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Development of a Context-Aware Publish/Subscribe Information System for Public Health Service Delivery

Awokola J.A. (Corresponding Author)
Department of Computer Science and Engineering,
Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria.
E-Mail: rhgonline@gmail.com Tel: +2348069019894

Emuoyibofarhe O.J.
Department of Computer Science and Engineering,
Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria.
E-Mail: eojustice@gmail.com Tel: +2348033850075

Awokola B.I.
Department Of Family Medicine, Obafemi Awolowo University Teaching Hospitals Complex,
Wesley Guild Hospital Unit, Ilesa, Osun State, Nigeria
E-Mail: tundeawokola@yahoo.com Tel: +2348069117354

Alamu F.O.
Department of Computer Science and Information Technology,
Bowen University, Iwo, Osun State, Nigeria.
E-Mail: femialamu@gmail.com Tel: +2348034905719

Awokola E.O.
Department Of Computer Science, University of Ibadan,
Ibadan, Oyo State, Nigeria
E-Mail: enduranceawokola@yahoo.com Tel: +2348064923512

Akomolafe O.P.
Department of Computer Science and Engineering,
University of Ibadan, Ibadan, Oyo State, Nigeria.
E-Mail: akomspatrick@yahoo.com Tel: +2348030848696

Abstract
Publish/Subscribe is a messaging paradigm where senders (publishers) of messages are not programmed to send their messages to specific receivers (subscribers). Rather, published messages are characterized into classes, without knowledge of what (if any) subscribers there may be. Subscribers express interest in one or more classes, and only receive messages that are of interest, without knowledge of what (if any) publishers there are. This paradigm helps to solve the problem of data redundancy, ensuring that only the required information gets to the end user. Public health is concerned more with improving the health of a population through prevention rather than healing individual patients. This is why the dissemination of relevant information on healthcare is a vital key to achieving the cardinal objective of Public Health.
At present, most Public health information systems are largely dependent on the Internet. This however poses a serious challenge in developing nations where occurrence of major diseases are high and the cost of internet is also high as well. In this paper, a Context-Aware model for Public health Service delivery was developed and implemented via a Publish/Subscribe Information System. The implementation was done on the .NET Platform. The eGranary was incorporated into the model to eliminate the cost of Internet. A mobile Subscriber module was also developed to enable users with mobile devices access the system.

Keywords: Context, Context-Awareness, Publish/Subscribe, Service, Public Health

1.0 Introduction

Public health is the science and art of preventing disease, prolonging life and promoting health through the organized efforts and informed choices of society, organizations, public and private, communities and individuals. While Medicine is concerned with individual patients, Public health regards the community as its patients, trying to improve the health of the population. Thus, Medicine focuses on healing patients who are ill while Public Health focuses on prevention of illness. In a bid to make this happen, Public Health agencies and practitioners all over the world are always involved with the collection, assembling, analysis and dissemination of relevant information on the health of the population .(Heymann,2008). Common public health programs include; Immunization, Rural and Urban Clinics, Disease Tracking and Epidemiology, Sanitation and Pollution Control, Medical Research and Public Education Campaigns.
Publish/Subscribe is a messaging paradigm where senders (publishers) of messages are not programmed to send their messages to specific receivers (subscribers). Rather, published messages are characterized into classes, without knowledge of what (if any) subscribers there may be (Baldoni et. al, 2003). Subscribers express interest in one or more classes, and only receive messages that are of interest, without knowledge of what (if any) publishers there are. This decoupling of publishers and subscribers can allow for greater scalability and a more dynamic network topology. In the publish/subscribe model, subscribers typically receive only a subset of the total messages published. The process of selecting messages for reception

and processing is called filtering. There are two common forms of filtering: topic-based and content-based. Figure 1 below shows a typical Publish/Subscribe scenario where subscriptions to topics control the message reaching each subscriber.

