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A Wearable Personal Healthcare and Emergency Information Based On Mobile Application

Sanjay S Bhadoria*[1] and Hitesh Gupta[2]

*[1,2]*Dept. of Software System, Patel College of Science and Technology, Bhopal, India*

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Abstract – Mobile computing makes it possible to achieve system of personal healthcare and emergency alert and tracking which can monitor personal health status in a real-time manner and automatically issue the alert for medical aids in case of emergency by tracking user's location correctly. With the development of the technologies such as mobile computing, distributed computing and wireless sensor network, it is possible to provide the elderly with healthcare services that can monitor the elderly anytime anywhere. This paper presents a review on mobile based health monitoring systems. It also discusses the desirable properties of a good mobile health care system as well as few existing health care applications are also briefly described.

Key Words- Wireless Sensor Networks, GSM, AMON, LAN, MobiHealth

I. INTRODUCTION

Recently, innovations in mobile communications and low-cost of wireless biosensors have paved the way for development of mobile healthcare applications that provide a convenient, safe and constant way of monitoring of vital signs of patients. A key in the provision of mobile healthcare services is the issue of using technological innovation to support continuous monitoring of patient conditions, providing a degree of self-diagnosis and enabling effective real-time decision making to reduce fatalities.

As mobile devices have become an inseparable part of our life, it can integrate health care more seamlessly to our everyday life. It enables the delivery of accurate medical information anytime anywhere by means of mobile devices. Recent technological advances in sensors, low-power integrated circuits, and wireless communications have enabled the design of low-cost, miniature, lightweight and intelligent bio-sensor nodes. These nodes, capable of sensing, processing, and communicating one or more vital signs, can be seamlessly integrated into wireless personal or body area networks for mobile health monitoring. The potential for pervasive computing is evident in almost every aspect of our lives including the hospital, emergency and critical situations, industry, education, or the hostile battlefield. The use of this technology in the field of health and wellness is known as *pervasive health care*. The integration of mobile computing to pervasive health care is termed as mobile health care.

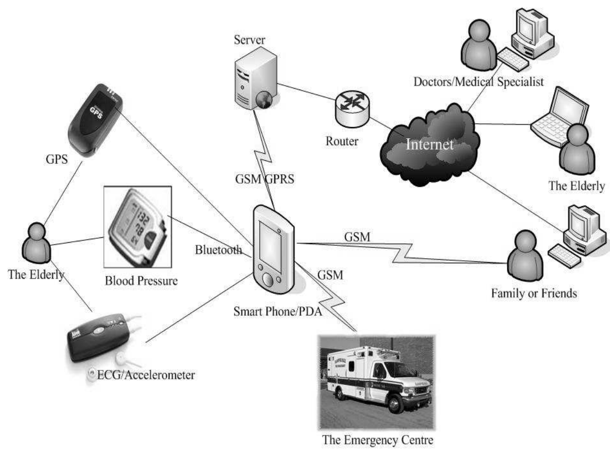

Fig.1. Typical Architecture of Mobile Health Care Systems

Typical architecture of mobile health care system is shown in Fig.1. The system used four parts. The first one is devices, including different body-sensors and other medical devices. Second part is smart phone that plays a main role in mobile health care as an intermediary. It receives physiological data from sensors, processes them and transmits them to the server. Smart phone monitors the physiological data received from sensors and automatically sends alerts to emergency centre, family and friends of the

Corresponding Author: *Sanjay S Bhadoria* elderly when detecting an emergency. In addition, it also designs unique auxiliary functions as a life assistant. The server is the third one that acts as the personal health information system. In the meanwhile, it also plays the role of the medical guidance which can offer the real-time medical guidance for users. The last part contains the emergency centre that will receive alarm messages via GSM protocol and call an ambulance to the location of the subject in the emergency status.

II. TYPES OF HEALTH MONITORING SYSTEMS

Real-time health monitoring systems constantly transfer health data in real time. These systems allow immediate response in case of emergency, but have high communication and energy costs. The constant surveillance may feel intrusive to some patients. *Store-and-forward health monitoring systems* record health data and transfer it only at regular intervals. These are more efficient for data collecting but are limited in terms of emergency handling. Privacy is still an issue, as still complete data is transferred. Some store-and-forward systems process the data on a home PC to reduce the amount of data sent, which makes the systems less intrusive, as only data relevant for the affliction is transmitted. Still, emergencies cannot be detected promptly. Other store-and-forward systems process the data on a mobile device instead of a fixed PC. As the mobile device can always be connected to the body health sensors, this enables real time emergency detection. This approach may retain privacy if the data is reduced sufficiently.

