Application of Nanotechnology to Networking and Telecommunication Domain

[Hugh Naval]

Abstract

This descriptive study will be carried out to identify the key problems and approaches in the adoption of nanotechnology in wireless communication devices. These include risks, costs, problems of transformation, implementation issues, design issues, remedies, and other management issues associated with each strategy. The basic information will be obtained from the related literature found on school supplies and magazines in public libraries, university libraries, online libraries and books. The survey data will be collected through questionnaires and background a research tool. Data collected will be from representatives involved in nanotechnology and wireless communications. It is expected that the main problems identified three strategies to provide information for those who wish to adopt nanotechnology in wireless communication devices. Because the wireless communication devices are widely used by all social groups of society in all countries, the results of this research can be collective and equal benefit of the end users of wireless nanotechnology. Although nanotechnology applications have recently increased, nanotechnology applications are still relatively new compared to semiconductor technology.

Table of Contents

Application of Nanotechnology to Networking and Telecommunication Domain

Introduction

Nanotechnology is the science of creating computer components and other structures measuring 100 nanometers or less (a nanometer is one-billionth of a meter) (Maguire, 2002). Designers of current wireless systems are interested in nanotechnology because nanotechnology has allowed the production and development of very small integrated circuits, or chips (Maguire, 2002). These chips have been incorporated into the development of very small batteries, small hard disks, small memory chips, and small processors, which are key ingredients of wireless communication devices such as cell phones, PDAs (Appendix A), modems, and network computers (Batmax, 2005). Although wireless devices are primarily produced by the miniaturization of existing semiconductor technology, the semiconductor technology has many limitations. Moore's Law (Moore, 1965) has stated that the transistor density on integrated circuits doubles every 24 months, resulting in increased performance and decreased cost. However, due to the current dominant technology and current manufacturing processes, such as lithography technologies, there is a lower limit to the miniaturization, which can hamper the future growth of wireless devices (Blyler, 2003).

The use of nanotechnology will allow building the wireless components one atom at a time, and components to be extremely small in size. Space in a wireless device has been a major constraint. Nanotechnology will allow more effective use of that space especially with respect to storage and power (Schulte, 2005). Appendix A contains the list of abbreviations used through the dissertation and Appendix B contains the nanotechnology related glossary of terms.

The scope of the dissertation encompasses the identification and analysis of key issues, strategies, and problems that are associated with the adoption of nanotechnology in wireless communication devices. A concomitant objective of the research will be to identify and define the methods used to resolve the anticipated and actual problems that may arise while implementing the strategies. In summary, the study will be designed to identify advantages and disadvantages, as well as the lessons learned from the various strategies used to resolve the key issues and problems associated with the introduction of nanotechnology in the wireless business environment.

Statement of the Problem

Many issues and problems are encountered while transitioning to nanotechnology from an older existing technology (Minoli, 2006). Key issues and strategies for the adoption of nanotechnology in wireless communications devices have been identified and characterized in this research study. The methodology that will be used in this research is qualitative, the design is descriptive, and it will be executed via survey research and analysis. The population used in the research will comprise of representatives of corporations, government agencies, and academic institutions involved in research and/or projects in wireless communications and nanotechnology within the United States.

Research Questions

The associated research questions are:

1. What are the key issues that should be considered by leaders and managers working for wireless companies to plan for the transition from semiconductor based wireless products to nanotechnology based wireless communication products?
2. What are the key impediments to the successful introduction of nanotechnology in the wireless industry?
3. What are the vital few strategies that the leaders of wireless industries are using to address the key impediments?

4. What are the key lessons learned that should be reviewed and possibly implemented by the leaders and managers in the wireless industry who will be future adaptors of nanotechnology?
5. What are the main problems that occur while deploying these strategies for the transition to nanotechnology from other technologies in wireless products?
6. How does the leadership of wireless companies address the problems that occur while deploying the strategies?

Literature Review

Technical Background for Nanotechnology and Wireless Communications

This section reviews literature that provides a technical background for nanotechnology and wireless communication devices. Some of the topics that will be discussed in the sections below are nanofibers, RF, MEMs, nanotribology, nanometer, nanostructures, QCA, nanowidget, nanotubes, nanostructures, nanocrystals, nanopositioning, nanoprobes, WLAN, LAN, WAP, and nanodrives. Appendix A and Appendix B provide definitions of these terms. The applications of nanotechnology and wireless in civil engineering were discussed by Fortner (2000). In particular, the paper had high resolution photographs providing an insight into the smart bolts. Fortner stated that buildings and bridges were being fitted with nanotechnology based wireless fiberoptic monitoring devices, wireless transportation systems were being designed to increase speed and efficiency, and materials were being developed using nanotechnology to enhance the performance of structures. The new technologies were claimed to provide benefits by making infrastructure last longer, perform more efficiently, and cost less to build and maintain. Microelectromechanical systems could result in hundreds or millions of sensors smaller than today's computer chips being embedded in structures (Fortner, 2000).