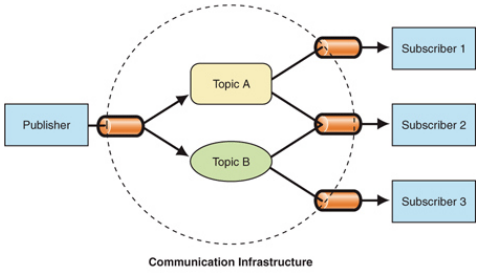

Fig. 1: A publish/subscribe scenario (Source: Lauri et.al, 2007)

Publish/Subscribe systems are usually patterned after three distinct models; Peer-to-Peer Model, Broker (Mediator Model) and Implicit Model (Eugster et al, 2003). Each of these models has their uniqueness and as such are applied based on how suitable they will be to the system at hand.

2.0 Information Systems

An Information System (IS) is any combination of information technology and people's activities using that technology to support operations, management, and decision-making (O'Brien, 2003). Silver et al. (1995) provided two views on Information Systems that includes software, hardware, data, people, and procedures. A second managerial view includes people, business processes, and Information Systems. There are various types of information systems, for example: transaction processing systems, office systems, decision support systems, knowledge management systems, database management systems, and office information systems.

In computer security, an information system is described by the following components:

- Repositories, which hold data permanently or temporarily, such as buffers, RAM hard disks, cache, etc. Often data stored in repositories is managed through a database management system.
- Interfaces, which support the interaction between humans and computers, such as keyboards, speakers, scanners, printers, etc.
- Channels, which connect repositories, such as routers, cables, etc.

3.0 Related Works

The following are examples of other works related to that which is being reported in this paper.

3.1 Management Information System (MIS) for Public Health

The MIS was developed in 1999 by Wang et al to automate the daily activities carried out by the members' of EPHEN (European Public Health and Environment Network). The existing System at the EPHEN prior to this time was based a traditional system of storing information in file cabinets. Thus, the new system has the following functions; Personal email system (which was independent of the existing one and is to used for only work related purposes), View and enter new timesheet rows, Security, Changing Passwords and setting reminders, Customer details, Mail Merge, Employee details, Skill details, Grade details, Different access levels for different members and Paper Generation. Figure 2 below shows the data flow diagram of the system.

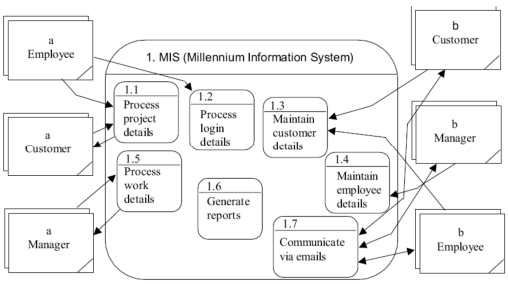

Fig. 2: Data Flow diagram for MIS (Source: Frank et. al, 2001)

However, a critical analysis of the MIS reveals certain drawbacks associated with it;

1. The MIS is only available for use to members of EPHEN. Non-members (who represent a huge percentage of the country's population) cannot benefit from this system. This places a great limitation on its impact in enhancing the health of population (which happens to be Public Health's key goal)

2. The design of the MIS does not factor in the issue of mobility which happens to be a current global reality (i.e. the system does not run on or support the mobile platform). These drawbacks leave a void for improvement upon this already built system.

3.2 Rwandan HIV/AIDS Information System

As reported by Donner in 2004, the US Centre for Disease Control in conjunction with the Rwandan Treatment and Research AIDS Centre (TRAC) in 2004 embarked on funding a pilot project to build an HIV/AIDS information System for Rwanda. This system is being built and deployed by Voxiva, Inc.(which has currently opened an office in Abuja, Nigeria), in partnership with the Centre for Global Health and Economic Development at Columbia University. Research shows that at the time this system was being developed, an estimated 8% to 14% of Rwanda's population was living with HIV or AIDS. Users with a PC and Internet can interact with the system and its database though a secure website. In the meantime, users

(generally in the rural areas) without a PC can add information to the system as well as request information through the use of any telephone, since the system uses menu trees and voice prompts to routinize standard data entry and queries. This unique combination of an internet and voice-based maximizes the amount of connectivity and information transfer possible given the levels of connectivity available in Rwanda (Donner, 2003).

