Optimization of Wireless Disaster Network Through Network Virtualization

A. Lehmann, A. Paguem Tchinda, and U. Trick
Research Group for Telecommunication Networks
Frankfurt University of Applied Sciences
Frankfurt/Main, Germany
Email: {lehmann, paguem, trick}@e-technik.org

***Abstract*—Natural disasters reported to have occurred increased dramatically over the second half of the 20th century. Floods, earthquakes, tsunamis and storms have appeared worldwide with catastrophic consequences. Right after the catastrophic events, the demand for communication services explosively increases, while communication resources are often affected entirely or partially. Without a working communication infrastructure, the coordination among numerous disorganized helpers and rescue teams is impossible. This paper proposes a wireless disaster network that integrates network functions virtualization (NFV), which offers a large number of possibilities to optimize a disaster network, such as availability, reliability, cost-efficiency, scalability, lower power consumption, and adaptable network configuration and topology. Finally, the paper concludes with a future perspective of a distributed orchestration system for the proposed disaster network.**

Keywords—Ad Hoc Networks; Disaster Networks; Network Functions Virtualization; Wireless Mesh Networks;

I. INTRODUCTION

In disaster situations, an operative communication infrastructure is essential, in order to rescue victims and organize, coordinate, and support rescue teams [1]. Existing communication infrastructures are often affected in case of disaster, so that the infrastructure is damaged in whole or part [2]. Consequently, the necessity occurs to develop a proper communication system. This system should be enabled to be established rapidly, easily, and cost-effectively in order to share information inside and with the disaster area constantly and robust. Moreover, a desirable system provides not only voice communication but also multimedia communication to support the rescue teams and helpers sufficiently [3]. Another crucial aspect within disaster networks are routing protocols and types of ad hoc networks, e.g. mobile ad hoc network (MANET) [4]. To overcome the challenges in disaster networks the concept of network functions virtualization (NFV) offers numerous new approaches to optimize availability, redundancy, reliability, reparability, recoverability, efficiency, and robustness of communication infrastructure in disaster situations. The main objective of this paper is to present a new approach to optimize disaster networks on basis of ad hoc networks with integrated NFV. Section 2 describes and summarizes challenges for ad hoc networks in disaster areas. Section 3 illustrates functions and architectures of MANET and wireless mesh network (WMN). Furthermore, a few ad hoc protocols are briefly shown. Section 4 illustrates different virtualization technologies and NFV. In addition, advantages and disadvantages are discussed under considerations of energy efficiency and performance. In section 5, an optimized wireless disaster network will be presented on basis of ad hoc technology, and finally conclusions and future perspectives are drawn in section 6.

II. CHALLENGES IN COMMUNICATION NETWORKS FOR DISASTER OPERATION

The impact of natural disasters on communication infrastructures leads to poor communication and coordination of disaster response workers and insufficient information. A working communication system is crucial to disaster response. Hence, a disaster network should be constructed rapidly to provide communication services in disaster areas. Due to the fact that a communication network is essential for disaster response, a large number of challenges arise. The following lists these challenges [5]-[8].

- **Popularity** – Common technologies, such as cell or smart phones should be utilized, because most people can use them. They are user friendly and easy to use. Furthermore, a sufficient amount of terminals should exist, which may be fulfilled by phones, notebooks and tablet PCs.
- **Usability** – To possess usability, a disaster network should provide task oriented communication services (e.g. push-to-talk), support mobility (e.g. small, light devices) and has adequate quality of service (QoS). Besides, the resources of disaster network should have long durability, which may be realized by rechargeable batteries. Therefore, efficient utilization of power is required.
- **Practicability** – The network should be constructed under limited budget as easy as possible within shortest time, also the equipment has to be easily accessible.
- **Capacity** – Support sufficient number of concurrent users and overcome traffic congestion.
- **Sustainability** – The communication network should operate until the public network is recovered and it should continually provide service, even if it is broken down, it should recover quickly.

