The Roles of Artificial Intelligence and Knowledge Management in Emergency Telecommunications

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ABSTRACT

Over the past decade, the international community has recognized the substantive role modern telecommunications can play in disaster relief operations and humanitarian actions. The Tampere Convention on "Emergency Telecommunications" was an initiative to facilitate these activities, endorsed by various international conferences. The role of artificial intelligence and knowledge management in emergency telecommunications could be tremendous, with applications potentially ranging from network and workflow management to training and decision support. In the future, a greater convergence among different technologies, artificial intelligence and knowledge management included, in the service of emergency telecommunications could be foreseen, thus achieving the noble goal of utilizing modern information and communications technologies for disaster mitigation.

Keywords

Emergency Telecommunications, artificial intelligence, knowledge management, Tampere Convention

1.0 INTRODUCTION

A flash flood inundated a coastal country, resulting in tremendous casualties and loss of shelters. Communications with the rest of the world were totally disrupted. Within hours, international search-and-rescue teams rushed to the capital, as urgently requested by the national government. The team leaders were amazed beyond belief when warned by the customs officials that heavy import duties must be paid for their telecommunications equipment, while their telecommunications operators must obtain operating licenses before commencing sorely needed telecommunications coordination of the various teams. As a result, precious time that could otherwise be used for saving lives was wasted in ensuing bureaucratic hassles.

Scenarios such as that described above are encountered time and again by various humanitarian relief agencies, both public and private, around the world. This is particularly unfortunate since modern telecommunications capabilities have proved themselves indispensable in humanitarian relief and disaster mitigation (Oh, 2001). In fact, mobile and satellite technology has found usage a wide variety of humanitarian-related fields, ranging from remote sensing for disaster mapping to global positioning system (GPS) for exact locationing of relief operations to real-time voice and text relays between headquarters and fields, sometimes employing global mobile personal communication via satellites (GMPCS) for worldwide communications, even where there is no cellular coverage. The incorporation of artificial intelligence and knowledge management in emergency telecommunications has added even more spectacular functions in these fields.

The present paper is divided into two parts. In the first part, the concept of emergency telecommunication is introduced together with its modern evolution. In the second part, the applications of artificial intelligence and knowledge management in emergency telecommunications will be reviewed and introduced. The paper will conclude with a prospective and a call to action in the noble field of utilizing telecommunications for humanitarian assistance.

2.0 THE CONCEPT OF EMERGENCY TELECOMMUNICATIONS

2.1 The Road to Tampere Convention

In 1991, a Conference on Disaster Communications was held in Tampere, Finland, attended by disaster-mitigation and telecommunications experts. The Conference adopted the Tampere Declaration on Disaster Communications, which stresses the need to create an international legal instrument on telecommunication provision for disaster mitigation and relief. This was done with the recognition that regular communication links were often disrupted during disasters, and that regulatory barriers often crippled the use of emergency communications equipment across artificial boundaries. The Declaration also requests the United Nations Emergency Relief Coordinator, in co-operation with the International Telecommunication Union (ITU) and other relevant organizations, to convene an intergovernmental conference for the adoption of a convention on disaster communications.

The Tampere Declaration was annexed to the unanimously adopted Resolution 7 (International Telecommunication Union, 1994a) of the first World Telecommunication Development Conference held at Buenos Aires in 1994. The Resolution urges all administrations to remove national regulatory barriers in order to allow the unhindered use of telecommunications in disaster mitigation and relief. It also requests the Secretary-General of the ITU to work closely with the United Nations towards an international convention on disaster communications.

Within the same year, Resolution 7 was in turn endorsed by Resolution 36 (International Telecommunication Union, 1994b) of the ITU Plenipotentiary Conference held at Kyoto in 1994. Resolution 36 reiterates the need for an international convention on disaster communications, and echoes Resolution 7 in urging administrations to reduce and/or remove regulatory barriers to facilitate rapid deployment and effective use of telecommunication resources for disaster relief operations.

On the other hand, the Working Group on Emergency Telecommunications (WGET) has been regularly convened by the UN Department of Humanitarian Affairs (now Office for the Coordination of Humanitarian Affairs (OCHA)) as a focal point for emergency telecommunication related issues. WGET consists of all partners in humanitarian assistance and emergency telecommunications, UN entities as well as major international and national, governmental and non-governmental organizations, and experts from the academia and the private sector.

After the circulation by the ITU Secretary-General to all ITU Member States of a draft of the Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations, the World Radiocommunication Conference held at Geneva in 1997, in its unanimously adopted Resolution 644 (Inter-national Telecommunication Union, 1997), urged all administrations to give their full support to the adoption of the convention and its national implementation.