When a caregiver or administrator in a rural hospital wants to use the system, he or she calls a special toll-free number on her mobile, and enters her clinic number, her ID number, and a PIN number. Then, the user can follow voice prompts to do the following; add weekly information on drug supplies, add monthly information on patient enrolment, check on the current or historical test results for her patients and send special alerts, either as text options "do you have any drug shortages? If so, press 1..." or as a voicemail, which can then be sent to her supervisors and/or her peers. Finally, the user can pick up or send voicemail messages. The simplicity and ease-of-use of these voicemail and voice prompt systems is critical to the overall usability of the system for caregivers without a lot of training in information technologies.

4.0 Software Model

The Model used in this work is a modification of an existing model called SANPARKS (Publish/Subscribe Architectural Framework for the South African National Parks) which was developed in 2006 by Linda et al. Figure 3 shows the conceptual framework for SANPARKS. The SANPARKS framework provides relevant information such as: plant information, animal information and the information about service providers and other such information that will help the tourist in the park. SANPARKS employs a broker based Model, and the information filter is topic based.

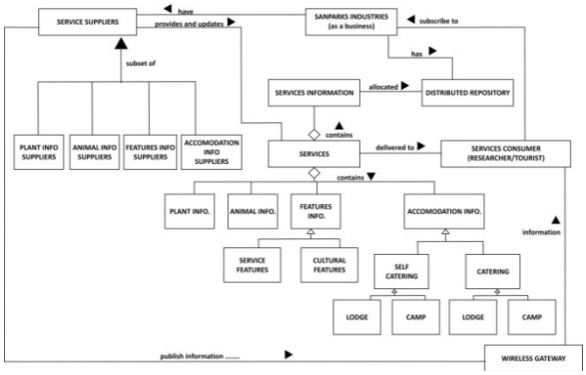

Fig. 3: Conceptual Model for SANPARKS Source: Linda et al (2006)

However, the model used in this paper differs from SANPARKS in the following ways;

1.) The model is a hybrid of both the implicit and the broker models of Publish/Subscribe systems.
2.) The information filter is extended to combine both topic-based and content-based filtering.
3.) The model has a context-awareness module.
4.) The e-Granary has been included into the model to serve as the database server.

The model is also extended to serve mobile users. The context awareness module is based on existing architectures. It is the hybrid of the service oriented architecture named omnipresent and the CATIS architecture developed at North Western University by Ariel in 2005. An additional component has been integrated into the system, which is the Mobile Network operator. The reason for this is that other mobile devices that are not GPS enabled should be able to use the application.

5.0 Applications Development

The development phase of this work was carried out using developmental tools in the .NET Framework (especially C# as the major programming language). Four applications were developed and deployed to enhance the working of the entire system. They include;

- The Server Application - This application is what resides on the server terminal that enables all the other components interact with each other.
- The Publisher Application – This application is what is installed on the publishers end to enable it connect to the server so as to publish information to it for interested Subscribers
- The Subscriber Application – This application is enables the subscriber to connect to and subscribe to interested information topics on the server, and have it published to them.
- The Mobile Subscriber Application – This enables a mobile user function as a subscriber on the mobile platform.

Figures 4 and 5 show the Model and the architecture for the context awareness module. Figures 6, 7 and 8 show the flowchart, Use-Case diagram and Activity diagrams for the entire system components.

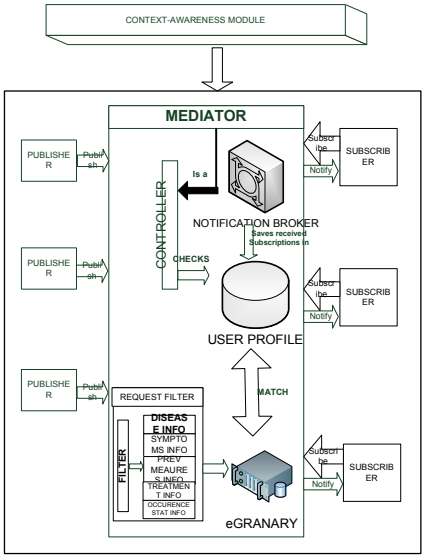

Fig. 4 – The Model for the entire system.