In order to take care of patient, the mobile health care system must know the answers of following questions:

- *Which diseases are more critical for potential users, and how the monitoring system could be useful to control the implications?*
- *Which vital signs should be controlled for each disease?*
- *Which sensors should be selected to collect the most valuable data without negative implications for users?*
- *How should data be analyzed to realize compromised state?*
- *How should the system react in a critical situation?*

The default answers to few of the above questions are already feed in the system but answers to the remaining questions must be feed while deploying the system. Based on these answers, the system acts and reacts to the situations.

III. RELATED WORK

The first projects that introduced the mobile health monitoring is presented in [4], MobiHealth project is a health service platform based on a mobile phone as a base station for the wireless sensors worn on the body. It forwards their measurements wirelessly using UMTS or GPRS to a service centre, it provides three services: collecting and storage of the received data, forwarding of data to a doctor or medical centre, and analysis of the data received and the sending of feedbacks to a predefined destination using SMS.

Choi et al. [7] proposed a system for ubiquitous health monitoring in the Bedroom via a Bluetooth Network and Wireless LAN, the system uses Bluetooth and wireless LAN technologies, information gathered from sensors connected to the patient's bed is transmitted to a monitoring station outside of the room where the data is processed and analyzed. Using the technologies of wireless body area networks (WBAN), Jovanov et al. [6] presented a Wearable health systems using WBAN for patient monitoring. The first level consists of physiological sensors, second level is the personal server, and the third level is the health care servers and related services.

Another example is the WiMoCA from Farella et al. [5] that is a custom-made WBSN where the sensing node consists of a triaxial integrated MEMS (micro-electro-mechanical system) accelerometer. The WiMoCa system's ability has to handle diverse application requirements such as posture detection system, bio-feedback application, and gait analysis. Morón et al. [12] presented a mobile monitoring system, which can provide medical feedback to the patients through mobile devices based on the biomedical and environmental data collected by deployed sensors, sensors compiles information about patient’s location and health status. These data are encrypted to be sent to a server through the mobile communications networks, the system provides access to patient’s data, even from a smart phone by a J2ME application.

Dai et al. [17] designed a wireless physiological multi-parameter monitoring system based on mobile communication networks; this system monitors vital signs such as ECG, SP02, body temperature and respiration. Data is transmitted via mobile communications networks to a mobile monitoring station and then to the hospitals central management system where, again, the data must be reviewed and interpreted by a physician or other medical personnel. Lee et al. [9] presented a ubiquitous monitoring system using the ZigBee protocol to wirelessly transmit patient sensor data so that it may be monitored at a local health station. This sensor data is then transmitted through the internet to a local monitoring station where it is processed and analyzed by a reasoning server.

Rodriguez et al [8] have made a classification which divides the solutions into three groups. The first group records signals and takes action off-line. The second group has the feature that systems perform remote real-time processing. The last group provides local real-time processing, with taking into account the level of mobility. The Holter device that records patients' ECG for 24 to 48 hours is analyzed afterwards by doctors. Therefore, Holter belongs to the group one. The drawback of Holter devices are their deficiency in offering real-time monitoring and no immediate action when the accident occurs. In order to overcome the restriction, many systems and devices are developed. Vitaphone commercializes a card that can transmit ECG data to a mobile phone. The mobile phone automatically transmits ECG data to the service center where ECG data are analyzed [13]. Similarly, Cardio Control [3], MediSense [15] and MobHealth project are all included in the group two, using mobile phone/PDA to get physiological signals and sending signals to other devices in which physiological signals are remote real-time monitored.

Besides, MORF is also one respective application of the second group. It uses mobile phone as an intermediary to get vital data from various sensors and transmit data to the server which processes the data [11]. However, the above applications still present certain limitations related to the fact that the analysis is not performed in the place where the signal is acquired. There may be a loss of efficiency in the wireless network when physiological signals are sent. Compared with the group two, the third group performs the local real-time monitoring in order to detect some anomalies and send alert to a control center or a hospital.