These sensors could then relay messages via wireless technology and the Internet about the performance of a bridge or building. The smart bolt was both a structural component and a sensor. Similar types of designs have been investigated by Gehl (2000), who investigated similar nanotechnology applications in the fields of science and engineering. These applications included designs related to nanotechnology and wireless communications. Wireless devices are being used extensively in various companies. Wines (1996) stated that wireless portable, battery-powered computers, and devices such as PDAs have helped speed up and streamline operations at a number of companies. Nanotechnology can help resolve many existing problems in various aspects of these wireless devices related to component size and energy consumption. One such example was discussed by Doherty (2002), where nanotechnology was identified for its potential in building computerized climate control systems by its use in new operating systems and invisible connections. Krashinsky and Balakrishnan (2002) discussed another problem that can be resolved by using nanotechnology. On many battery-powered mobile computing devices, the wireless network connection when the device was idle was found to be a significant contributor to the total energy consumption. Krashinsky and Balakrishnan also investigated the interaction between energy-saving protocols and TCP (Appendix A) performance for Web-like transfers.

Effects on the Wireless Businesses Effects on the Wireless Businesses

Wireless was being touted as the next big wave, according to Ellermann (2002). He concluded that creating a good overall business strategy was the most important step towards a successful wireless venture. The various steps of the strategy include creating a roadmap, using caution, and evaluation of the existing systems and technologies. Similar steps need to be used for nanotechnology. Hemblen (2002) discussed the growing popularity of wearable computers and communication devices, the role of nanotechnology in the enhancement of wearables, projected growth on wireless wearable computing and communication devices by 2006-2011, social issues limiting wearable technologies, and projects involving wearable computing and communication devices. Salamanca (2005) discussed 10 nanotechnology applications that the third world experts said would have the most impact on developing nations. One of the applications was wireless communications. These impacts would be commercial, legal, and social in nature.

Shapera (2000) discussed the miniaturization of computers, information on a small scale, rearranging a hundred tiny atoms, the shrinking semiconductor technology such as the basis of Moore's Law and semiconductors, the manufacturing of semiconductors, the effects and future of nanotechnology, and their effects on wireless telecommunications technology. Both researchers discussed the implementation of nanotechnology in creating tiny computers and components embedded in wireless communication devices. Karoub (2001) discussed the effect of miniature technology or nanotechnology on the future of the mobile and wireless business. He stated that technology, such as radio frequency MEMs, was attracting the attention of the wireless industry because the technology could boost performance, reliability, and function while driving down size - and eventually cost. The solutions to some of the problems posed by system-on-a-chip (SOC) technology, which is driven by nanometer-process technologies, have been provided by Wang (2000). OC design technologies were expected to deal with the growing needs in the wireless, communications, and multimedia market segments. The author stipulated the problems incurred due to the growing convergence of digital, memory, and analog elements in high-integration SOCs. Crowcroft (2001) discussed nanotechnology and novel modulation techniques, as well as the deployment of 4th or 5th generation wireless networks, which would allow the disposal of external devices altogether. Crowcroft also stated that computers would change drastically in the next few years, including pervasive high bandwidth and low frequency wireless communications.

