

# Interoperability by ‘Edgeware’: Wireless Grids for Emergency Response

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## Abstract

*‘Edgeware’ for wireless grid connectivity, utilizes open specifications developed by the National Science Foundation (NSF) Partnerships for Innovation (PFI) ‘Wireless Grid Innovation Testbed’ (WiGiT) to enable greater interoperability across devices, networks, applications, content and services. A wide range of new ‘edgeware’ applications is emerging for businesses, education, government agencies and individuals.*

*Challenges in emergency response include interoperability, social and human factors. ‘Edgeware,’ a new class of software designed to share resources across people, devices, services and content has the potential capacity to solve problems of interoperability and control over resources, by the creation of wireless grids. This will allow people to access programs and data on disparate devices, across available wired and wireless networks and provide greater access to resources.*

*Emergency services applications of wireless grids will empower citizens through their devices to contribute to their own community response. The authors describe ‘Neighborhood Notification System’ gridlets, now in development, which are just the first examples of use of wireless grids for emergency response. The authors conclude that police, fire, EMS, hospitals, municipal services, utilities, gas companies, media, and community residents will benefit from enhanced information sharing in emergencies based on this interoperability by ‘edgeware’ solution.*

## 1. Introduction

Substantial investments in disparate devices and systems for use in emergency response situations have been made by various entities in communities across the globe. The hopeful notion of discarding

current technological resources to employ only cutting edge technologies is not realistic from a management perspective. Training and upgrade costs are high. The concern that one solution may or may not continue to rise as an accepted standard across the board is a real concern for managers. What is needed in this environment is a means for integration of diverse devices, programs and access in spite of the incompatibilities. In an emergency, all available resources must be utilized, yet the prevailing approach is to discard anything that is not compatible with the ‘latest and greatest’ solution.

‘Edgeware’ provides a means for securing these desired ends. The notion of wireless grids [1] emerged some years ago but the capability to make its application happen is only now becoming a reality. Addressing the need for sharing devices, security, control over resources and robustness to continue availability in uncertain and dynamic conditions as is the case with many emergency response situations is paramount.

Having the ability to share critical emergency related data; maps, situational reports, medical resources, on demand and in real time is imperative in today’s response environment. While this need has been apparent for years, comprehensive standards do not yet exist, because the systems and the range of standards required is complex. For example, public safety networks must be available in remote locations and the infrastructure must be able to withstand disasters, like hurricanes or earthquakes. “Edgeware is introduced as a new class of software for wireless grid connectivity. It utilizes open specifications developed within the NSF PFI (NSF PFI#0917973) funded Wireless Grid Innovation Testbed (WiGiT) to enable more seamless and controlled interoperability across networks, applications, devices, content and services [2], [3], [4].

A 2006 study of public safety information systems in the United States identified no less than 266 different systems in use or planned for use [5].

Historically, radio systems for public service agencies were on different frequencies so that they would not interfere with their neighboring department's communication. As a result of this and other practices, such as adoption of multiple independent vendor solutions, there remains a variety of software and hardware used for emergency response [6]. It is time to consider an alternate approach.

A wide range of new 'edgware' applications, or 'gridlets' - it is too soon to say what the generally preferred moniker will be - is emerging creating wireless grids for businesses, education, government agencies and private individuals. Emergency services applications of wireless grids can empower citizens and their devices to contribute to their own community response. We conclude that police, fire, Emergency Medical Services (EMS), hospitals, municipal services, utilities, gas companies, media, schools and assisted living communities all benefit from greater information sharing in emergencies.

This paper argues that key problems in emergency response have been previously identified and include interoperability, social and human factors. What are also lacking are tools to achieve interoperability without relying on 'hard-wired' solutions. It is understandable that vendors will all claim that their exclusive approach is best. This is a logically flawed argument; in an emergency the first objective is to coordinate response with what is available or on hand, not to be limited to certain devices or networks to be used toward that purpose.

Problems for emergency response given the disparate systems won't just go away. The objective here is to identify the problems in the emergency response arena and suggest solutions which may be undertaken using existing and emerging technology and policy as well as considering the social and human factors, following an action research model.