- **Adaptability** – Cause of constantly changes due to aftershocks, fires and progress of disaster response, etc. the communication system should be adaptable and flexible.
- **Operability** – Operation, administration and maintenance (OAM) functions are needed to keep the system running, adjust network topology, and allocate bandwidth according to the requirements of the user groups, e.g. response workers.
- **Connectivity** – Communication among different user groups, such as rescue team members, headquarters and victims, has to be guaranteed, which represents inter and intra communication.
- **Security** – Security functions should protect the network, also against attackers. In addition, high reliability and availability is necessary.

Considering these challenges for different technologies that are known to be candidates for disaster networks the following conclusions can be drawn. Microwave radio relays and mobile satellite equipment, such as very small aperture terminal (VSAT), should be used for long range inter communication. These technologies including TETRA/TETRAPOL, which has very low bitrates, are specialized and not accessible for everyone. Cellular communications such as Long Term Evolution advanced (LTE-advanced) device-to-device mode also allows communication between two terminals [9]. A drawback of the device-to-device mode is that the terminals need the telecommunication infrastructure to start the communication. The infrastructure is responsible for detecting the candidates for ad hoc communication. This fact leads to a problem; in disaster scenarios, the deployed infrastructure can be damaged. Consequently, this technology is not always applicable [4]. Technologies such as Wi-Fi or Bluetooth are very common, free of charge, and many devices are equipped with transceivers for these technologies. Based on these technologies MANET and WMN can be established, which are relevant for ad hoc networks in disaster areas.

III. Mobile Ad Hoc and Wireless Mesh Networks

A MANET is an autonomous system of mobile routers connected by wireless links (see Fig. 1). The routers are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. Such a network may operate in a standalone fashion, or may be connected to Internet [10].

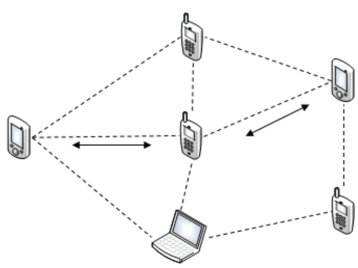

Fig. 1. Ad hoc network architecture

One special feature of a MANET is the capability of self-organizing and self-configuring. MANETs are so-called self-organized networks (SON), which offer a good load balancing and do not use centralized management. The main advantages of MANETs are saving of energy, scalability and robustness. Such a network can adapt its resources by the number of participants. The network's robustness and stability increases with the number of participants, because there will be more relays (senders/receivers).

A next step in evolution of wireless ad hoc networks are WMN, they are dynamically self-organized and self-configured. WMNs are comprised of two types of nodes: mesh routers and mesh clients. Other than conventional wireless router, the capability for gateway/bridge functions differs in additional routing functions to support mesh network. The architecture of WMNs can be classified into three types [11]:

- **Backbone** – The mesh routers/gateways form an infrastructure for clients and can be connected to various networks, e.g. Internet. Furthermore, the mesh routers have minimal mobility.
- **Client** – Client meshing provides peer-to-peer networks among client devices. In this type of architecture, client nodes constitute the actual network to perform end-user applications to customers.
- **Hybrid** – This architecture is the combination of backbone and client meshing, as shown in Fig. 2. Mesh clients can access the network through mesh routers and directly connect to other mesh clients. The backbone provides connectivity to other networks.

