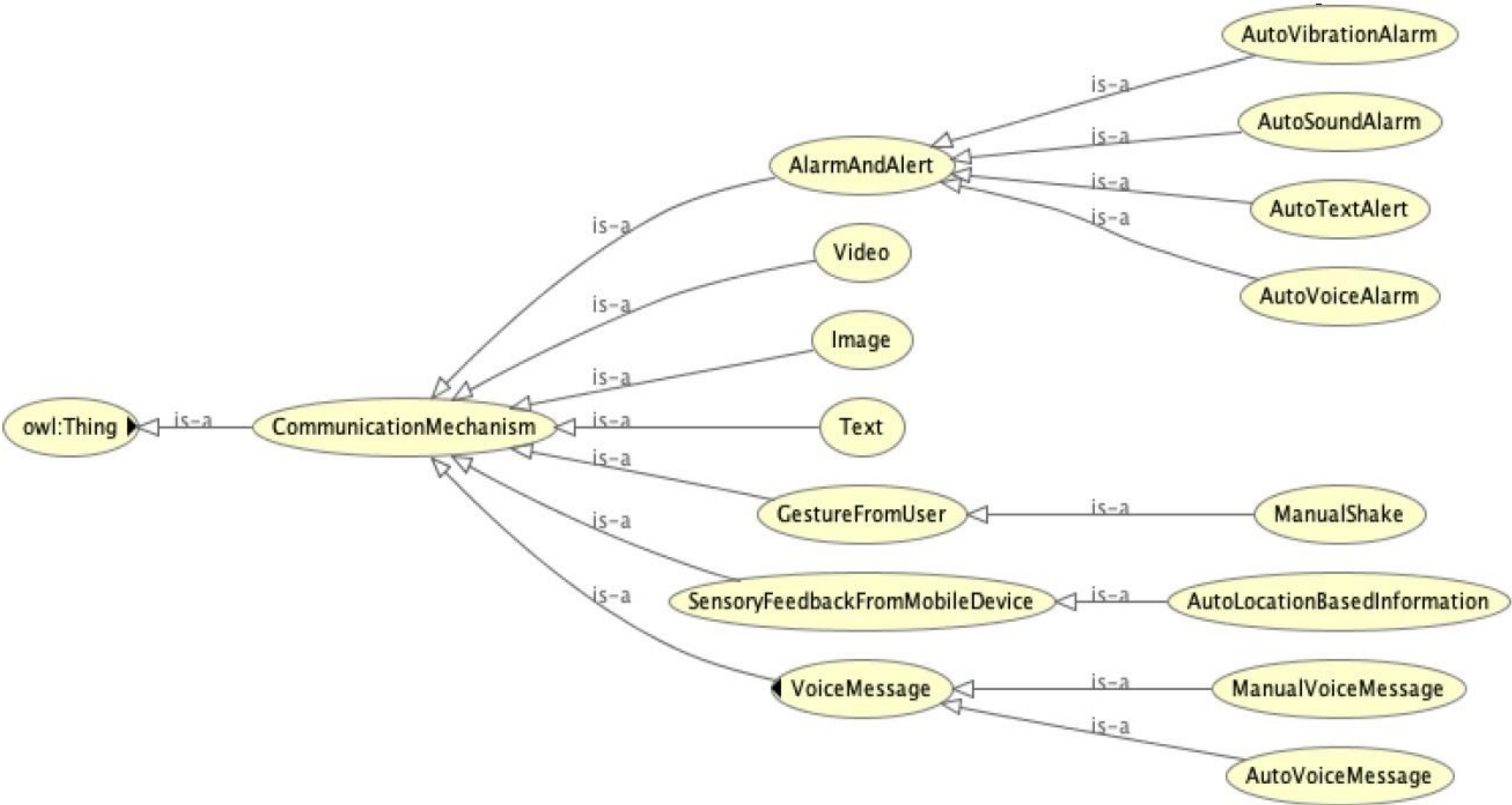
# The Agent Ontology



# Role Ontology



# Communication Mechanism Ontology

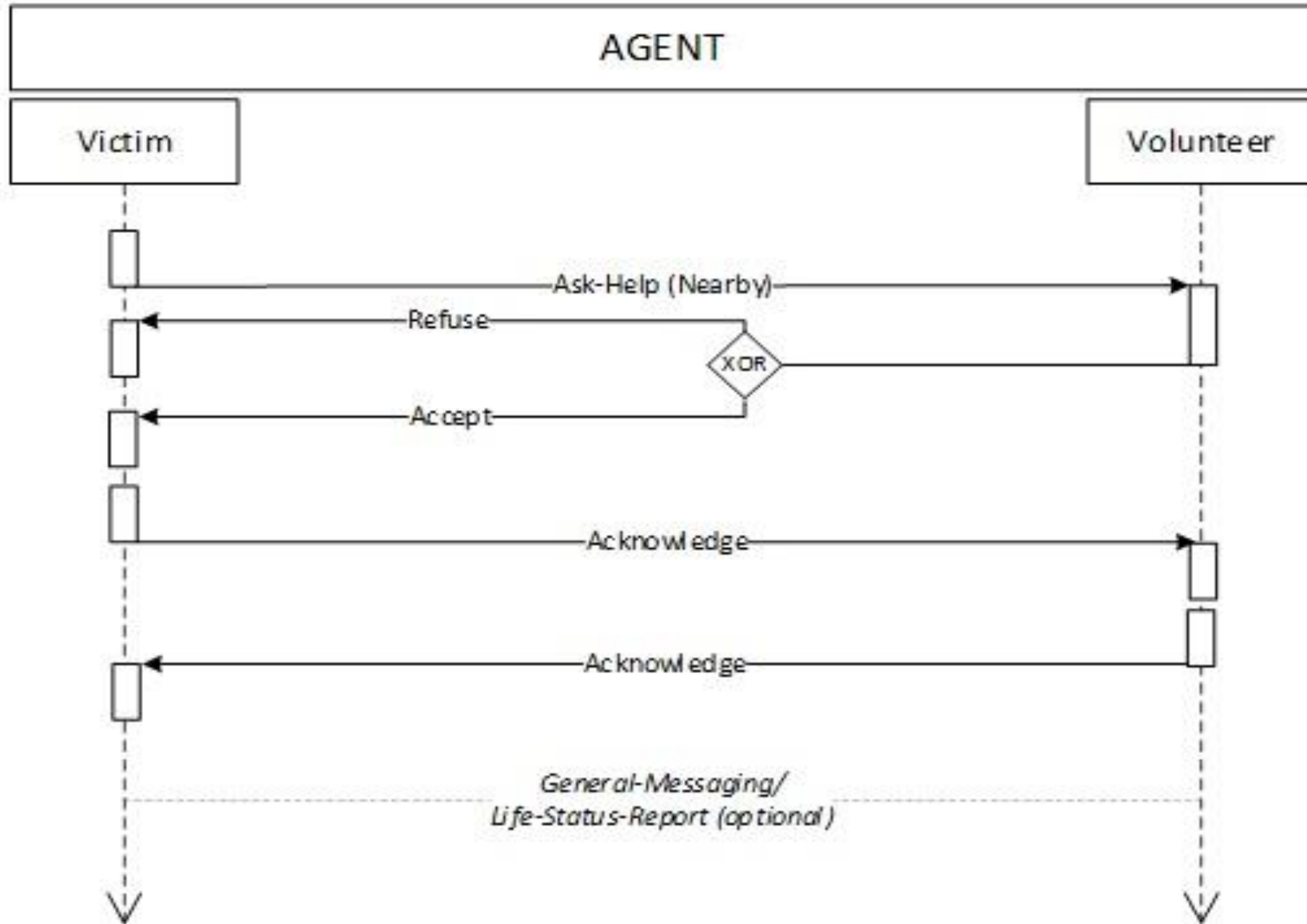


# New Emergency Response ACL Performative

<b>Performative</b>	<b>Description</b>	<b>Status</b>
<b>Ask-help</b>	Use for the sender (victim) to a send help message to the receiver (volunteer)	New
<b>Ask-help-forward</b>	Use for the sender (volunteer/family) to forward help message to the receiver (another volunteer)	New
<b>Offer-help</b>	Use for the sender (helper) to send an offer help message to the receiver (victim)	New
<b>Accept</b>	Use to accept a message and replying current situation of sender agent	New
<b>Acknowledge</b>	Use to acknowledge message received from sender	New
<b>Send</b>	Use to send normal messaging between agent	New
<b>Reply-to</b>	Use to reply normal messaging between agent	New
<b>Reply-with</b>	Use to reply-with normal messaging between agent	New
<b>Status-report</b>	Use to send report status to message between agent	New
<b>Channel</b>	The connection method used for data transferring	New
refuse	The action of refusing to perform a given action and explaining the reason for the refusal.	Existing