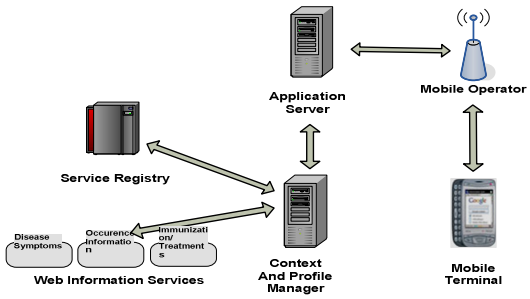

Fig. 5 – The Architecture for the context-awareness module

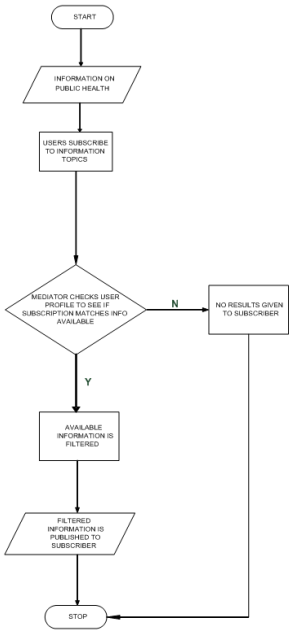

Fig. 6 – Flowchart for the system

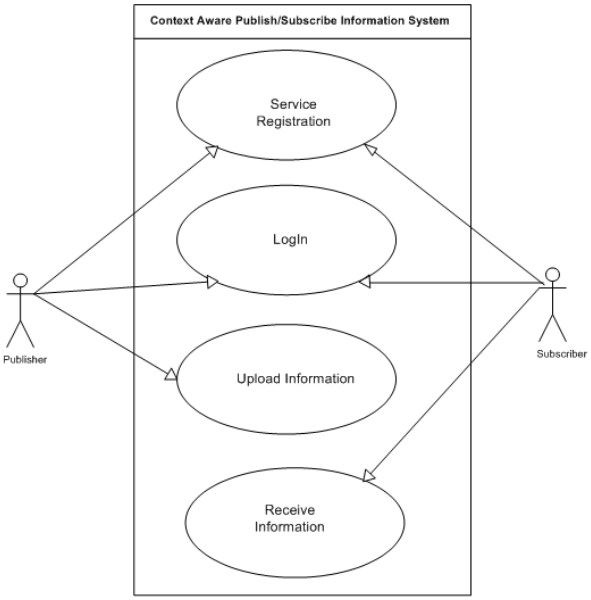

Fig. 7 – Use-case diagram for the System

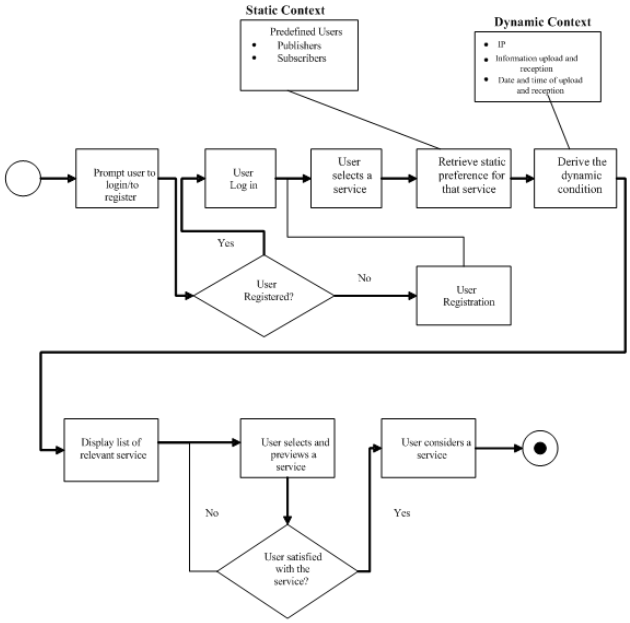

Fig. 8 – Activity diagram for the System

6.0 Result and Discussion

After all the developed applications have been installed on the various terminals, the system is now ready for use. The server application enables Publishers and Subscribers to register so that they can be authenticated from their ends. Figures 9, 10, 11 and 12 show the operations of the server application. The Server application also has a facility that makes it possible to view all registered publisher and subscribers at any given point in time.