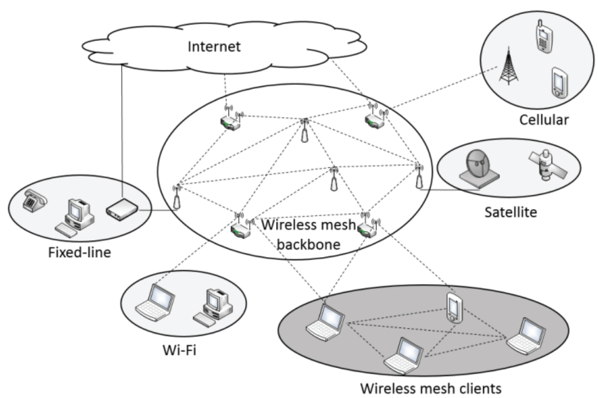

Fig. 2. Hybrid WMN architecture

Mobile ad hoc networks are multi-hop networks that utilize routing protocols. Numerous routing protocols have been introduced in recent years. The protocols can be classified into three groups – proactive, reactive, and hybrid (see Fig. 3). In proactive routing protocols, the routes to the destination are determined at the start up, and maintained by using a periodic route update process. In reactive protocols, routes are determined when they are required by the source using a route discovery process. Hybrid routing protocols combine the basic properties of the first two classes of protocols into one [12].

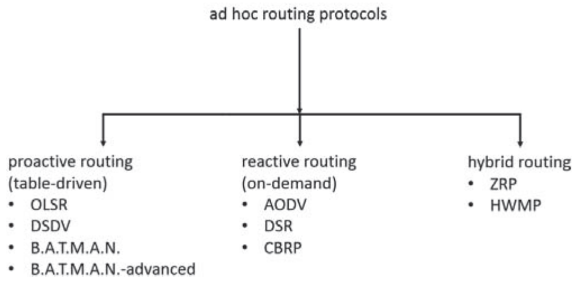

Fig. 3. Ad hoc routing protocols

In [13]-[16] several routing protocols for MANETs are evaluated in disaster scenarios. Further evaluations on routing protocols regarding performance analysis have been made in [17]-[20]. The results of these researches vary significantly. Some only evaluated reactive protocols, such as ad hoc on-demand distance vector (AODV), dynamic source routing (DSR) and cluster based routing protocol (CBRP). AODV and CBRP resulted as suitable protocols for disaster or emergency scenarios. Others evaluated proactive protocols such as optimized link state routing protocol (OLSR), better approach to mobile ad hoc networking (B.A.T.M.A.N.) and B.A.T.M.A.N.-advanced. The last-named routing protocol was highlighted to be a good candidate. Despite the results from numerous investigations, further research should be done. For instance, all shown protocols presented in Fig. 3 should be examined against each other under special consideration of disaster scenarios, performance and energy efficiency. Especially routing protocols such as B.A.T.M.A.N.-advanced and hybrid wireless mesh routing protocol (HWMP) should be focused on. These protocols work on the data link layer and offer a number of advantages.

- Support of IPv4 and IPv6
- Interface bonding, to increase reliability or throughput
- Network coding, to improve throughput, efficiency and scalability
- Faster roaming and simple configuration, MAC addresses are unique

Certainly, these protocols also have disadvantages such as overhead in data link layer and performance issues regarding to a large number of nodes. Based on top of the routing protocols further services can be provided, for example dynamic host configuration protocol (DHCP), virtual private network (VPN), network and port translation (NAPT) or voice over IP (VoIP). These network functions can be virtualized, managed and orchestrated by utilization of NFV. The benefit of utilizing NFV will be described in the next section.

IV. Network Virtualization

Some of the leading telecom operators initiated a new specification group for virtualization of network functions at European Telecommunications Standards Institute (ETSI) in 2012. Their aim is to transform the way network operators architect networks by evolving standard virtualization technology to consolidate many network equipment types onto standard high volume servers, switches and storage, which could be located in datacenters, network nodes and in end-user premises. It involves the implementation of network functions in software that can run on industry standard server hardware, and that can be moved to various locations in the network as required, without the need for installation of new equipment [24]. Fig. 4 represents an overview of the NFV framework specified by ETSI. The framework consists of the network functions virtualization infrastructure (NFVI) that is composed by hardware resources, the virtualization layer for running the virtual network functions (VNF), the VNFs , and a component named NFV management and orchestration to support orchestration and lifecycle management of physical and/or software resources that support the infrastructure virtualization, and the lifecycle management of VNFs [25]. The following advantages may result cause of NFV deployment: reduced costs for equipment, provisioning and operation; faster introduction of new network features; high scalability; network configuration can be adapted regarding the actual traffic in nearly real-time; lower electrical power consumption.