Blyler (2003) explained the basics of nanotechnology and the possible impacts on the wireless business due to the introduction of nanotechnology in the production of wireless devices. The author concluded that nanotechnology may be the up and coming next generation technology that might replace semiconductor technology. Wolinsky (2003) discussed various aspects of nanotechnology, including its use to develop new wireless chips. These chips could be used in smart phones that, for example, could identify the location of the closest grocery store. The need for government agencies to anticipate emerging technological issues related to nanotechnology and other scientific discoveries was discussed by Rejeski (2003). Subsequently, an anonymous author wrote a paper in the Issues in Science and Technology magazine (2004) that discussed an event that occurred on December 3. President Bush signed a bill that would authorize the spending of almost $3.7 billion on nanotechnology research and development in five agencies over four years. The 21st Century Nanotechnology Research and Development Act passed the House and Senate during the week of November 17, 2004. This level of funding sent out a positive message to the people in the marketplace that nanotechnology and its applications, including wireless communication devices, are here to stay. Mann (2004) discussed the political implications related to the (then) latest research in the field of nanotechnology, especially regarding international communities and trade organizations. The political implications were tightly coupled with ethical assurances. These issues could be the cause of the dip, as discovered by Rejeski and Stuart (2005) in the government's pool of research and development money allocated to nanotechnology initiatives. As cited in Sullivan (2005), researchers at Deloitte Touche Tohmatsu predicted that digital crime and online security threats would skyrocket in 2005 as a result of the rapid growth in portable Internet and mobile technology. Furthermore, Sullivan posited that the technology industry would see a boom in the development of nanotechnology and fuel-cell batteries. However, Forman (2005) discussed the effects of globalization and outsourcing on the business of nanotechnology. He stated that nanotechnology might be as impacted as any other technology. The outsourcing may have an effect on wireless communication device manufacturers as well.

Maguire (2002) stated that computer makers, in particular, see advantages in the technology of miniaturization, which enables development of chips that are not only smaller, but also faster and cheaper. However, Blyler (2003) stated that chip manufacturers are struggling to develop nanoscale (Appendix B) products using current manufacturing processes and lithography technologies. The problem stated by Blyler is only one of the many problems that could be encountered during transition to nanotechnology from the semiconductor technology.

Tianrong (2001) has described the strategy in his business plan along with a commitment for providing industrial customers with nanomaterials (Appendix B) and application-processing solutions to help them lower costs, improve processing, and strengthen the value-added products. Tianrong stated in the plan that the company will work together with the clients as their partner to help them to obtain and maintain a long-term competitive advantage. Ziegler and Stan (2002) have suggested a design methodology to accompany the concept that circuits composed of mixed silicon semiconductors and nanoelectronics (Appendix B) could provide a means for gradually switching technology paradigms from semiconductor technologies to nanoelectronic solutions.

Tianrong (2001) and Ziegler and Stan (2002) have provided detailed information for adopting nanotechnology in electronics, which may be used in wireless communication devices.

Methodology

The research methodology for the dissertation is qualitative and the design is descriptive. The anticipated design will first focus on acquiring the richest possible data related to the adoption strategies of nanotechnology in wireless businesses. The qualitative methodology and descriptive design helps avoid external controls over the various factors governing the research such as differential selection procedures. The descriptive data required for the dissertation will be collected from a predefined sample set, resulting from the use of a survey instrument (Appendix C) and background questionnaire (Appendix D), focus groups, and formal and informal interviews. The qualitative data will be collected from a predefined sample set using nondirective interviewing, interviewing as dialog, and informally interviewing focus groups (Boeree, 2006).

The current dissertation requires the use of the qualitative methodology and descriptive design. The design will be used to address both the identification and analysis of key issues and problems that are associated with the adoption of nanotechnology in wireless communication devices. A key research objective is to identify and study the strategies that are employed to resolve the problems and issues that arise while managing a program whose main goal is to facilitate the successful adoption of nanotechnology in the design and production of wireless communication devices. The dissertation study is primarily focused on defining, characterizing, and comparing the different classes of transitional strategies. The dissertation study requires the primary use of the qualitative methodology and descriptive design, which includes the use of both observations and augmented responses from the background questionnaire, the survey instrument, and formal and informal interviews.

Operational Definition of Constructs and Key Variables

Measure of Risk. This variable will be used in the dissertation to measure the risk involved in implementing the technology transition from the existing technology to nanotechnology. The different components of risk, such as revenue risk, business risk, operating leverage, financial leverage, and the total risk will be investigated for their utility in developing a general metric.

Nanotechnology Implementation Strategy. Implementation strategies used by the leaders of wireless companies to transition to nanotechnology (Schulte, 2005).

Remedial Measures. The activities will be undertaken by the leaders of organizations to address either key nanotechnology adoption and/or nanotechnology strategy implementation issues.

Transition Strategy. The strategy selected by an organization to guide its transition from semiconductor-based technology to nanotechnology-based technology.

Technology Transition Cost. The specific costs incurred by a wireless business in making the transition to nanotechnology, such as labor costs to build new systems, set up new processes, and provide training; other costs for buying new technology, software, and tools; and cost associated with replacing the existing technology (Bessen, 2001).