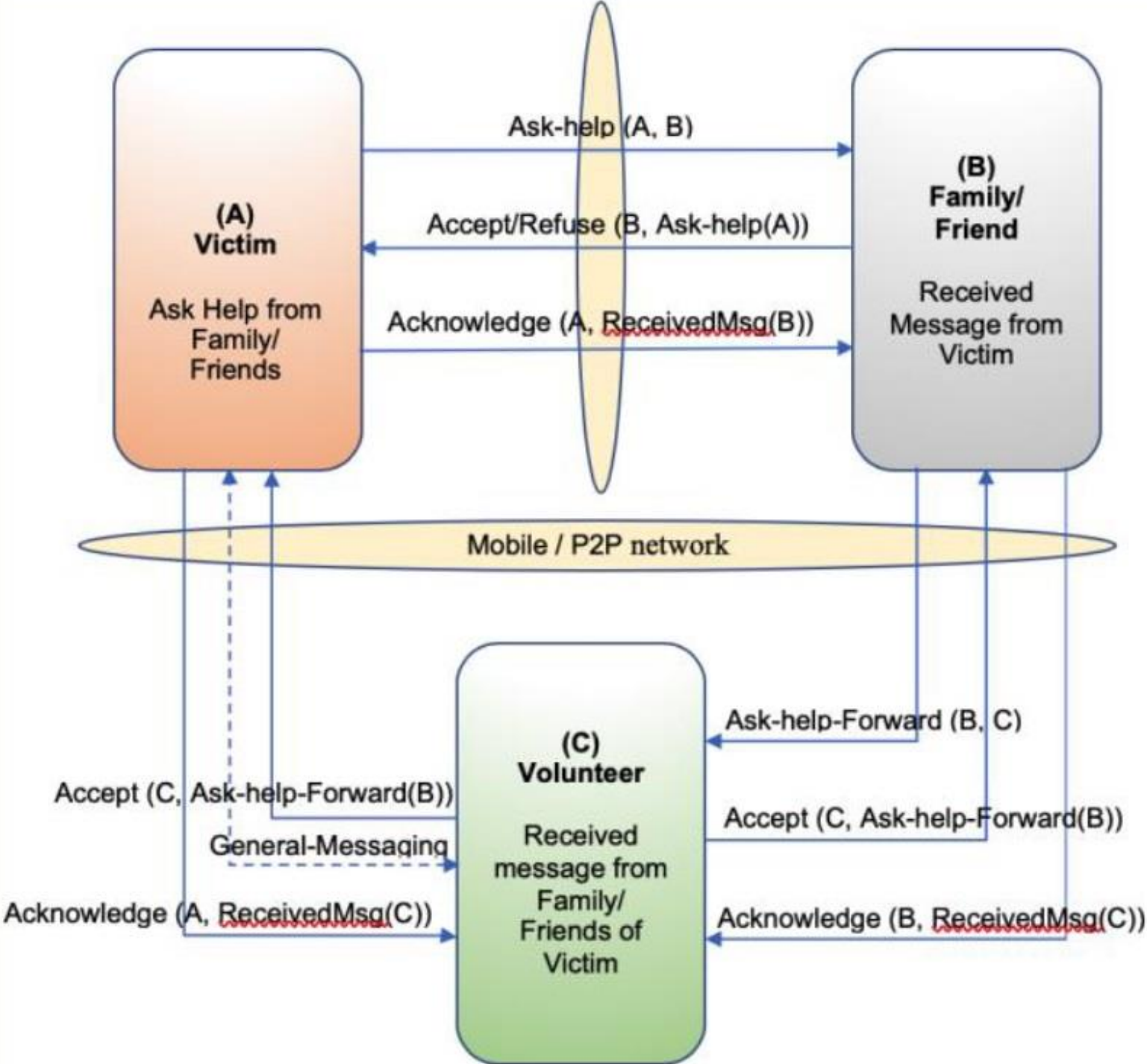


# Ask-Help