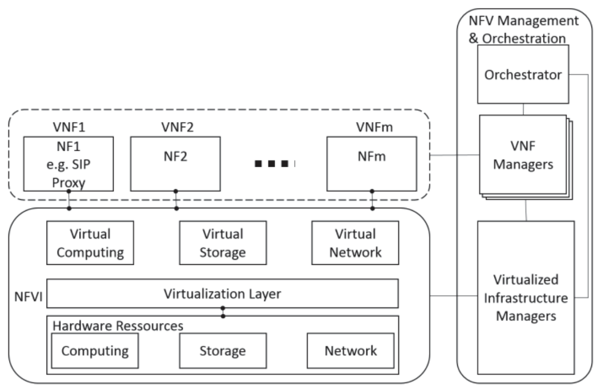

Fig. 4. NFV framework

Mainly two kinds of virtualization technologies are utilized nowadays. Hypervisors-based virtualization and container-based virtualization are common technologies in use now (see Fig. 5). In hypervisor-based virtualization, the hypervisor operates at hardware level, thus supporting standalone virtual machines that are isolated and independent of the host system. So any operating system may be used on top. The disadvantages here are that a full operating system is installed to virtual machine and the emulation of virtual hardware devices incurs more overhead [21]. Two different types of hypervisors are classified – native hypervisors, which operate on top of the host's hardware and hosted hypervisors, which operate on top of the host's operating system. Container-based virtualization can be considered as a lightweight alternative to hypervisor-based virtualization. Containers are running on top of shared operating system kernel of the underlying host machine. An advantage of container-based solutions is that the size of the disk images are smaller compared to hypervisor-based solutions. Container-based virtualization solutions also have some disadvantages, such as that no different operating system can run on top of the host (e.g. Windows on top of

Linux) and containers do not isolate resources, because the kernel is exposed to the containers, which may be an issue of security for multi-tenancy [21].

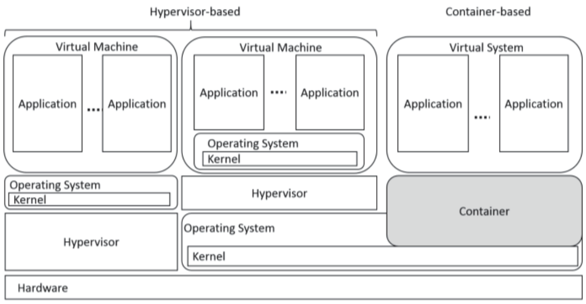

Fig. 5. Virtualization architectures

The specification of NFV primarily focuses on the use of hypervisor-based virtualization, but it also says that further research on container-based virtualization is needed [22] as well as in [23]. With respect to virtualization, container-based solutions offer further advantages such as low latency, low overhead, instant booting and energy efficiency especially in terms of networking [26]. In [22] requirements for energy efficiency are defined to be fulfilled by NFV.

A complement of NFV is mobile-edge computing (MEC), which provides IT and cloud-computing capabilities within the radio access network (RAN) in close proximity to mobile subscribers [27]. In MEC, for instance services and applications can be shifted to the base stations onto a so-called MEC server (see Fig. 6). The MEC server consists of a hosting infrastructure and an application platform. Compared with the NFV framework a real difference between the hosting infrastructure and NFVI is not noticeable. A distinctive difference is the MEC application platform that provides capabilities for the virtualized applications and consists of the application's virtualization manager and application platform services. However as MEC is a complement to NFV it also utilizes virtualization and is focused on benefits such as rapid deployment of new services and placing applications near to consumers to reduce the volume of network traffic to the core network, where normally applications are hosted.