Selection of Participants

The research study will be limited to the adoption of nanotechnology in wireless communication devices. The group of targeted participants in the research will be limited to government organizations and departments involved in nanotechnology and wireless communications, that is, companies, academic institutions, ventures, and people involved in nanotechnology and wireless communications in the USA, Europe and India. The research methodology, analysis of data, and conclusions will rely heavily on the accuracy of the input from the participants who completed the surveys as well as the accuracy of the input from the representatives who will participate in the interview and focus groups.

Discussion of Data Analysis

Microsoft Excel™ will be used for summarizing and analyzing most of the statistical data and creating tables and other statistical representations deemed useful for addressing the research questions. The data from the background questionnaire will be entered into Microsoft Excel™. These data will be divided into six categories – corporate nanotechnology, corporate wireless, government, individual, venture capitalist/investor, and academic/university.

The survey will be distributed to the set of representative organizations. Narrative space is available for answering descriptive questions and special notes. The responses to the survey will be counted. The types of nanofabrication strategies will be used for the adoption and implementation of nanotechnology in wireless communication devices will be identified from the information collected via interviews. The survey responses will be were categorized based on the type of strategy using the answers to the descriptive section of the survey. Graphical representation of the data will be deemed unnecessary because the information in the table categorized by the type of strategy was sufficient to interpret the data leading to objective conclusions.

Ethical Assurances

Nanotechnology can lead to the world's biggest breakthroughs and at the same time could produce the world's most devastating problems. Nanotechnology is demonstrating promising developments in many areas and may benefit both the general health and welfare (Gordijn, 2005). However, we should be aware of possible unwanted side effects. Nanotechnology means new materials and components, which can be included in many different existing products or enable new products. Applications include sustainable energy, healthcare, cars, information and communication, and household products. The main concern is currently the health and environmental impact of small nanoparticles (Appendix B). Risk research is ongoing (Gordijn, 2005). Also, in the public debate, long-term scenarios and science fiction including nanorobots play a role, as well as ethical and social aspects of priorities in research such as military applications and the nanodivide (Appendix B) between haves and have-nots (Daly, 2005). The political debate on regulating nanotechnology is just the beginning.

Optimistic and positive thinkers, visionaries, and scientists seem to think that nanotechnology will help resolve many of the world's most significant problems, such as eliminating hunger in the world and finding cures to various diseases thereby increasing the human life span (Gordijn, 2005). Pessimistic and negative thinkers envision the worst-case scenarios that may arise from nanotechnology, such as disruption of societies and cultures and apocalyptic destruction of the earth as depicted in Michael Crichton's book Prey (Crichton, 2002).

Research Expectations

The objective of the research is to identify key issues and strategies for the adoption of nanotechnology in wireless communication devices which included risks, transformational strategies, implementation issues, technology limitations, and other associated management problems. The key issues and strategies identified in the research are expected to provide insights to those who are attempting to adopt nanotechnology in wireless communication devices. Because wireless communications devices are extensively used by all social factions of society in all countries, the results of the research study could also be collectively and equitably beneficial to the ultimate users of wireless nanotechnology.

References

Batmax. (2005, January 27). Nanotechnology brings world's first battery life extender for mobile phones. Retrieved from, http://physorg.com/news2852.htmI

Bessen, J. (2001, October). Technology transition costs and productivity growth: The transition to information technology. Retrieved from, http://researchoninnovation.org/qadopt.pdf

Blyler, J. (2003, March). Nanotechnology plans its entry into wireless. Wireless Systems Design. Retrieved from http://www.wsdmag.com/Articles/ArticlelD/6572/6572.html

Blyler, J. (2003, March). Nanotechnology plans its entry into wireless. Wireless Systems Design. Retrieved from http://www.wsdmag.com/Articles/ArticlelD/6572/6572.html

Boeree, G. (2006). Qualitative methods workbook. Retrieved from http://www.ship.edu/~cgboeree/qualmeth.html

Brant, R. (2005). Inference for proportions: Comparing two independent samples. Retrieved from http://www.health.ucalgary.ca/~rollin/stats/ssize/b2.html

Crowcroft, J. (2001, March). Never lost, never forgotten. Communications of the Association of Computing Machinery, 44(3), 81.

Doherty, P. (2002, July). The future of controls is wireless and small. Heating/Piping/Air Conditioning Engineering, 74(7), 40-2.

Ellermann, T. (2002, May). Rehearsing your high wireless act. The Journal of Business Strategy, 23(3), 11-12.

Forman, D. (2005, April). Globalization alters manufacturers' rules. Small Times, 5(3).

