MALIGNANT SPAGHETTI

A Symposium on Wireless Technologies in Hospital Health Care

Friday
November 14, 2008
9 a.m. to 5 p.m.

Polytechnic Institute of New York University
The Dibner Library Building
Five MetroTech Center
Brooklyn, NY

Presented by The Wireless Internet Center for Advanced Technology (WICAT), The Center for Advanced Technology in Telecommunications (CATT) and The Othmer Institute for Interdisciplinary Studies.

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NEW YORK UNIVERSITY

9:00 AM
Welcome

Erich Kunhardt
Provost, Polytechnic Institute of New York University

Kurt Becker
Associate Provost for Research and Technology Initiatives
Polytechnic Institute of New York University

9:15 AM
Role of Wireless Technologies in the Hospital

Presenter: Marc Bloom, Clinical Associate Professor, Director of Neuroanethesiology Program, Director of Perioperative Technology, Department of Anesthesiology, New York University

Abstract: Why wireless? There MUST be a better way. The Problems: Many independent devices, massive disparate, non-standard data, potential for RFI and ground loops, lack of interconnectivity, tethering, trip hazards. In anesthesia, interconnectivity is key and many people must interact. Potential solutions include applications (patient tracking, doctor tracking, equipment tracking, drug tracking, device status reporting, device interconnectivity, device data integration into EMR) and technologies (RFID, smart pumps, smarter alarms, wireless sensors, implanted devices, telemetry (ECG, glucose, BP, pO2) and data access (handheld, tablets, COWs). The presentation focuses on the benefits of wireless in this environment (improved patient safety, improved patient flow and throughput, improved workflow, process improvements, measurable results, disaster and failure recovery, and procedure tracking and billing), challenges (infant technologies, lack of standards, proprietary protocols, lack of infrastructure, lack of MONEY) and novel solutions (wearable transducers, body networks, implantable RFID and real-time data mining/decision support).

Bio: Marc J. Bloom, MD, PhD, is currently the Director of the Neuroanesthesia Program at New York University School of Medicine. Prior to this position, Dr. Bloom has held previous appointments as Director of Neuroanesthesia and Neurophysiology Programs at New York University School of Medicine, Clinical Associate Professor of Anesthesiology and New York University School of Medicine, Assistant Professor of Anesthesiology and Director of Neuroanesthia at the University of Pittsburgh School of Medicine, and Assistant Professor of Anesthesiology at the University of Pennsylvania School of Medicine.

He has earned four degrees at the University of Pennsylvania: a BA in Natural Sciences, a BSE in Electrical Engineering, a MD, and a PhD in Bioengineering. He is a Fellow of the American Society of Neurophysiologic Monitoring (ASNM). He has held society board or office positions at the ASNM as President and serves on the Executive Board, the SCCPMA as Executive Board member and Past President, and is an Executive board member of the ESCTAIC. He is also active in numerous professional societies; has authored and co-authored significant technical papers, books and chapters; and is a reviewer on the editorial boards of many industry and technology publications.

9:45 AM
Operating Room of the Future

Presenter: Julian M. Goldman, Director, Medical Device "Plug and Play" Interoperability Program, Massachusetts General Hospital, Harvard Medical School

Abstract: Traditional operating rooms are inefficient and overcrowded. Patient data are not integrated and displayed to caregivers in a timely fashion, and turnover time between cases is lengthy.

Technologies designed to impact procedural medicine are often introduced in isolation, usually failing to improve efficiency and safety, or reduce costs. Devices are often haphazardly introduced into a technologically complex environment. Integrating high-technology components, however, is not sufficient to achieve the goal of better patient care; teamwork and communication in a high-tech environment is equally essential.

To address many of these problems, Dr. Goldman's talk explores new technology platforms and systems of care for performing minimally invasive surgical procedures. Accurate data capture and analysis, multidisciplinary teamwork, and thoughtful integration of technology are the building blocks in this environment that optimizes patient safety and comfort, staff satisfaction, and financial efficiency.

Bio: Julian M. Goldman, MD is Director of the Program on Interoperability at CIMIT (Center for Integration of Medicine and Innovative Technology), a principal anesthesiologist in the Massachusetts General Hospital "Operating Room of the Future", a Physician Advisor to Partners HealthCare Biomedical Engineering at the Massachusetts General Hospital, and Director of the Medical Device "Plug-and-Play" (MD PnP) Interoperability Program.

Dr. Goldman founded the MD PnP Program at the Massachusetts General Hospital in 2004 to enable innovation in patient safety and clinical care by leading the adoption of "plug-and-play" patient-centric medical device integration solutions. The MD PnP program team was the recipient of the 2007 CIMIT Edward M. Kennedy Award for Health Care Innovation.

Dr. Goldman received his Medical Doctorate from SUNY Downstate Medical Center in New York and performed anesthesiology residency and research fellowship training at the University of Colorado School of Medicine in Denver. Dr. Goldman practiced anesthesia in private practice prior to joining the teaching faculty at the University of Colorado in 1990. His research fellowship concentrated on artificial intelligence applications for medical monitoring, and anesthesia simulation. Dr. Goldman departed the University of Colorado as a tenured Associate Professor in 1998 to work as Vice President of Medical Affairs of a medical monitoring company. He joined Harvard Medical School and the Departments of Anesthesia and Biomedical Engineering at the Massachusetts General Hospital in 2002.