Wu et al [19] proposes a wearable personal healthcare and emergency aid system called WAITER. It employs tiny wearable sensors to continuously collect users' vital signals and uses Bluetooth devices to transmit the sensory data to a mobile phone, which can perform on-site vital data storage and processing. After local data processing, the mobile phone can periodically report users' health status to the healthcare centre via its GSM module and issue alert for medical aids when detecting the emergency. But it only develops one relatively static monitoring system in which the status is set statically and doctors are called when mobile phone send alert messages. It is not sufficient in real-time and dynamic monitoring.

Prognosis [1] is a physiological data fusion model of wearable health-monitoring system for people at risk which contains decision support system and finite-state machine. It can estimate users' health status and offer corresponding alerts.

IV. USER EXPERIENCE WITH MOBILE HEALTH CARE SYSTEMS

In a survey in Australia, 70 low and medium risk cardiac patients, aged 22 to 90 years old used the PHM system at a Sydney Hospital (Cardiology Department). The patients were given a heart monitor and a mobile phone to monitor and record their cardiac rhythm for a few weeks in their normal environment. The trial already demonstrated that the detection of important cardiac arrhythmias is feasible using the PHM system compared to conventional Holter monitors. The ECG signal quality is in the majority of cases of sufficient quality for a cardiologist to make an assessment. Patients were able to record their cardiac rhythm when they feel something and the PHM records automatically if it detects an abnormal rhythm. "Catching" an arrhythmia event greatly improves satisfaction for those patients for whom nothing showed up on an ECG taken by the cardiologist. Most patients had no difficulty using a mobile phone and ECG sensor and the PHM application is straightforward to use. All patients who had used a Holter monitor found the PHM far less intrusive and more practical. Patients leading an active life appreciated the fact no one could see they were wearing sensors and being monitored.

Another survey carried out in Europe, revealed that Technical failures (such as system instability and loss of network connectivity), sub-optimal interface design and a difficult (re)start sequence understandably cause irritation and confusion to users. Notwithstanding some such technical problems in the first generation prototypes the utility of the mobile health monitoring service was acknowledged by all classes of user: professionals and patients, who agreed that 'a stable commercial product would be very useful'. Adding the *telemedicine* dimension with feedback from the remote therapist further improves clinical outcomes related to pain and disability. Patients reacted positively to a feature allowing them to view their bio signals in real time on the MBU and quickly learnt to 'read' the displays and use them to improve relaxation [3].

V. DESIRABLE PROPERTIES OF A MOBILE HEALTH CARE SYSTEM

There are few properties, which are desirable in a commercial mobile health care system and can affect the overall acceptability of the system.

- Non-Disturbing: The system should work silently without disturbing the patient or any one else in the vicinity. Generally patients do not like to let others know that they are ill and are being monitored. Also the graphical user interface should not interfere the normal user-mobile interaction.
- Lightweight and Portable: It should not be a heavy application otherwise the performance of underlying mobile or tablet may degrade considerably. Generally Real-time health monitoring systems require more processing and thus they are not suitable for slow devices.
- Data Privacy and Security: The privacy and security of patient's data is a major concern and should never be overlooked. Standard encryption techniques should be employed.
- Reliable: The system should have a very low failure rate. Also it should contain a failure detection system so that whenever the system fails, it should inform the user about its failure.
- Robustness: The system should be able to send the data in its correct form to the server even if certain well defined failure occurs. Also if the failure is temporary then the system should recover itself.

VI. FEW EXISTING COMMERCIAL SYSTEMS

In this section, we will review some of the well documented and implemented leading commercial and academic efforts in development of mobile medical care. Some of the applications are field research, while others are actual commercial products and some are advanced research projects that use mobile health sensors as a tool.