Another important aspect of sharing involves understanding and being able to find and make use of the data and resources accessible on a system. It is inaccurate to assume that one will be familiar with all resources that may be available. For example if you have the ability to share a database of plant employees that does not automatically mean that you know how to retrieve information from or navigate that particular system. Incorporation of specific, predefined database views for such information has potential value here.

It may also be that the language or naming conventions in a particular system are not the same as the user's concept and so there may be errors or misinterpretation of otherwise accurate data. There are also nuances in interpreting or understanding the

metaphors or representations in the different packages or systems used. Common descriptors for individuals and locations are hard to standardize.

As noted 'edgware' will allow for greater access to information but not necessarily to knowledge of the particularities of the systems and information. Therefore, it is as necessary to have access to the knowledge and understanding of the system as it is to gain physical or virtual access, for without such knowledge the resource will be of minimal use.

What is needed is a way to overlay all systems willing to 'opt in' to a shared emergency response solution, or wireless grid. 'Edgware' has the capacity to solve problems of interoperability, trust, access and control over information resources. Wireless grids 'edgware' solution allows personnel to access programs and data on disparate devices, integrating both old and new technology seamlessly.

## 2. Wireless Grids and Edgware

We have seen the evolution of communication networks from centralized, hierarchical systems under the management of a single entity toward decentralized, distributed systems under the collective management of many entities. Intelligence has shifted to edge-nodes, which increasingly are capable of acting as autonomous agents making complex decisions to create, deliver, or receive services [7] [8], [9]. Previously, grid computing focused on large-scale sharing of computing resources such as software, hardware, databases and data sources [10]. The growth of wireless increased opportunities for computing to become ubiquitous (always available, always connected). Heterogeneity of networking resources needs to be managed (mobility and wireless/wired interconnection). There are an increasing number of end nodes (connected computers in everything from our bodies to clothes, appliances, cars, and walls). This has led to a transition; wireless grids, which are organized as ad hoc networks and represent the epitome of evolution in communication networks [8], [9].

Wireless grids are defined as the ad-hoc dynamic sharing of physical and virtual resources among heterogeneous devices. Wireless grid applications may be considered in three categories of applications (1) those that collect or aggregate data (2) take advantage of their location or where they can move to and (3) take advantage of cooperation among a mesh of mobile devices.

Related work regarding wireless grids include works on user and socio-technical perspectives and challenges [7], [8] coordination of user and device behaviors [9] future internet applications and

bridging communicative channels [11], [12], [13]. There has been increasing acknowledgement of the nascent growth of wireless grids as a new engineering field of scientific inquiry and innovation [14].

The grid is an emerging infrastructure that will fundamentally change the way we think about and use computing [13]. The concept of this virtual workspace is a configurable execution environment created and managed by reflecting client requirements [10], [15]. A broader understanding of the nature of the opportunities offered by grid computing and the technologies or standards needed to realize those opportunities is now required [10].

‘Edgeware’ describes software that resides beyond the cloud, across edge network devices, both wired and wireless [4]. Wireless Grids ‘edgeware’ technology sits at the outermost limits of networks, allowing all facets of a user’s environment to be interoperated and shared easily. This new class of software for ad hoc distributed resource collaboration allows for coordination of devices and content on a new scale. There are many kinds of devices that can be shared using this service, for example, mobile phones and Internet devices, printers, displays, remote sensing devices, local weather sensors, wireless sensor networks, etc.

The fundamental difference that this form of interconnection has over traditional networking is that it allows for true resource sharing and not simply access. In the case of wireless grids you access distant resources and programs similar to using the device directly. In this way legacy concerns and incompatibility issues are overcome. Security and access controls have been established such that owners determine use and constraints. Ownership, user autonomy and sovereignty regarding the sharing and process are maintained. The wireless grids technology identified here transforms disparate devices into a shared and interactive grid of accessible resources. Technical standards and open application programming interfaces (API) are needed to enable the adoption and growth of this new technology.