Communication Protocol

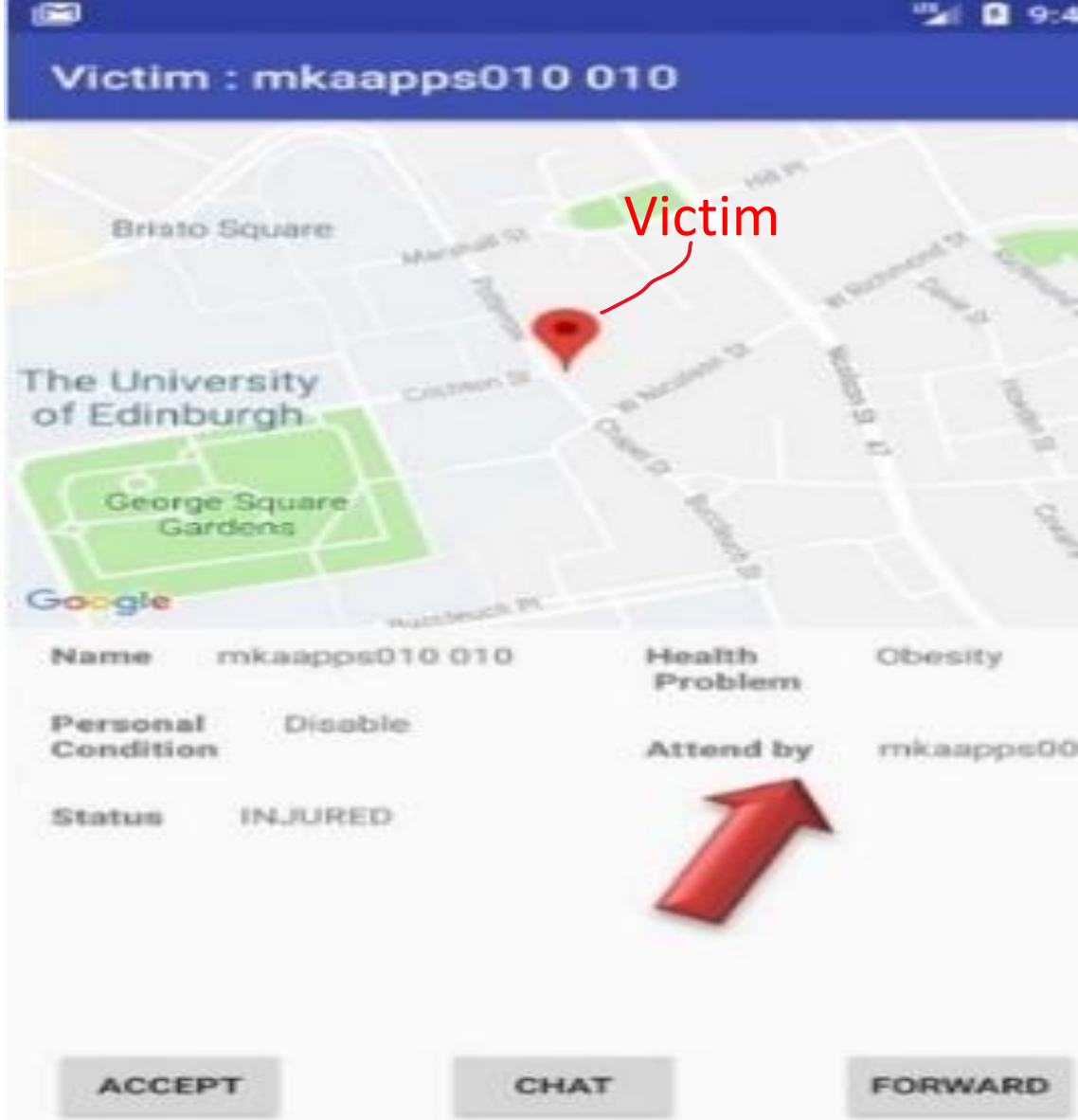