- AID-N: Advanced Health and Disaster Aid Network (AID-N) [13] is developed at The Johns Hopkins University Applied Physics Laboratory. The system facilitates communication between health providers at disaster scene, medical professionals at local hospitals, and specialists available for consultation from distant facilities. The system comprises three separate tiers: mote wristband with finger sensor, a tablet PC and a medical center. A wearable mote (MICAZ) attached to the patient's wrist sense and record vital signs into an electronic patient record database. In addition to several sensors the mote contains an electronic triage tag which allows the medic to set triage color (red/yellow/green) of the patient. It replaces the paper triage tags that are commonly used by medic today to prioritize the patients. The mote forms an ad-hoc wireless network with the first responder's portable tablet PC. The system is capable of measuring HR, BP, SpO2, body temperature, patient's activity and indoor/outdoor location. GPS provides geo-location and the indoor detection system (based on the MoteTrack project developed at Harvard Univ.) provides location where the GPS signals are unreachable. Although during the research some difficulties with sensors instrumentation design have been reported, the system can be useful for medics for patient monitoring and tracking in case of emergency situation.
- AMON: AMON [7] is the advanced care and alert portable tele-medical MONitor project financed by the EU FP5 IST program. It is a wearable (wrist-worn) medical monitoring and alert system that targets high-risk cardiac/respiratory patients. The system comprises two separate parts: a wrist-worn unit (WWU) and a stationary unit at telemedicine center (TMC). AMON provides continuous collection and evaluation of multiple vital signs, online analysis with emergency detection via a rule-based approach with well defined heuristics and a cellular connection to the TMC. It features a flexible communication channel that can use a direct connection as well as short message system (SMS) services. In the event of a failure to initiate communication with the TMC, for noncritical situations the data can be stored (up to 4 days) on device and send when communication is restored, and the user is informed appropriately. The AMON system is capable of measuring BP, SpO2, one lead ECG and activity recognition, all in a single device. The authors carried out medical trials on 33 patients that highlighted some problems with the prototype but also validated the feasibility of the concepts and solutions adopted by the project.
- CodeBlue: CodeBlue [14] is a wireless infrastructure intended to provide common protocol and software

framework in a disaster response scenario. The architecture was developed at Harvard University which allows wireless monitoring and tracking of patients and first responders. The system integrates low-power wireless wearable vital sign sensors, handheld computers and location tracking tags. The CodeBlue software framework provides protocols for resource naming and discovery; publish/subscribe multi-hop routing, authentication and encryption provisions. It also offers services for credential establishment and handoff, location tracking, and in-network filtering and aggregation of sensor-produced data. A simple query interface allows emergency medical technicians (EMT) to request data from groups of patients.

- HealthGear: HealthGear [4] is designed as real-time wearable system for constant monitoring, visualizing and analyzing the user's SpO2, HR, plethysmographic signals and location information available in the cell phone. It was developed at Microsoft Research which consists of a set of non-invasive biosensors wirelessly connected via Bluetooth to a cell phone which stores, transmits and analyze the physiological data and presents it to the user. There are mainly three parts in the system: Sensing module, Oximeter and a cell phone. The sensing module comprises DSP unit, Bluetooth module and batteries. The central processing unit in the system is an Audiovox SMT5600 GSM cell phone, running Microsoft Windows Mobile 2003 OS. Health Gear is implemented as a Windows Mobile application, with all its modules (sensor data reception, analysis, display and storage) running simultaneously in real-time on the cell phone. The current implementation includes an Oximeter, but the system architecture allows for any number of sensors of heterogeneous nature. The system was tested on subjects with sleep apnea. For automatic detection of sleep apnea events, two algorithms were developed. The first algorithm 'Multithreshold time analysis' operates in the time domain, while the second 'Spectral analysis' operates in the frequency domain. The authors reported the results from a sleep study on 20 participants, which validated the feasibility of the concepts and solutions adopted by the project.
- LifeShirt: The LifeShirt [8] System by VivoMetrics [23] is a miniaturized, ambulatory version of an in-patient system. The system consists of the LifeShirt garment, data recorder, VivoLogic analysis and reporting software. The LifeShirt is a lightweight, easy to use shirt with embedded sensors. To measure respiratory function, sensors are woven into the shirt around the patient's chest and abdomen. A single channel ECG measures heart rate, and a three-axis accelerometer records patient posture and activity level. It also correlates data collected by optional peripheral devices that measure blood pressure, blood oxygen saturation, EEG, EOG, periodic leg movement, core body temperature, skin temperature, end tidal CO2, and cough. The LifeShirt has been used in clinical trials and research. It is available as a commercial prescription medical device.
- M-health: M-health [24] integrates mobile computing, medical sensor, and communication technologies for mobile health applications. Wireless Body Area Network (WBAN) of intelligent sensors represents an emerging technology for system integration with great potential for unobtrusive ambulatory health monitoring. The lowest level of data flow hierarchy of m-health consist of intelligent physiological sensors integrated into WBAN for example, ECGs, EMGs, EEGs, motion sensors, etc called as sensor node (SN). All messages from SN are collected by network controller (NC) and processed on personal server (PS). A personal server application can run on a PDA, cell phone or home personal computer. Typically all messages from SN are saved and retransmitted to the medical server (MS). Communication between PS and internet gateway is accomplished using standard WLAN and WAN technologies, GSM/GPRS, UMTS and other wireless local and wide area network technologies.
- MobiHealth: The MobiHealth [25] is a European Union project aims to provide continuous monitoring of patients outside the hospital environment. MobiHealth targets the introduction of new mobile value added services in the area of health, based on 2.5/3 G GSM/GPRS/UMTS technologies. They propose on integration of sensors and actuators, to a wireless BAN. MobiHealth targets improving the quality of life of patients by enabling new value added services in the areas of disease prevention, disease diagnosis, remote assistance, clinical research, physical state monitoring (sports) and even clinical research. The goal of the MobiHealth project was to test the ability of 2.5/3G infrastructures to support value added healthcare services. For this a number of trials were organized spanning four European countries (Netherlands, Spain, Germany and Sweden) and covering a range of conditions like pregnancy, trauma, cardiology,