### **3. Standards and Protocols Development**

Governments are responding to the need for standards in public warning systems. Examples of these activities include; “Partnership for Public Warning” in the U.S., “Forum for Public Safety Communication Europe”, and also the Internet Society's "Public Warning Network Challenge" [15]. These examples signify recognition of the importance

of crisis-ready, multi-channel, regional and international public warning dissemination networks.

Protocols are being established and adopted in the emergency services realm. The Common Alerting Protocol (CAP) is an Extensible Markup Language (XML) based format that allows for messages to be disseminated consistently, maintaining integrity, across communications warning applications through the use of compatible alert formats. The goal here was to create a neutral and open format for warning systems interoperability. It was created through an unofficial and non-commercial initiative [16]. The use of the CAP was initially limited but gained wider acceptance following its adoption as an OASIS standard in 2004 and it has since been implemented in the U.S. and other countries [16]. Open source initiatives are proving to be valuable for public warning and commercial ICT-based warning services continue to exist as well [16].

Because emergency response situations are emergent and dynamic it is very difficult to account for every exigency in advance. At the crisis scene it may be that planned technologies may not function or are inadequate under the given circumstances. Emergency response personnel may need to mix and match other disparate and possibly unfamiliar technologies to fit the tasks at hand [17].

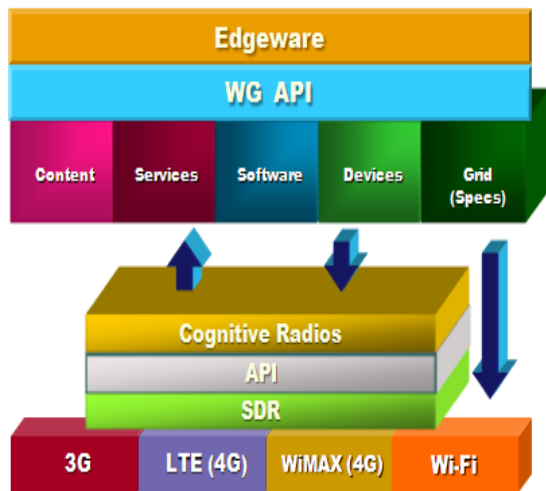
When it comes to emergency response additional requirements need to be taken into account. Among others this includes coordination of resources in ad hoc situations. Interoperability for emergency response could be defined as: “The ability of disparate and diverse emergency response units to interact in emergency situations towards common goals, involving the sharing of information and knowledge between involved organizations and units via defined or ad hoc processes to achieve coordinated actions, by means of the exchange of data between their respective information and communication technology (ICT) systems” [18].

To achieve interoperability among diverse emergency response units and organizations, they developed and agreed on “Interoperability Principles”. Together with the general objectives of emergency response services, the interoperability principles are policy guidelines and define what should (and what should not) be achieved.. Agencies that may have differing techniques for operating, these principles serve as a uniform guide. They can provide additional guidance and compliance checks for implementation on a system, process, and organization level. These guidelines are necessary to make it clear to all participants what is meant when speaking about interoperability. This goes far beyond technical issues [19]. A best practice example of how

such interoperability principles work is given in the European Interoperability Framework (EIF) [18] in the context of e-government. Similar principles need to be developed for the emergency response sector in a broadly supported multi-stakeholder forum.

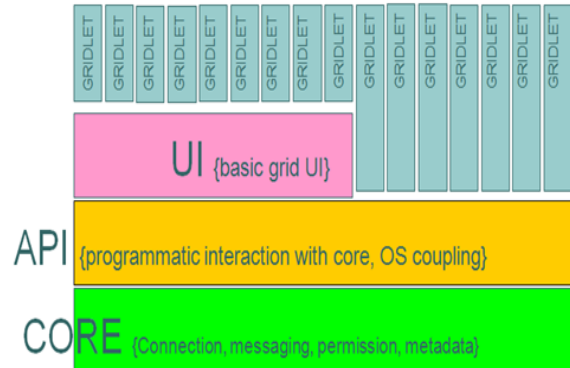
Principles are hardly enough to address the complex challenges that interoperability poses. A conceptual framework is needed to investigate different facets of this challenge as not only technical and semantic issues but also organizational and legal issues and the current political context need to be taken into account. The EIF [18] introduces a framework that considers five levels – political context, legal, organizational, semantic, and technical – that need to be considered to establish interoperability. From an analytical point of view the five levels offer helpful insights: "where" and "what" interoperability issues may arise and "which" actor may respond to them (i.e. a legally non-compliant transaction on the organizational level that needs to be addressed by a legislative function).