Fig. 9 – Logging into the Server Application

Fig. 10 – The Server Application Environment

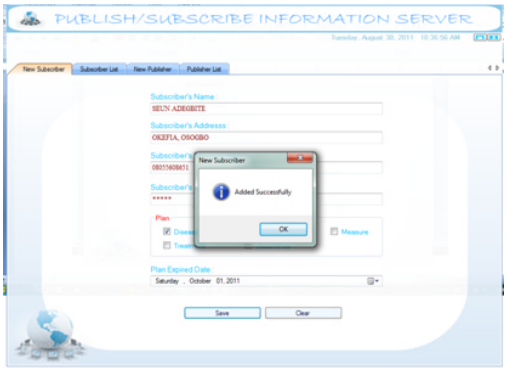

Fig. 11 –Registration of a New Subscriber

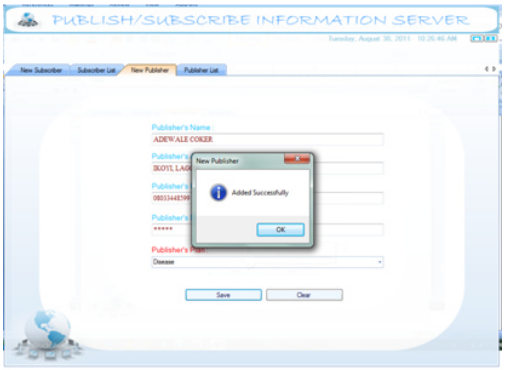

Fig. 12 –Registration of a New Publisher

The moment both Publishers and Subscribers are successfully registered on the Server, they can now (with the help of the installed applications) access their respective Services registered for. Figures 13 to 16 below shows

the operation of a Publisher and a Subscriber after successfully installing the Publisher and Subscriber Applications on their end.

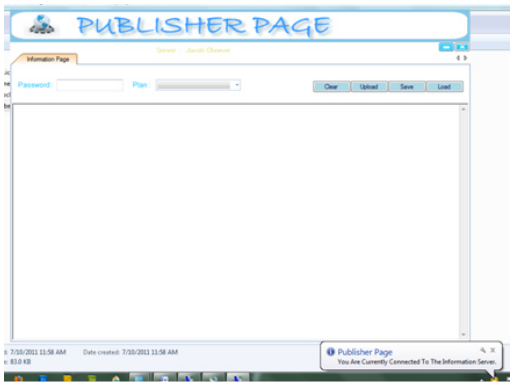

Fig. 13 –Publisher page showing connection to the Server

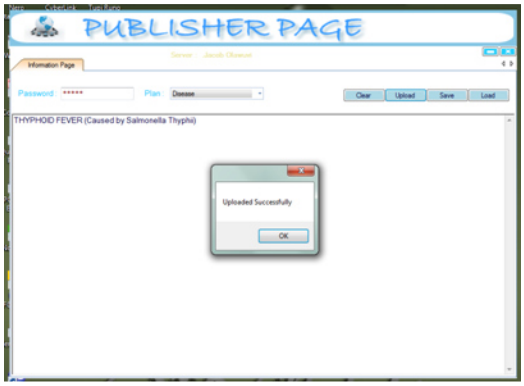

Fig. 14 –Publishing information to the Server

Fig. 15 –Subscriber Page showing connection to the Server

Fig. 16 –Subscriber Page showing messages received by the Subscriber.

The Mobile Subscriber is also not left out. In this work, an emulator was used to demonstrate the Mobile Subscriber's features. The Mobile Subscriber application (like all the other applications) is installed and launched so that the user can use it just like the Subscriber. Figures 17 to 19 capture how the mobile Subscriber works.