Similarly, the World Telecommunication Development Conference held at Valletta in 1998 adopted Resolution 19 (International Telecommunication Union, 1998a). Beside endorsing all the aforementioned resolutions, Resolution 19 invites the UN Emergency Relief Coordinator and the WGET to collaborate closely with ITU in supporting administrations and international and regional telecommunication organizations in the implementation of the Convention. The ITU Telecommunication Development Sector is also invited to ensure that proper consideration be given to emergency telecommunications as an element of telecommunication development, including the encouragement for the use of decentralized means of telecommunications.

The international effort in emergency telecommunications came to a climax when, from 16 to 18 June 1998, at the kind invitation of the Government of Finland, 76 countries and various inter-governmental and non-governmental organizations participated in the Intergovernmental Conference on Emergency Telecommunications (ICET-98) at Tampere, Finland. After long deliberations, 33 states signed the *Tampere Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations* (Tampere Convention) [10], with many others expected to follow suit in the near future.

During the Plenipotentiary Conference of the ITU held at Minneapolis in 1998 – the highest governing organ of the ITU – the national plenipotentiaries unanimously adopted Resolution 36 (International Telecommunication Union, 1998b), urging national administrations to sign and ratify the Tampere Convention as soon as practicable. The resolution also urges speedy application of the Convention.

In WORLD TELECOM 99 + Interactive 99, the ITU-sponsored world telecommunication exhibition and forum, a special session on "Telecommunications in the Service of Humanitarian Assistance" was held, which was participated by both public and private sector partners in humanitarian affairs and telecommunications. During the session, Mrs. Sadako Ogata, the United Nations High Commissioner for Refugees (UNHCR), urged the private telecommunications companies to work closely with humanitarian organizations in terms of equipment, personnel, education and technology, among other items, for the benefits of all parties concerned.

2.2 Tempere Convention as an International Regulatory Framework for Emergency Telecommunications

The Tampere Convention creates an international framework for the provision of telecommunication resources for disaster mitigation and relief between States and between a State and a non-State entity. Under this framework, a State which perceives the need for disaster telecommunication assistance in its territory will request such assistance through the UN Emergency Relief Coordinator, who is the Operational Coordinator under the Convention and who will then channel the requests to other concerned entities. On the other hand, a providing State party is obliged to set down in writing the fees it expects to receive or have reimbursed. The fees, if any, will be based on an agreed model of payment and reimbursement, as well as on other factors such as the nature of the disaster and the particular needs of developing countries. Procedures are also set forth in the Convention for termination of telecommunication assistance and for dispute settlement. Nevertheless, this framework does not preclude the existing or future arrangements between States and between a State and a non-State entity in emergency telecommunication assistance.

The Convention also recommends States to reduce or remove regulatory barriers that currently impede the use of telecommunications resources for disaster mitigation and relief operations. It further safeguards the privileges, immunities and facilities accorded to persons providing disaster assistance by granting them immunity from arrest and detention and exempting them from taxation and duties.

Under the Tampere Convention, ITU will work closely with the Operational Coordinator on several provisions of the Convention. These include maintaining contact with focal points within States that are authorized to request, offer, accept and terminate telecommunications assistance. States will also compile a telecommunication assistance information inventory listing, among others, competent authorities and points of contact. This inventory will be maintained and updated by the Operational Coordinator with the help of ITU.

It is worth noting that many provisions of the Convention are also applicable to non-state entities such as intergovernmental organizations and non-governmental organizations. This is evidently important because non-state entities often work in conjunction with governmental organizations in disaster mitigation and relief operations. In addition, States which have not yet signed the Convention may also apply the Convention provisionally.

3.0 ARTIFICIAL INTELLIGENCE AND KNOWLEDGE MANAGEMENT IN THE SERVICE OF EMERGENCY TELECOMMUNICATIONS

As the above introduction on emergency telecommunications shows, the subject matter may be thought of as consisting of two elements, "emergency" and "telecommunications". As such, a discussion on the roles of artificial intelligence and knowledge management in emergency telecommunications would not be fruitful in isolation. Rather, any meaningful look at these "niche" application areas of artificial intelligence and knowledge management technologies must necessarily entail excursions into, and contributions from, artificial intelligence and knowledge management applications in telecommunications in general, as well as in the related "emergency" areas of search-and-rescue, disaster prevention and relief, rehabilitation and refugee management, as well as military and law-enforcement operations (Gray, 2000), to name but a few.

3.1 Intelligent Agents

It could be said that the greatest impact by artificial intelligence in telecommunications in general (and emergency telecommunications specifically) has been in the form of artificial agents (Cheek, 1994). The exacting demands of telecommunications on artificial agents require the latter to bear features such as reliability, real-time performance, openness, security management and mobility (Albayrak, 1998). As such intelligent agents have to be fully dependable and typically require an integrated set of capabilities (Albayrak, 1998). And this remains the challenge for intelligent agents technology in the more general application area of telecommunications (Albayrak, 1998).