The WiGiT team is also inspired by Free/Libre Open Source Software development processes. Wireless grids computing extend the traditional grid computing paradigm to include a diverse collection of mobile devices. WiGiT anticipates defining through iterative and flexible processes modular components across various layers which can be mixed and matched as partners wish (see Figure 1). All participants in WiGiT can contribute their ideas, and/or their software, to the development of open specifications for wireless grids. Participating members will determine how the WiGiT process will change, and which partner organizations may join in to contribute to broadening participation in WiGiT processes.



**Figure 1: WiGiT layers composition**  
(Source: WiGiT, 2010)

An example of the interaction of the 'gridlets' with the other architecture elements is shown in Figure 2. The 'gridlets' interact directly with the User Interface (UI) and Application Program Interface (API). The connection, messaging, permissions and metadata, (CORE operations) are accessed indirectly through the interface layers. Each 'gridlet' serves its unique purpose or service as defined by the user.



**Figure 2: WCG architecture**  
(Source: Wireless Grids Corporation, 2010)

Establishing open, non-proprietary protocols for emergency response communication and information dissemination systems would allow systems to evolve more readily, incorporate more intelligent and robust capabilities which would make them more effective.

Here we add WiGiT will interact with other industry standard organizations and forums to include the wireless innovation forum, Institute of Electrical and Electronics Engineers (IEEE 802.15.5) as well as open source efforts [47]. To increase these with which WiGiT protocols may fit within broader industry and commercialization efforts. WiGiT as its own virtual organization (VO) can work cooperatively with a variety of disparate groups who do not need to change their own operating procedures to have their specifications incorporated seamlessly into the WiGiT specifications. With this evolving suite of 'meta standards' we anticipate continued evolution and growth incorporating additional areas of complimentary work. As a VO anyone may join, the entry cost being only time and effort.

#### 4. Relevant Literature and Open Issues

There is a growing body of literature regarding information sharing in emergency response contexts. Adam, Atluri, Chun, et al., investigated secure information sharing in emergency management contexts [20]. Glomseth et. al., looked at occupational culture as determinant of knowledge

sharing by law enforcement agencies in an international study [21]. Research on emergency services sponsored by the NSF reports “technical environments such as other agencies’ information assurance level and technical standards seem to encourage information sharing systems use” [22]. Pardo, et. al., looked at the effects of governance structures in state and local criminal justice information sharing [23]. Local to state agency, information sharing [24] was the subject of the work by Akbulut et. al. . Rational choice, trust and other issues for organizations were studied by Williams et al., and Gil-Garcia et. al. [25],[ 26].

Recent case studies on knowledge sharing within public sector inter-organizational networks confirm information sharing difficulties across agencies [27], [28]. Emergency response agencies overlap jurisdictions and responsibility; each with a duty to their own constituencies. Traditionally there has been a top down approach to attempt implementation of information sharing mandates, typically from the Federal level downwards. Success has been limited.

Some of the recurring problems which have been identified include (1) agencies have not established sufficient trust, (2) time sensitive information affects the sharing potential, (3) technical issues such as incompatibility, lack of standards and system reliability exist (4) policies are not consistent or in pace with technology or society and may conflict with sharing interests and personnel issues that involve social and security concerns can interfere with the information sharing processes.

Problems can be classified into three major areas: technology, personnel, and policy. Technology factors include interoperability issues, availability and control. Personnel factors involve social issues, trust, shadow networks and criticality. Policy factors involve concerns over law and policy conflict and under what governance model or structure activities are allowed or restricted. Theoretical and empirical work has been done to identify factors that influence the sharing of information between local and state agencies [24]. They identify similar technical, agency and environmental factors that influence information sharing. We further include issues of security and trust in our discussion here as there are particularities attending the emergency response arena deserving special attention.