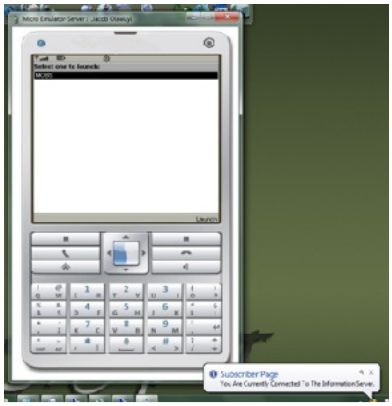

Fig. 17 – Mobile Subscriber Interface showing connection to the Server.

Fig. 18 – Logging into the Mobile Subscriber Environment after launching the application

Fig. 19 – Mobile Subscriber Interface Showing messages received.

7.0 Conclusion and Recommendations

This paper reports the implementation of a context aware Publish/Subscribe information system for Public Health Service delivery. The server (as well as the other systems) is designed to run on a windows operating system with .NET framework. This implies that the applications can run on operating systems used by most computer users. Given the constant increase in the development of Information and Communication Technology (ICT) as well as constant innovations in Mobile technologies, there arises a need to continue to harness both as tools for delivering qualitative healthcare related Services. Hence we make the following recommendations;

- More research effort should be targeted at ensuring that quality Smart Phones (which have the capacity for driving a lot of useful and relevant applications to healthcare) are more affordable and available in developing nations.
- Research should be carried out in ensuring that there is increase in the amount of reliable communication networks that can power more healthcare related information Services.

8.0 References

Ariel P. (2005), *Mobile Web Services*; Cambridge University Press, UK.

Baldoni R.M., Contenti B and Virgillito A. (2003). "*The Evolution of Publish/Subscribe Communication Systems." Future Directions of Distributed Computing*. Springer Verlag LNCS Vol. 2584.

Beynon-Davies P. (2009). The 'language' of informatics: the nature of information systems. International Journal of Information Management. 29(2). 92-103

Black R, Cousens S, Johnson H.L, Lawn J.E, Rudan I and Bassani D.G (2010). Global, regional, and national causes of child mortality in 2008: a systematic analysis. *The Lancet* ;375:1969-87.

Braa, J. O. R. and Hedberg, C. (2002). The Struggle for District-Based Health Information Systems in South Africa. *The Information Society, 18*(2), 113 - 127.

Brandt A.M. and Gardner M. (2000). '*Antagonism and Accommodation: Interpreting the Relationship between Public Health and Medicine in the United States During the Twentieth Century'*, American Journal of Public Health 90:707 – 715.

Dey A. K and Abowd G.D (1999), Towards a Better Understanding of Context and Context- Awareness, Proceedings of 1st International Symposium on Handheld and Ubiquitous Computing, vol. 1707, pp. 304–307, Karlsruhe ,Germany.

Dey A. K (2000), Providing Architectural Support for Building Context-Aware Applications, Ph.D. dissertation, Georgia Institute of Technology, November.

Donner, J. (2003). What Mobile Phones Mean to Rwandan Entrepreneurs. In K. Nyíri (Ed.), *Mobile Democracy: Essays on Society, Self and Politics* (pp. 393-410). Budapest, Hungary: Passagen Verlag.

Donner, J. (2004). Inventions in Mobile-Based Public Health Information System in the Developing World; An example from Rwanda. *Mobile Technology and Health; Benefits and Risks: Workshop discussion*. Udine, Italy.

Edward, K. (1995). *Software testing in the real world*: improving the process, ACM Press, Reading.

Eugster P., Felber P.A., Guerraoui R. and Kermarrec A. (2003). The many faces of Publish/Subscribe. *ACM Computing Surveys, 35(2): 114–131*

Encyclopedia Britannica (Standard Edition ed.). Chicago: *Encyclopedia Britannica, Inc.. 2007.*

Fee A. and Acheson J. (1991), *A History of education in public health: Health that mocks the doctors' rules*, OUP.