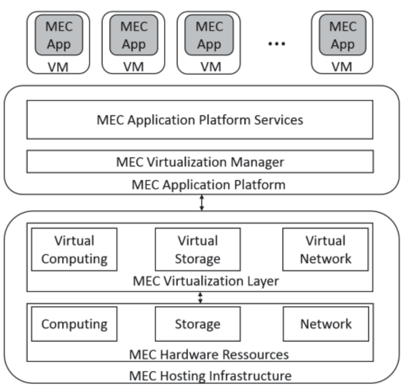

Fig. 6. MEC server architecture

To solve the challenges, sustainability and operability regarding to disaster networks, network virtualization implemented by NFV will help to optimize a wireless mesh network, which will be discussed in the next section.

V. Wireless mesh network for optimized disaster operation

Because several nodes, which span the WMN, are not connected to a fixed power supply, one of the key criterion in this relation is the energy demand of each wireless mesh node. All requested tasks, as for instance sustain of internet access shall accomplished as long as possible even if energy sources such as batteries or generators are used. This leads to an approach, which integrates and utilizes NFV functionalities on basis of a WMN to operate an optimized disaster network. Fig. 7 depicts an overview of a WMN NFV node's architecture. A distinctive difference regarding the already presented NFV framework architecture is that the network part of the underlying hardware resources and operating system implements mesh routing protocols. These routing protocols should be optimized with respect to energy consumption, scalability, reliability, and support of real-time communication, such as voice or video, because these are essential services in disaster scenarios. Through abstraction of network interfaces and mesh routing protocols from the arranged components on top new overlay networks can be constructed, to provide special services in virtually separated networks. Another distinction is the replacement of the hypervisor by a container-based virtualization. This will result in lower latency, lower overhead, smaller disk images, and higher energy efficiency. Further advantages are resulting from NFV utilization, which enables to provide special services and network functions on top of the WMN. A NFV infrastructure contains three elements, virtual network, virtual computing, and virtual storage. The virtual network element is responsible to provide virtual networks for VNFs. These networks can be established between VNFs and to connect them to external networks. Consequently, arbitrary complex networks can be build and combined. Virtual computing supplies the processing unit to each VNF. The virtual storage element represents a virtual disk space for e.g. images of VNFs, which will be utilized by virtual computing. Applying NFV in disaster networks will benefit in terms of flexibility and availability of services and network functions. Furthermore, the proposed infrastructure benefits from the MEC notion by adoption of the idea to place applications and services near to customers to reduce the volume of network traffic, which will lead to reduce power consumption too.

The resulting WMN framework consists of nodes implementing NFV according to Fig. 7 and building a backbone network as represented in Fig. 2. Based on the architecture an optimized disaster network can be established to provide real-time communication services and several other functions such as data communication for water supply or medical help to support disaster response workers effectively. The nodes within the proposed WMN are non- or minimal moving during deployment. They offer an extendable and resilient backbone network to connect other networks such as Internet and provide in addition the possibility to be constructed very fast, because common technologies like Wi-Fi are used [28].

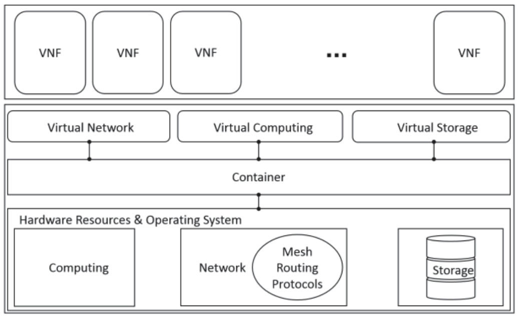

Fig. 7. WMN NFV framework architecture

Utilizing NFV implies the possibility to handle network functions dynamically. VNFs can be switched on and off on demand on any virtual computing instance. The usage of container-based virtualization implicates instant booting of a VNF. Furthermore, VNFs can be relocated to other virtual computing instances near to places where they are needed. For instance, if a session initiation protocol (SIP) proxy server is needed in only one special network segment, e.g. at the edge, it does not make sense to carry the traffic through the whole network. Therefore, it might be helpful to place the SIP proxy server close to the point where it is needed.