#### 4.1 Security, Trust and Control

Protecting information and information systems from unauthorized use, access disclosure, modification, disruption or destruction falls within

the domain of information security. The field of information security involves consideration of three main components: confidentiality, integrity and availability [29]. Governments and agencies involved with emergency response must address all of these concerns. There is greater pressure to share and cooperate in crisis situations. Still, privacy and security considerations must be addressed. We discuss these aspects in greater detail as they apply further in this paper.

Trust affects information sharing in all of the described areas. Individual agencies may not trust other agencies that participate and have access to the information that is shared on a collaborative information system [30]. Agencies also may compete with each other for recognition or resources and this negatively impacts information sharing. Typically, grant programs base funding on numbers of incidents handled or cleared and so there is pressure to retain information for one's own use and to act autonomously and not collaboratively.

Control as perceived by the users is most important for information sharing and systems adoption. Systems must be capable of monitoring and managing all usage and dissemination of information for tracking purposes to provide assurance, which is required for trust [31]. There is no broadly accepted set of minimum security and access control standards and protocols for information systems that has been uniformly adopted for use across agencies [32]. Distributed workflow control tasks in these integrated and grid environments become complex and may require both local and remote executions [33]. Provenance and user control tasks and capabilities must be suitable to varied environs.

In countries such as China and England there is more formal and established control over emergency response participants. This is not the case for all countries and certainly not the case where critical incidents cross borders and jurisdictions. There are successful governance and collaboration arrangement models that may improve the success, participation and ultimately sharing of information and resources in mixed interest environments [34].

#### 4.2 Technology Problems

Interoperability is a critical issue facing public sector entities which must access information from multiple information systems and sources. Establishing semantic interoperability among heterogeneous and distributed information sources remains a critical issue in research and practice [35]. There are many different information systems currently being used by law enforcement agencies for

data management and communication, such as; COPLINK, OneDOJ, N-DEx, ALECS and others [6], [36]. This lack of standardization creates obstacles for resource sharing and innovation adoption. Having uniform standards in hardware and software allows for greater innovation and product development [37].

The experience of trying to interconnect disparate phone systems in the United States has many parallels to the problem of integrating emergency response systems and the provision of universal service [38]. The issue of when to use competition versus regulation to improve interconnectivity remains to be determined. A lack of accepted standards in this arena may make it harder for developers and manufacturers to create products and services in this environment. This is further complicated by the fact that as time goes on agencies become engaged with and invested in different technologies. More is at stake in the future, such that when they are asked to make a change to more universal or standardized method of operation, the transition costs may be too high.

Availability means that the systems must respond in a timely manner and have a sufficient quality user interface for acceptance by the users in a given situation. These systems must have a high degree of survivability and function in mission critical environments where parts of the network may be compromised but adequate service must be continued [39]. Network availability impacts the acceptance and use of systems [40]. Information must be kept updated and in accordance with the users' interests and needs. For new systems to integrate with various technology and protocols, the processing load increases and performance and reliability is compromised. Systems become more prone to delays or failures as they must incorporate legacy and other protocols into their core programming and functions. Increases in security and authentication processes also add to the workload and potential for system delay or failure. Systems that are considered slow or non-responsive will typically not be adopted [40]. This is the paradox created.

#### 4.3 Technology Change and Influence

Disruptive technology transformations happen once every 10 to 15 years [41]. Mobile broadband represents the convergence of the last two great disruptive technologies and may be more transformative than either of the previous breakthroughs. Mobile broadband is scaling faster and presents a bigger opportunity.

A current standardization initiative in the United States involves a grant program for development of a

nationwide public safety broadband network through incentive-based partnerships [41]. The program will give public safety its own "hardened" broadband wireless access network; ensuring that the most vulnerable areas of the United States have the coverage they require; provide public safety with additional capacity and resiliency via access to nearby commercial spectrum; ensure that the emergency response community has the tools it requires; and optimize the effective use of resources.