According to the Intelligent Agents Group (IAG) (Artificial Intelligence Group, 2002) at the Department of Computer Science, Trinity College Dublin, intelligent agents act autonomously on behalf of a user or a process, without the direct intervention of humans or others. These agents contain some level of intelligence, ranging from pre-defined rules up to self-learning, which enables the agents to act both reactively and proactively. Moreover, the agents may communicate or even cooperate with the user, system resources and other agents in order to do their jobs, sometimes moving from one system to another. Based on these characteristics, IAG divided intelligent agents in telecommunications into three types – interface agents, collaborative / competitive agents, and mobile agents.

An interface agent is "a computer program to provide assistance to a user dealing with a particular computer application" (Maes and Kozierok, 1993). Interface agents perform different tasks such as information retrieving and filtering, as they communicate with their user or other agents. More advanced interface agents learn by detecting patterns and regularities in the user's behavior, so that they may make decisions in novel situations without interaction with the user (Artificial Intelligence Group, 2002). One application for interface agents is in telecommunications network supervision and management. The interface agents may automate some network management and supervision tasks such as log recording and fault detection, freeing up the network operator to focus on more important tasks. The interface agent observes and learns how the user remedies faults, thereby constructing possible future scenarios that it can then use to guide its actions without having to interact with the user (Cheek, 1994; Artificial Intelligence Group, 2002). This is of course very important in an emergency or disastrous setting, when, typically, the telecommunications network of a whole city (sometimes the whole country) may go down, necessitating the already heavily-burdened network operators to take part in recovery efforts.

As stated above, agents often have to not only communicate with its user and system resources; they also extensively communicate and work with each other, solving problems and performing tasks that are beyond their individual abilities (Artificial Intelligence Group, 2002). There are two types of agents which are active in this respect:

- Competitive agents whose aim is maximization of their (or their users') own interests when attempting to reach agreement with other agents; and

- collaborative agents who share their knowledge and experience to try to maximize the benefit of the whole agent (or user/system) community (Artificial Intelligence Group, 2002).

These agents also found applications in telecommunications. For example, researchers from the Department of Computer Science at Dartmouth College (Dartmouth College, 2002) proposed a graph-based abstraction for collecting, aggregating, and disseminating context information as well as a prototype "Solar" system which could be used in "ubiquitous" or "pervasive" computing applications where a constant flow of information about the computing environment is necessary so that the changing context could be adapted to (Chen and Kotz, 2002a; Chen and Kotz, 2002b). In pervasive computing, a user may interact with many computing devices which compete for his attention, and he or she is often expected to manage or configure these devices while they and their interaction change with the changing environment (Chen and Kotz, 2002a). Artificial agents could assist in these "context-aware" environments, which are quite often found during a disaster relief operations after the onset of a major disaster, when the disparate, often incompatible telecommunication equipments of various search-and-rescue teams clamor for the attention and service of the on-site as well as remote telecommunications coordinator.

A mobile agent is an executing program that can migrate, at times of its own choosing, from machine to machine in a heterogeneous network (Gray et al., 2000). On each machine, the agent interacts with stationary service agents and other resources to accomplish its tasks (Gray et al., 2000). Various advantages of mobile agents have been identified. They include bandwidth conservation (Gray et al., 2000; Gray, 2001), completion-time and latency reduction (Moizumi and Cybenko, 2001), and dynamic deployment (Gray et al., 2000). Some researchers predict that the Internet will soon be hosting a lot of mobile agents (Kotz and Gray, 1999). In the aftermath of the September 11, 2001, tragedies, it may be worthwhile to note that one mobile agent application which is somewhat related to emergency telecommunications is counter-terrorism, where mobile agents are used to dynamically scenario-specific code onto the soldiers' (communications) devices, and to perform queries against available information resources (Gray, 2000; Gray et al., 2000).

3.1.1 Network Management

As briefly mentioned above, one of the most extensive applications of artificial intelligence in telecommunication in general and emergency telecommunication specifically has been in the field of telecommunications network management (Pruitt , 1986; Karpinski, 1991; Kennedy, 1996). Network management encompasses three areas, in all of which artificial intelligence is applicable: 1. monitoring and control, 2. administration, and 3. planning and design (Valovic, 1987). There are two types of network management techniques which involve artificial intelligence. The first is a partially distributed network management system, where the main management system is centralized while intelligent agents are released to the network to distribute some network management tasks and to share knowledge and workload, often for a specific network area (Artificial Intelligence Group, 2002; Meyer et al., 1995; Busuioc, 1996; Gyires and Muthuswamy, 1996). The other network management technique is a fully distributed one, which could avoid the trade off between network size and management precision as found in the centralized management system (Artificial Intelligence Group, 2002).