The following Fig. 8 shows a set of network functions. Some of these functions are bound to hardware, which makes them immovable. All bound functions are access technologies such as IEEE 802.11 or Ethernet. They comprise different physical layers and provide gateway functionality to the bridge that sits on top of these.

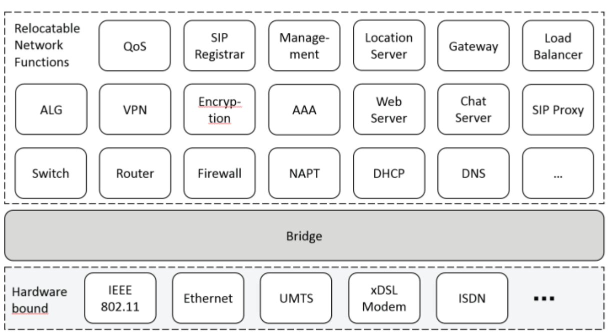

Fig. 8. WMN NFV network functions

The so-called relocatable network functions can be placed on any node within a NFV, because they are virtualized network functions. The fact that VNFs can be relocated will offer a new chance within disaster networks for conservation of energy. Other possibilities to save energy might be to relocate network functions depending on the network load or in dependence of local existing energy resources. Network functions also may be placed on a different node due to computational power or a network function can be distributed onto multiple nodes. The distributed network functions can cooperate through a load balancer for instance. The bridge functionality generally is required in any NFV component, because it serves as basis for all other functions. Through the bridge, any VNF can be directly connected to an access network or different VNFs can be chained to realize a network service.

Another crucial criterion in terms of providing VNFs is the orchestration of them. By orchestration and management for NFV the energy consumption can be monitored and dynamically controlled to be minimized. In [29] the network functions virtualization management and orchestration (NFV-MANO) architectural framework is specified (see Fig. 9). The role of NFV-MANO is to manage the NFVI and orchestrate the allocation of resources needed by the network services and VNFs. NFV-MANO handles the discovery of available services, management of virtualized resources i.e. availability, allocation, release, and virtualized resource fault/performance management. The management and orchestration refreshes and controls the resources within the NFVI that are:

- Compute, including machines (e.g. hosts), and virtual machines, as resources that comprise both CPU and memory.
- Storage, including volumes of storage at either block or file-system level.
- Network, including networks, subnets, ports, addresses, links and forwarding rules, for the purpose of ensuring intra- and inter-VNF connectivity.

The orchestrator particularly is responsible for the network service lifecycle management, which means the registration and instantiation of a network service. In addition, scaling of network services is a responsibility of the orchestrator, i. e. grow or reduce the capacity of network service. Furthermore, network services can be updated and terminated by the orchestrator. As consequence, orchestration is the main factor to achieve reduction of energy consumption by NFV. It is possible to control and manage all virtual elements within NFVI. In disaster networks energy consumption is an important item as already mentioned in section two.

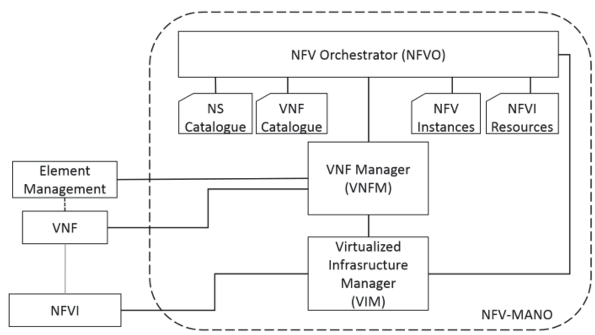

Fig. 9. NFV-MANO framework architecture

Another issue regarding to disaster network's reliability, when using NFV, is the orchestration and management. It would be not beneficial if this component loses connectivity to NFVI. In datacenters, it is possible to implement a centralized

NFV-MANO, however in WMN-based disaster networks utilizing NFV this could be an obstacle. In conclusion, the distribution of orchestration and management over all WMN nodes might be a better solution.