According to a local Emergency Communications Commissioner in the United States everything in the area of broadband resource sharing is still unsettled. There are a number of vendors posing solutions and there are still no set accepted standards in this area. For agencies to take up the challenge and move ahead with implementing a large scale system incorporating one system or standard may leave them out of the picture if an alternate path is later taken up, supported commercially or recognized federally (for funding purposes). There remains a great risk for agencies and governments, by adopting one vendor solution or standard that it may not be the solution ultimately taken up by the other entities; further creating compatibility issues. This also affects support especially when funding for these large projects and later one must upgrade or add to them, the costs are high and if you are not using what is accepted or being readily available your costs can be compounded down the road. These sentiments were confirmed in interviews with Emergency Services practitioners.

In the United States pressures to resolve the communications problems for emergency response lead to the current nationwide broadband interoperability and use plan for public safety [41]. The link to next generation 911 (NG911) and the integration of networking other devices and services into the emergency services realm will require collaboration in the same way as the consolidated radio system policy. The processes and people (culture and policy) that were successful in the radio spectrum implementation will likely translate to success in fostering a move to the next level of services provision. Unfortunately, the adoption of standards in this arena will not likely resolve in a predictable or timely fashion. There are also other unapparent organizations and interests to consider.

#### 4.4 Humanitarian Involvement

Humanitarian organizations play a considerable role in crisis management. In instances where humanitarian organizations are integrated with government and other emergency response agencies

to address a crisis the use of 'edgeware' services is most useful.

Communication channels and information sharing systems across these domains is scattered and inconsistent. There are a variety of ICTs in use by these organizations and the same issues related to incompatibility and lack of standards, responsibility and control exist. Lines of authority are not always clear and the interests and motivation of each party involved may clash as well. It should be clear that access to timely, complete, relevant, and credible information are essential to effective humanitarian support operations. Having greater efficiency and effectiveness in communications, data gathering and sharing allows for the best possible response and benefit to affected persons [42]. This is discussed in following use cases..

## 5. Uses and Applications

Wireless Grid technology will be used to enable an interactive neighborhood Emergency Notification System (ENS) by two disparate communities within a city in the Eastern United States. Dr. Murali Venkatesh of Syracuse University is leading this research through WiGiT. Community members and church leaders in this economically depressed area did not have an efficient way to notify each other, or other support resources, in emergency situations. Church leaders have emphasized their need to provide intervention in terms of support and services to victims in emergency and crisis situations. Their intent is not to interfere but to provide support or other services to the victim or response personnel as needed. In order to intervene effectively, they need to be able to "get the word out" and quickly mobilize selected individuals to or take other necessary steps allowable under the law [48]. A second neighborhood of Asian immigrants have felt threatened by crime and harassment. They see value in a neighborhood notification system to increase their collective safety and well-being through improved contact, coordination and interaction with public agencies such as the police or other service providers.

The systems here involve using 'edgeware' and a Software Defined Radio (SDR) front-end together with a wireless WiFi infrastructure for emergency notification purposes [43]. A SDR is a radio communication system having computer based components that manage modulation, amplification, detection and other functions that were previously handled by dedicated hardware components. This component of the research is lead by Dr. Tamal Bose of Virginia Tech through WiGiT .

Those on system notification list would receive data alerts on multiple devices, including laptops, cell phones and other devices. The list of persons to be notified would be managed through a web-based management interface; this interface would also allow authorized users to prioritize notifications over other uses of the wireless infrastructure without disruption. The notifications will not be using the frequency bands assigned to public safety agencies. The wireless infrastructure in development will use 5+ GHz backhaul devices with Wi-Fi for the distribution..Through 'edgeware', emergency response and community notification will be able to share select information and distribute multimedia information according to defined protocols.

This will improve the capability to create interconnections of disparate systems for emergency response and support services between police, fire, emergency services providers and the community.