rheumatoid arthritis and respiratory insufficiency. The analysis of results from these trials revealed technical issues related to UMTS networks performance. The most important issues reported are the restricted available data bandwidth for uplinks, delay variation, delays in transmission and handovers.

- UbiMon: UbiMon [26] is part of the UbiCare [27] centre, which is funded by the Department of Trade and Industry's (DTI) Next Wave research initiative in the UK. Ubi-Mon aims to provide a continuous and unobtrusive monitoring system for patient in order to capture transient but life threatening events. With the current Ubi-Mon structure, a number of biosensors including 3-lead ECG, 2-lead ECG strip, SpO2, sensors have been developed. To facilitate the incorporation of context information, context sensors including accelerometer, temperature, skin conductance and humidity are also integrated in BSN node. The system comprises of five major components namely, the BSN nodes, the local processing unit (LPU), the central server (CS), the patient database (PD) and the workstation (WS). Apart from local processing LPU - a PDA device - it also serves as the router between the BSN node and the central server. The sensor data is collected and transmitted to CS via WiFi/GPRS network for long term storage and trend analysis.

VII. CONCLUSION

Many patients can benefit from continuous monitoring as part of a diagnostic procedure, optimal maintenance of a chronic condition or during supervised recovery from an acute event or surgical procedure. Mobile health care systems have great potential for continuous monitoring in ambulatory settings, early detection of abnormal conditions and, supervised rehabilitation.

They can provide patients with increased confidence and a better quality life. They also promote healthy behavior and health awareness. To achieve the level of robustness required for medical telemetry, significant research must be undertaken to design communication protocols, efficient energy-management schemes, and encryption algorithms. Tools and principles for selecting the right hardware components for specific applications would be desirable. Software support for the mobile sensors needs more research and is still at an early stage. In addition to these technical issues, economics of operating a mobile healthcare system also need to be analyzed carefully to ensure emergency and preventive healthcare monitoring is affordable to all levels of society.

REFERENCES

[1] A. Pantelopoulos, N. G. Bourbakis, "Prognosis - A Wearable Health-Monitoring System for People at Risk: Methodology and Modeling," IEEE Transactions on Information Technology in Biomedicine, Vol.14, No.3, 2010.

[2] Abderrahim Bourouis,Mohamed Feham and Abdelhamid Bouchachia, "Ubiquitous Mobile Health Monitoring System For Elderly (Umhmse)," International Journal of Computer Science & Information Technology, Vol.3, No.3, Jun.2011, pp.74–82.

[3] Cardio Control. http://www.cardiocontrol.com/cardio.htm.

[4] D Konstantas , A Van Halteren1,R Bults , K Wac , V Jones , I Widya and R Herzog, "Mobihealth Ambulant Patient Monitoring Over Public Wireless Networks," Mediterranean Conference on Medical and Biological Engineering MEDICON, 2004.