VI. Conclusions

Due to the characteristic of wireless mesh networks, a disaster network can be setup spontaneously if a previous existing infrastructure and communication system is destroyed after a disaster. Fundamental challenges for disaster networks are presented with special attention to energy consumption. Choosing the right routing algorithm and virtualization of network functions can lower the consumption and increase the performance. As a result, we propose utilizing the advantages of NFV to increase the energy efficiency, so that the devices used in disaster networks will have a long working time, which is a novelty in wireless mesh networks and disaster networks. A further innovation regarding the improvement of the introduced optimized WMN for disaster operation is the distribution of the orchestration and management over all WMN nodes for the NFV.

References

[1] International Telecommunication Union (ITU), “Technical Report on telecommunications and disaster mitigation,” Technical Report, Version 1.0, June 2013.

[2] N. Marchetti, “Telecommunications in disaster areas,” River Publishers Series in Communications, vol. 12, pp. 1-9, 2010.

[3] K. Kanachana, A. Tunpan, M. A. Awal, D. K. Das, T. Wongsaardsakul, and Y. Suchimoto, “DUMBONET: a multimedia communication system for collaborative emergency response operations in disaster-affected areas,” Int. Journal of Emergency Management, vol. 4, pp. 670-681, 2007.

[4] D. G. Reina, M. Askalani, S. L. Toral, F. Barrero, E. Asimakopoulou, and N. Bessis, “A survey on multihop ad hoc networks for disaster response scenarios,” Int. Journal of Distributed Sensor Networks, vol. 2015, Article ID 647037, 16 pages, 2015.

[5] J.-S. Huang and Y.-N. Lien,“Challenges of emergency communication network for disaster response," in Proc. IEEE International Conference on Communication Systems (ICCS), Singapore, pp.528-532, Nov. 2012.

[6] K. Ali, H. X. Nguyen, Q.-T. Vien, and P. Shah, “Disaster management communication networks: challenges and architecture design,” in Proc. IEEE International Conference on Pervasive Computing and Communication Workshop (PerCom Workshop), St. Louis, pp. 537-542, Mar. 2015.

[7] N. Gondaliya and D. Kathiriya, “An application of ad hoc networks in disaster area for search and rescue operation: a survey and challenges,” International Journal of Advanced Research in Computer and Communication Engineering, vol. 3, no. 3, pp. 5711-5714, Mar. 2014.

[8] C. B. Nelson, B. D. Steckler, and J. A. Stamberger, “The evolution of hastily formed networks for disaster response,” in Proc. IEEE Global Humanitarian Technology Conference (GHTC), Seattle, pp. 467-475, Nov. 2011.

[9] K. Doppler, M. Rinne, C. Wijting, C. B. Ribeiro, and K. Hug, “Device-to-device communication as an underlay to LTE-advanced networks,” IEEE Communications Magazine, vol. 47, no. 12, pp. 42-49, Dec. 2009.

[10] N. Pratas, N. Marchetti, N. R. Prasad, A. Rodrigues, and R. Prasad, “Self-organizing cognitive disaster relief networks,” River Publishers Series in Communications, vol. 12, pp. 95-125, 2010.

[11] I. F. Akyildiz, X. Wang, “A survey on wireless mesh networks,” IEEE Communications Magazine, vol. 43, no. 9, pp. 23-30, Sept. 2005.