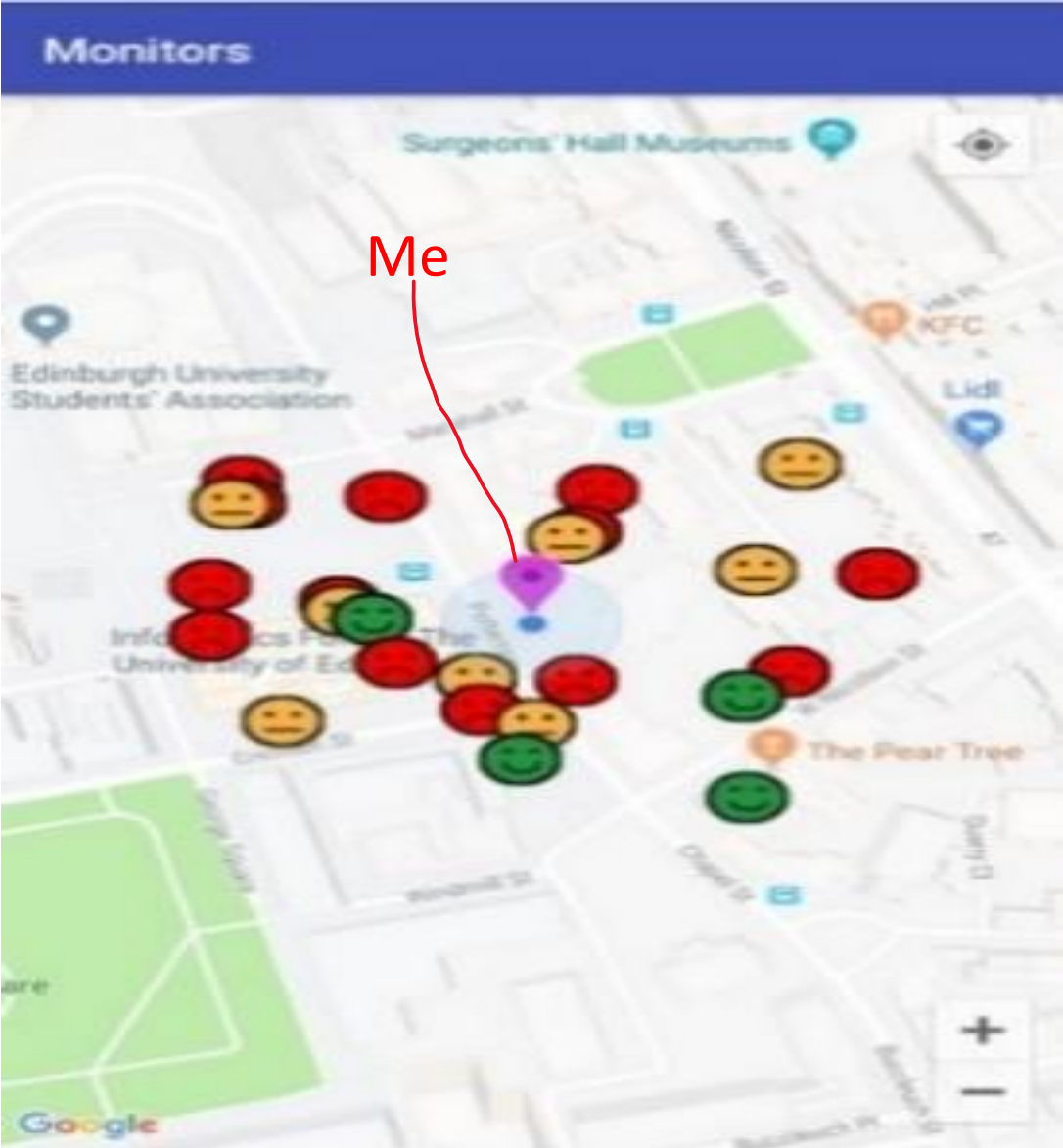