[5] E. Farella, A. Pieracci , D. Brunelli , L. Benini , B. Ricco and A. Acquaviva, "Design and implementation of WiMoCA node for a body area wireless sensor network," in Proceedings of the 2005 Systems communications, 2005, pp.342-347.

[6] E. Jovanov , A. Milenkovic, C. Otto and P. C. De Groen, "A wireless body area network of intelligent motionsensors for computer assisted physical rehabilitation," Journal of NeuroEngineering and Rehabilitation, 2005, Vol.2.

[7] J. M. Choi, B. H. Choi, J. W. Seo ,R. H. Sohn, M. S. Ryu and W. Yi,A, "System for Ubiquitous Health Monitoring in the Bedroom via a Bluetooth Network and Wireless LAN". The 26th Annual International Conference of the IEEE EMBS, San Fransisco, CA, USA: Engineering in Medicine and Biology Society, Vol.2, 2004, pp.3362-3365.

[8] J. Rodriguez, A. Goni, and A. Illarramendi, "Real-Time Classification of ECGs on a PDA," IEEE Transactions on Information Technology in Biomedicine, Vol.9, 2005, pp.23-34.

[9] J. W. Lee and J. Y. Jung, "ZigBee Device Design and Implementation for Context-Aware UHealthcare System," The IEEE 2nd International Conference on Systems and Networks

Communications, Cap Esterel, French Riviera, 2007, IEEE Computer Society, pp.22.

[10] Johannes Barnickel, Hakan Karahan and Ulrike Meyer, “Security and Privacy for Mobile Electronic Health Monitoring and Recording Systems,” IEEE International Symposium on a World of Wireless Mobile and Multimedia Networks, 14-17 Jun.2010, pp.1–6.

[11] L. Docksteader and R. Benlamri, “MORF: A Mobile Health-Monitoring Platform,” IT Professional, Vol.12, 2010, pp.18–25.

[12] M. J. Morón ,J. R. Luque , A. A. Botella , E. J. Cuberos ,E. Casilari and A. Diaz-Estrella, “A Smart Phone-based Personal Area Network for Remote Monitoring of Biosignals,” 4th International Workshop on Wearable and Implantable Body Sensor Networks (BSN 2007) IFMBE Proceedings, 2007, Vol.13, pp.116-121.

[13] N. Daja, I. Relin, and B. Reljin, “Telemonitoring in cardiology-ECG transmission through mobile phones,” J.Annals Academy Studenica, Vol.4, 2001, pp.63-66.

[14] Prajakta Kulkarni and Yusuf Ozturk, “Requirements and Design Spaces of Mobile Medical Care,” Mobile Computing and Communications Review, Vol.11, No.3, Jul.2007, pp.12-30.

[15] R. C. Hawkins, “Evaluation of Roche Accu-Chek Go and Medisense Optium blood glucose meters,” Clin Chim Acta 353, 2005, pp.127-131.

[16] Rifat Shahriyar, Md. Faizul Bari, Gourab Kundu, Sheikh Iqbal Ahamed and Md. Mostofa Akbar, “Intelligent Mobile Health Monitoring System (IMHMS),” Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, Springer, Vol.27, 2010, pp.5-12.

[17] S. Dai and Y. Zhang, ”Wireless Physiological Multi-parameter Monitoring System Based on Mobile Communication Networks,” 19th IEEE Symposium on Computer-Based Medical Systems Based on Mobile Communication Networks, Washington, DC, USA: IEEE Computer Soceity, 2006, pp.473-478.

[18] Shahram Jalaliniya, Thomas Pederson, “A wearable kids' health monitoring system on smartphone,” In 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design, 2012, pp.791-792.

[19] W. Wu, J. Cao, Y. Zheng, and Y. Zheng, “WAITER: A wearable personal healthcare and emergency aid system,” IEEE International Conference on Pervasive Computing and Communications, 2008.

[20] Ziyu Lv, Feng Xia, Guowei Wu, Lin Yao, Zhikui Chen, “iCare: A Mobile Health Monitoring System for the Elderly,” IEEE/ACM International Conference on Green Computing and Communications, 18-20 Dec.2010, pp.699 –705.