Fortner, B. (2000, July). On the cutting edge. Civil Engineering, 70(7), 44.

Gehl, J. (2000, July). Nanotechnology: Designs for the future. Ubiquity, 1(20), 1.

Gordijn, B. (2005). Nanoethics. Retrieved from http://portal.unesco.org/shs/fr/file_download.php/7c19013ff6599f7bfd12e38868a1fbcaNanoethics.pdf

Institute of Nanotechnology. (2004). The effect of nanotechnology on wireless communications. Retrieved from http://www.azonano.com/details.asp?ArticlelD=909

Karoub, J. (2001, August 2). Small Tech is poised to pounce on the mobile, wireless future. Small Times. Retrieved from http://www.smalltimes.com/print_doc.cfm?doc_id=1829

Krashinsky, R., & Balakrishnan, H. (2002). Minimizing energy for wireless Webaccess with bounded slowdown. Proceedings of the 8th Annual International Conference on Mobile Computing and Networking, Atlanta, Georgia, USA, 119-130.

Maguire, J. (2002, September 9). HP researchers claim nanotech breakthrough. Newsfactor. Retrieved on March 10, 2004, from http://www.newsfactor.com/perl/story/19343.Html

Mann, C. (2004, August). Near term nanotech. Technology Review, 707(6), 22.

Minoli, D. (2006). Nanotechnology applications to telecommunications and networking. Indianapolis, IN: Wiley.

Rejeski, D. (2003, December). Making policy in a Moore's Law world. Ubiquity, 4(42), 1.

Salamanca-Buentello, F. (June, 2005). Taking nano to the needy. Small Times, 5(4).

Schulte, J. (August, 2005). Nanotechnology: Global strategies, industry trends and applications. New York: Wiley.

Shapera, T. (2000, December). Understanding semiconductors: The heart of the information revolution. The Quill, 88(10), 21-4.

Sullivan, B. (2005, January 20). Deloitte: Tech future includes cybercrime, nanotechnology. Computerworld. Retrieved from http://www.comDuterworld.eom/mobiletoDics/mobile/storv/Q. 10801.99097.00.html

Tianrong, L. (2001, September). Business plan. Shanxi four high nanotechnology. Retrieved from http://www.fhnm.com/english/jhs.htm

Wang, S. (2000. October 23). Convergence in nanometer SOCs threatens a design crisis system-on-a-chip. Electronic News, 46(43), 40-44.

Wines, L. (1996, January). Taking technology in hand. The Journal of Business Strategy, 17(1), 36.

Wolinsky, H. (2003, April 22). Small revolution coming in business world. Chicago Sun-Times, 50.

Ziegler, M., & Stan, M. (2002). A case for CMOS/nano co-design. Proceedings of the 2002 IEEE/ACM International Conference on Computer Aided Design, San Jose, California, 348-352. New York: ACM Press.

Appendix A

List of Abbreviations

ACM	Association of Computing Machinery
CASRO	Council of American Survey Research Organizations
CEO	Chief executive officer
CMOS	Complementary metal oxide semiconductor
CRT	Cathode ray tube
CTO	Chief technology officer
EC	European Commission
ECOC	European Conference on Optical Communication
EEEL	Electronics and electrical engineering laboratory
Ga	Gallium
HP	Hewlett Packard
HTTP	Hyper text transfer protocol
IEEE	Institute of Electronics and Electrical Engineers
IMEC	International Micro and Nano-electronics Center
J2ME	Java 2 Micro Edition
LAN	Local area network
LCD	Liquid crystal display
M4	Multi-mode multi-media
M-commerce	Mobile commerce
MEMs	Micro-electro-mechanical systems
MIDP	Mobile information device profile
MIT	Massachusetts Institute of Technology
MRAM	Magnetic random access memory

NASA	National Aero-Space Association
NCI	National Cancer Institute
NEM	Nano-electro-mechanical systems
NIST	National Institute of Science and Technology
NRAM	Nanotechnology-based, high-density, non-volatile random access memory chip
PCS	Personal cellular system
PDA	Personal data assistance
PLC	Programmable logic controller
QCA	Quantum cellular automata
R&D	Research and development
RF	Radio frequency
RFIC	Radio frequency integrated circuit
Si	Silicon
SIGCOMM	ACM's professional forum for discussing computer-related topics
SiGe	Silicon germanium
SOC	System on a chip
TCP	Transfer communication protocol
VC	Venture capitalist
WAP	Wireless application protocol
WiFi	Wireless fidelity
WLAN	Wireless local area network