### 5.1 Proposed Method

The objective behind our data gathering is to understand the roles of information and technology in response to emergencies as well as the influence of the response on the subsequent work of government agencies, private organizations and citizens. At this stage we see value in the case study approach. Our design methods are based on end-user interviews with Emergency Services and Law enforcement personnel at the front line and administrative levels, research on tactics, training and observation. Our participants include public officials, service providers, community leaders as well as residents from the specific neighborhoods. Interviews will be conducted in a similar manner as described by Harrison et al. [44]. The interviews would be semi-structured, open ended and not exceeding two hours. The focus of the interviews is on information-related responses to emergencies with special attention to data needs and resources during the response period; social factors; use of wireless grids in the response; inter-organizational relationships during the response period; the effect of pre-existing resources, plans, or programs on the ability to respond; and the effect of rules and laws on the ability to respond.

## 6. Discussion

Having the capability to create ad-hoc networks at incident sites that incorporate voice, messaging, graphics, and video means command and control personnel will have much richer information resources to use for decision making and

coordination [45]. The atmosphere required to provide ICT based support for improvisation is one that facilitates emergent interoperability: "a structured approach to real-time mixing and matching of diverse ICTs to support individuals and organizations in undertaking response activities" [17]. Common devices such as cell phones also provide information processing support as many integrate text and multimedia capabilities. These platform dependent technologies can be integrated with more sophisticated technologies, such as sensor networks or other devices through 'edgware' services such as the wireless grid.

An identified issue that needs to be resolved is how to manage the problem of having access to systems or services but not being able to translate or navigate to the needed data, information or action. Resolving differences in how material and personnel resources are identified and described is a problem separate from gaining physical access or control. Ontologies can help improve our understanding of other systems here. The U.S. Federal Emergency Management Agency (FEMA) is working to address this through its promotion of standardized ontologies of conceptual mappings for resources [17].

Information overload has been identified as a problem for emergency responders [46]. The capabilities afforded through wireless grids will make even more information available in these cases, contributing to that aspect of the problem. Having the ability to filter and create hierarchical or rule based controls for information access will mitigate the overload and at the same time provide richer and more current information flows to those who need it most.

Soon there are likely to be even more robust communication-based collaborative tools developed that would critically filter out nonessential or duplicate information while placing emphasis on vital information intelligently [17]. In this way new support systems and a greater amount of information will enhance and not impede operational processes.

## 7. Conclusions

Much research still needs to be done on information interoperability especially within the context of emergency response systems.

The 'edgware' solution allows for cooperation and resource sharing to occur in the existing blended environment. Going forward, systems can grow and even change platforms but will retain their functionality and interoperability by having this intermediary service. The capability that wireless

grids provide will foster testing of new and varied solutions in emergency services. Many of the identified barriers to entry and the degree of potential risk that must be taken to implement a new technology is reduced because options can be tried in the present operating environment and if successful it can be continued. New potential solutions can be implemented with the most successful ones being identified, refined and continued.

The neighborhood notification systems described is only the first iteration of an entirely new approach to solving the emergency response problem that has stymied many well-meaning public agencies. Rather than create a standard for emergency response we propose to create a standard for overlaying available devices and networks into a grid. These "gridlets" are created voluntarily by community residents, emergency responders and others to serve their own needs. This community grid, once established, can bring significant expansion in the number and variety of devices and networks available to assist in emergency response, is for those residents secondary to their improved ability to look after themselves and each other in the routine emergencies any community can face on a daily basis. Following the initial design, evaluation, and results that support 'interoperability by edgware', an emergency response 'do it yourself' developer toolkit may be made available to bring these solutions together. Over time these user created solutions could be shared across communities to address similar scenarios. There is no one magic solution but a multitude of focused solutions that can interoperate and be adapted as necessary.

The goal of this project is to help people help themselves. Emergency services applications of wireless grids can empower citizens through their devices to contribute to their own community response. We assert that police, fire, EMS, hospitals, municipal services, utilities, gas companies, media, and community residents will benefit from enhanced information sharing in emergencies based on interoperability by new wireless grids 'edgware'.

## 8. Acknowledgements

The development of the WGiT has been primarily funded by the National Science Foundation (NSF) under (NSF #0227879) 2002-2006 and will be continued under (NSF # 0917973) 2009 -2011. We are grateful for the continued support by all our collaborators and partners

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