Ferscha A., (2002) Context-aware: Bridging Physical and Virtual Worlds, Proceedings of the 7th International Conference on Reliable Software Technologies, ADA-EUROPE 2002, June 17–21, Vienna

Frank W., Na Helian F. and Narayana J., (2002). A Management Information System for Public Health. *Proceedings of ECIS, IEEE Press, pages 1454 – 1464.*

Galliers, R.D., Markus, M.L. and Newell, S. (2006). *Exploring Information Systems Research Approaches.* New York, NY: Routledge.

Happner M., Burridge R. and Sharma R. (1998). Java Message Service. Sun Microsystems Inc.

Heeks, R. (2002). Information Systems and Developing Countries: Failure, Success, and Local Improvisations. *The Information Society, 18*(2), 101-112.
Hevner A., March F., Park H. and Ram P. (2004): Design Science in Information Systems Research. *MIS* Quarterly, *28(1), 75-105.*
Heymann D.L. (2008). *Control of Communicable Diseases Manual*. Washington, D.C.: American Public Health Association.
Hohpe G. and Woolf B. (2004). *Enterprise Integration Patterns: Designing, Building and Deploying Messaging Solutions*. Addison-Wesley.
Laudon K.C. and Laudon, J.P (1988). Management Information Systems, (2nd edition), Macmillan.
Lauri I. W., David M. E. and Bacon J. (2007) Encryption-Enforced Access Control in Dynamic Multi-Domain Publish/Subscribe Networks. Proceedings of the International Conference on Distributed Event-Based Systems (DEBS'07), pages 104 - 115. ACM Press.
Linda M.B., Adigun M.O and Emuoyibofarhe O.J., (2006). 'Personalization in a design of Mobile Publish/Subscribe Architectural Framework for South African National Parks'. *Proceedings of the 10th IASTED International Conference on Software Engineering and Applications, Dallas Texas pp 300 - 306.*
Mapeis S., Altherr M. and Erzberger M. (1999). iBus - A Software Bus Middleware for the Java Platform. International Workshop on Reliable Middleware Systems pages 43-53.
O'Brien, J A. (2003). Introduction to information systems: essentials for the e-business enterprise. McGraw-Hill, Boston, MA.
Oki B., Pfluegel M., Siegel A. and Skeen D. (1993). "The Information Bus - Architecture for Extensive Distributed Systems." *Proceedings of the 1993 ACM Symposium on Operating Systems Principles.*
Pascoe J, Ryan N, and Morse D (1999), Issues in Developing Context-Aware Computing, Proceedings of the 1st International Symposium on Handheld and Ubiquitous Computing, Karlsruhe, Germany, pp. 208–221.
Patel E., Kant T., Rushefsky M., Mark E., McFarlane R. and Deborah R (2005). *The Politics of Public Health in the United States*, M.E. Sharpe, p. 91. (ISBN 076561135X).
Qusay H.M., (2001). MobiAgent: A Mobile Agent-based Approach to Wireless Information Systems, Proceedings of the 3rd International Bi-Conference Workshop on Agent-Oriented Information Systems, Montreal, Canada.
Schilit N, Adams N, and Want R (1994), Context-Aware Computing Applications, Proc. of IEEE Workshop on Mobile Computing Systems and Applications, Santa Cruz, CA, December , pp. 85–90.
Silver M., Mark S., Lynne M. and Cynthia M.B. (1995). The Information Technology Interaction Model: A Foundation for the MBA Core Course, *MIS Quarterly*, Vol. 19, No. 3, Special Issue on IS Curricula and Pedagogy, pp. 361-390.
Steve, G. (1996). Information Systems Design, Thomson Computer Press, London.
URL http://wikipedia.org/ (URL accessed on 24/02/2010).
URL http://widernet.org/ (URL accessed on 05/04/2010).
URL http://publichealth.org/ (URL accessed on 20/02/2010).
White, K. L. (1991). Healing the schism: Epidemiology, Medicine and the public's health. New York: Springer-Verlag.
Wilkinson R. and Marmot M. (2003), '*The Solid Facts: Social Determinants of Health'*. New York: Springer-Verlag.