In Singapore a cellular mobile network management system which incorporates elements of artificial intelligence has enhanced the operational efficiency and network capacity and increased customer satisfaction with the network (Low et al., 1995). Indeed, artificial intelligence has found applications in graphic-based network management centers (Reedich, 1988) as well as in high-frequency (HF) communications systems (Darnell, 1988). The latter application is particularly relevant in during the early aftermath of a disaster, when disaster relief and search-and-rescue teams often employed wireless communication devices for coordination of their joint efforts.

In addition, prototypes of network-sensing systems and network-aware mobile-agent applications, some of which are built using off-the-shelf components (Corr and Okino, 2000; Corr, 2001), are also being designed and built that are robust in the presence of network volatility (Caripe et al., 1998), such as typical during and after a disaster, when communications facilities and devices are disrupted. Research is also being carried out in the utilization of intelligent agents for enhancing the performance of ad hoc multi-hop telecommunication networks (Gupta and Kumar, 1997; Caripe, 1998; Li and Rus, 2000; Li et al., 2001a; Li et al. 2001b), which can find its application in telecommunications coordination among the disaster relief teams working in the same or nearby disaster sites.

3.1.2 Workflow Management

Another artificial-intelligence application which are beneficial for disaster relief and emergency telecommunications purposes is in workflow management. It has often been a cliché to note that some of the international relief agencies are overstuffed with inefficient bureaucracy; it would be a tragedy if their critical, life-saving tasks of providing first-hand relief to the victims of disasters are thus hampered. The deployment of intelligent agents could help in automating some of the more mundane processes, reducing waste and freeing up more manpower which is sorely needed nowadays, especially in the "knowledge worker" context in developing countries such as Malaysia (Kasim, 2001). Applications in this area range from intelligent procurement methods (Kashiwagi and Mayo, 2001) and electronic contracting (Lee, 1988), to inventory optimization (Saba, 2001) and cost control (Harris, 2001), as well as to administration management (Pearson, 2001) and scheduling (Lee, 2001).

3.2 Knowledge Management & Expert Systems

As modern beings, we are constantly bombarded by an avalanche of information, rendering us often incapable to digest and apply the information effectively. In a disaster scenario, the situation gets worse. Loads of information, some true but more false, must be processed by crisis managers, who have to discern the useful information from the a wide-ranging pool of data. This is where the concept of knowledge management with the aid of artificial intelligence comes in. Artificial intelligence has and will continue to play an important role in knowledge management, especially assisting in sifting through information, culling for those useful for problem solving and disposing of the rest. Some of these artificial intelligence systems are called "expert systems". Expert systems applications include help desks, network filtering, network management, capacity planning, operations, and purchasing (Hochron, 1990). Although encountering difficulties in its early days (Cook, 1989), expert systems have been widely used in, for example, addressing telecommunications problems (Cheslow, 1986). Expert systems are considered to be able to preserve and disseminate expertise (Kirvan, 1986) – hence enhancing organizational learning (Bhatt and Zaveri, 2002), provide a more actively usable knowledge base of information than that found in books (Kirvan, 1986) and increase the efficiency and speed of problem solving (Kirvan, 1986). Expert systems can provide learned guidance to decision-makers who often have to make split-second decisions which nonetheless may affect the life of thousands.

3.2.1 Training

The shortage of experienced telecommunications professionals has been a long-standing issue worldwide (Sullivan-Trainor, 1988). The situation is especially serious in emergency telecommunications, since, in addition to purely technical skills, telecommunications operators who worked in a disaster scenario must possess other desirable characteristics such as ability to perform under stress, rapid psychological and cultural adaptability, and experience in dealing with bureaucracy, etc. Training in these and other related fields can be enhanced by artificial intelligence (Heathman and Kleiner, 1991) and knowledge management. For example, realistic simulations and games, which are increasingly being used militarily, could be designed incorporating artificial-intelligence elements (The Economist, 2002).

4.0 CONCLUSIONS

For most people, emergency telecommunications may seem a rather exoteric, even trivial subject area of research. However, for those who have long been involved in humanitarian affairs, as well as the worldwide effort to promote the adoption and implementation of the Tampere Convention on "Emergency Telecommunication", this is a subject which concerns the life and death of thousand of disaster victims around the world. It is the noble and lofty deed of attempting to make the best use of modern information and communications technologies to alleviate human sufferings, be it natural or man-made.

The role of artificial intelligence and knowledge management in telecommunications in general and emergency telecommunications specifically has long been recognized and is developing in leap and bounds, transforming both the architecture and applications of information and communications technologies. In the future, it could be foreseen that the "convergence" of many different technologies, ranging from artificial intelligence and knowledge management technology to biosciences and space applications, will further enhance the ability of disaster relief workers to carry out their painful but noble works of mitigating the damages caused by disasters.

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