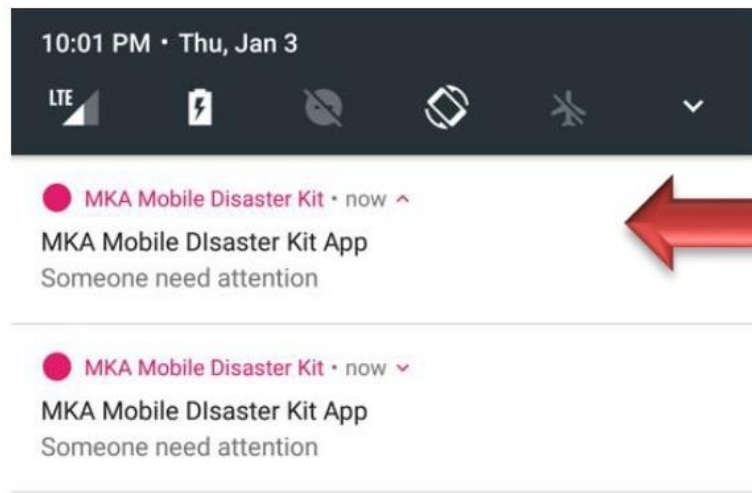
Three-way handshake

# Simplified view of Ask-help and Ask-help-forward Communication Protocol between agents

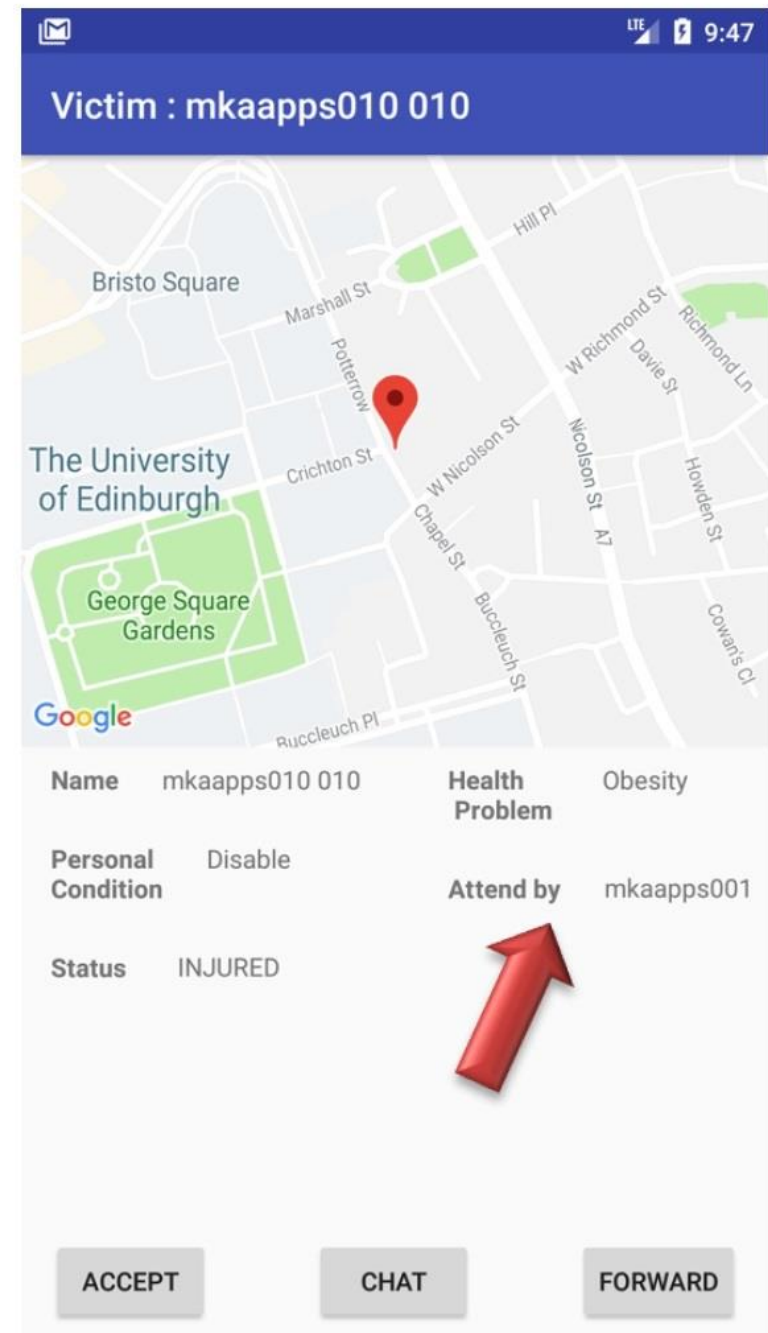


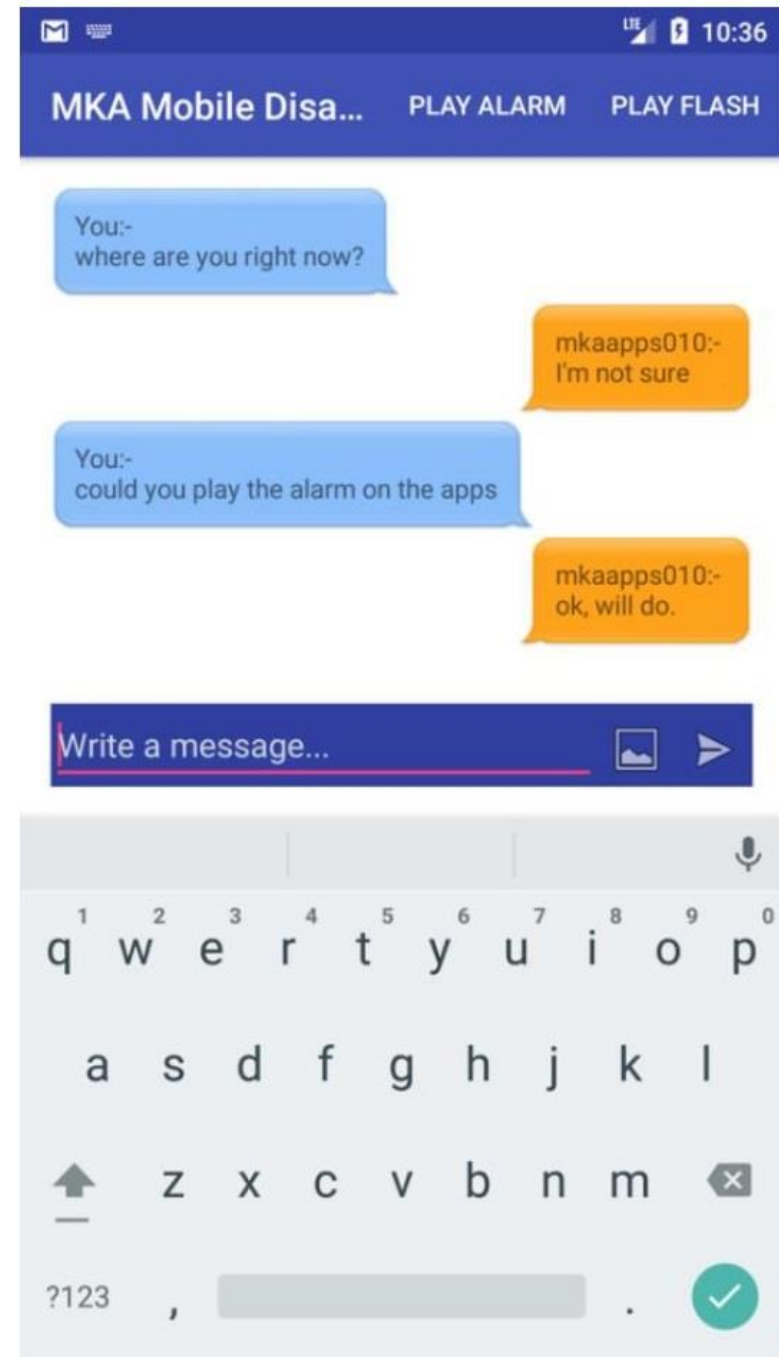
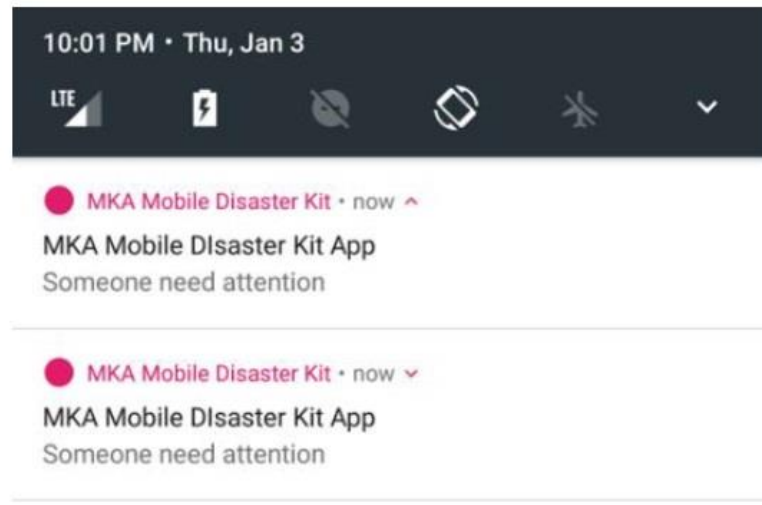
# Mobile Kit Disaster Assistant (MKDA)





Helper's message notification  
And map-based User Interface





# Messaging User Interface

# Summary and Conclusions

- New innovative personalisable mobile communication system for emergency response
- Person-centric, victim-centric approach
- Precise, accurate, real-time information feed w provenance
- User-controlled information sharing
- Emergency Response framed as Agent Based Problems
- Formal based framework and foundations
- Targeted user group 9-99 years old
- Development with domain experts
- Good feedback on initial trials

# Thank you for Listening !

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