[12] M. Abolhasan, T. Wysocki, and E. Dutkiewicz, “A review of routing protocols for mobile ad hoc networks,” Elsevier Journal Ad Hoc Networks, vol 2, no. 1, pp. 1-22, Jan. 2004.

[13] D. G. Reina, S. L. Toral, F. Barrero, N. Bessis, and E. Asimakopoulou, “Evaluation of ad hoc networks in disaster scenarios,” in Proc. 3rd IEEE International Conference on Intelligent Networking and Collaborative Systems (INCoS), pp. 759-764, Fukuoka, Japan, Dec. 2011.

[14] D. G. Reina, S. L. Toral, F. Barrero, N. Bessis, and E. Asimakopoulou, “Modelling and assessing ad hoc networks in disaster scenarios,” Journal of Ambient Intelligence and Humanized Computing, vol.4, no. 5, pp. 571-579, 2013.

[15] C. Raffelsberger and H. Hellwagner, “Evaluation of MANET routing protocols in a realistic emergency response scenario,” in Proc. 10th International Workshop on Intelligent Solutions in Embedded Systems, pp. 88-92, July 2012.

[16] L. E. Quispe and L. M. Galan, “Behavior of ad hoc routing protocols, analyzed for emergency and rescue scenarios, on a real urban area,” Elsevier Journal Expert Systems with Applications, vol. 41, no.5 pp. 2565-2573, 2014.

[17] A. Sharma and N. Rajagopalan, “A comparative study of B:A:T:M:A:N: and OLSR routing protocols for MANETs,” International Journal of Advanced Trends in Computer Science and Engineering, vol 2, no. 5, pp. 13-17, 2013.

[18] V. M. Sarabu and N. Kasiviswanath, “Routing protocols for wireless mesh networks,” International Journal of Scientific and Engineering Research, vol. 2, no. 8, pp. 42-46, 2011.

[19] D. Seither, A. König, and M. Hollick, „Routing performance of wireless mesh networks: a practical evaluation of BATMAN advanced,” in Proc. 36th IEEE International Workshop on Local Computer Networks (LCN), pp. 897-904, Oct. 2011.

[20] M. Liechti, “Real-world evaluation of ad hoc routing algorithms,” Semester Thesis SA-2012-35 ETH Zürich, 2013.

[21] R. Morabito, J. Kjällman, and M. Komu, “Hypervisors vs. lightweight virtualization: a performance comparison,” in Proc. IEEE International Conference on Cloud Engineering (IC2E), Tempe, pp. 386-393, Mar. 2015.

[22] ETSI Group Specification, “Network functions virtualization (NFV); infrastructure; hypervisor domain,” NFV-INF 004, V1.1.1, Jan. 2015.

[23] S. Natarajan, R. Krishnan, A. Ghanwani, D. Krishnaswamy, P. Willis, and A Chaudhary, „An analysis of container-based platforms for NFV,” IETF Draft, Oct. 2015.

[24] ETSI ISG NFV, “Network functions virtualization – an introduction, benefits, enablers, challenges & call for action,” SDN and OpenFlow World Congress, Oct 2012.

[25] ETSI ISG NFV, “Network functions virtualization – network operator perspectives on industry progress,” SDN and OpenFlow World Congress, Oct. 2013.

[26] R. Morabito, “Power consumption of virtualization technologies: an empirical investigation,” to appear in Proc. 8th IEEE/ACM International Conference on Utility and Cloud Computing (UCC), 2015.

[27] ETSI ISG MEC, “Mobile-edge computing – introductory white paper,” White Paper, Sept. 2014.

[28] R. Miura et al., “Disaster-resilient wireless mesh network – experimental test-bed and demonstartion,” in Proc. 16th International Symposium on Wireless Personal Multimedia Communications (WPMC), pp. 1-4, June 2013.

[29] ETSI Group Specification, “Network functions virtualization (NFV); management and orchestration,” NFV-MAN 001, V1.1.1, Dez. 2014.