Dr. Goldman recently served as Visiting Scholar in the FDA Medical Device Fellowship Program, chairs the Use Case Working Group of the Continua Health Alliance, leads several ASTM, ISO, and IEC medical-device standardization activities, and is a founding member and Past-President of the Society for Technology in Anesthesia.

10:15 AM
Break

10:30 AM
Patient Monitoring

Presenter: Maria R. Ebling, Senior Manager, Responsive Enterprise Solutions, IBM TJ Watson Research Center

Abstract: The health care industry around the world faces significant challenges to improve quality with fewer resources. One technology that offers a promising approach to addressing these challenges is patient monitoring. However, unless we are careful in how we proceed down this path, we risk overwhelming our patients with wires and our medical practitioners with data. Ms. Ebling will discuss some of her team's work in the area of patient monitoring and will start by discussing our efforts in wireless, remote patient monitoring and then move on to more recent work in figuring out what to do with that data once you have it. Ms. Ebling and her team have created an infrastructure, which is called Artemis, upon which healthcare analytics can be built, managed, and deployed. They are leveraging IBM's upcoming InfoSphere Streams platform, adding extensions to support the needs of the health care industry. The team is currently working with a customer in Canada to build a proof-of-concept that will be deployed in a Neonatal Intensive Care Unit in mid-2009 with the goal of discovering infant distress before observable symptoms are manifested.

Bio: Maria Ebling is a research staff member and Senior Manager at the IBM T. J. Watson Research Center, where she manages the Real-World Aware Systems and Solutions Department. Her team focuses on supporting systems that take input from sensors and streaming input, make sense of that input, and then trigger actions based on that information. One domain of particular focus is that of health care, specifically patient monitoring with online health care analytics. She received a BS from Harvey Mudd College and an MS and a PhD in Computer Science from Carnegie Mellon University. Her interests are in distributed systems supporting mobile and pervasive computing, privacy, and human-computer interaction.

11:00 AM
The Value-added of a Wireless Healthcare Industry

Presenter: Ibrahim Habib, Professor of Electrical Engineering, City University of New York

Bio: Dr. Ibrahim Habib is a Professor in the Department of Electrical Engineering at the City University of New York. He is also the Director of the Advanced Networking Research Laboratory and his research interests include the architecture and design of next generation networks; traffic engineering in IP-MPLS and IP optical-based networks; and allocation of resources and management of Quality of Service (QOS) in 3G wireless networks.

Dr. Habib received his PhD in Electrical Engineering from the City University of New York in 1991, his MSc in Electrical Engineering from Polytechnic University of New York in 1984 and his BSc in Electrical Engineering for Ain Shams University in Cairo, Egypt in 1981.

11:30 AM
Wireless EKG Glove: Its Applications and Commercial Potential

Presenter: G. Gopinathan, Clinical Professor of Neurology, NYU Medical Center; Chairman, Ineedmd, Inc.

Abstract: Electrocardiography is a comparatively recent invention in clinical medicine. The main scientist behind perfecting the string galvanometer and using it to develop electrocardiography was Willem Einthoven(1860-1927), a Dutch physiologist. He received the Nobel Prize in 1927 for discovering the Einthoven Triangle, which is the fundamental underpinning of the science of electrocardiography. When one installs EKG electrodes on the right wrist, left wrist and left ankle and connect these three points, the equilateral triangle it generates is the Einthoven Triangle. The heart is supposed to sit in the center of this triangle and the electrical signals the heart generates is captured by these electrodes and transported to the string galvanometer where the EKG waveforms are constructed.

Bio: After finishing graduate and postgraduate education in medicine in Kerala University India, Dr.Gopinathan started his career in the U.S in 1973. He did his internship and residency in Internal Medicine at the Coney Island/Maimonides Medical Centers. In 1975, he joined NYU Medical Center as a resident in neurology, which he completed in 1978. From 1978-1980, Dr.Gopinathan held a Fellowship in Expermental Therapeutics at the National Institute of Health, Bethesda, MD. He joined NYU neurology faculty in 1980 as Associate Professor. In 1981, he was appointed Director and Chief of the Neurology Division at the Manhattan VA Hospital. In 1987, he was named Clinical Professor of Neurology at NYU Medical Center.

Credentials: Board Certified in Internal Medicine: Royal College of Physicians of Canada (FRCP), Board Certified in Neurology by the Royal College of Physicians of Canada (FRCP), Board Certified in Neurology by the American Board of Neurology & Psychiatry, Fellow of the American Academy of Neurology, Fellow Emeritus, Royal Society of Medicine, London.

12:00 PM
Lunch

1:00 PM
Prevailing Over Wires in Health Care Environments: Benefits and Challenges

Presenter: Nada Golmie, Manager, Emerging and Mobile Network Technologies Group, National Institute of Standards and Technology

Abstract: This talk surveys the benefits and challenges posed by the deployment and operation of wireless communications in support of health care networks. While the main advantage of wireless communications remains to provide ubiquitous connectivity, thus allowing greater physical mobility and interoperability, a number of

engineering issues need to be addressed before this vision is realized. The intent of this talk is to explore some of these issues, including deployment, interference, and mobility, and provide insights for potential solutions.

Bio: Nada Golmie (nada@nist.gov) received her PhD in Computer Science from the University of Maryland at College Park. Since 1993, she has been a Research Engineer in the Advanced Networking Technologies Division at the National Institute of Standards and Technology (NIST). She is currently the Manager of the Emerging and Mobile Network Technologies Group. Her research in media access control and protocols for wireless networks led to over 100 technical papers presented at professional conferences, journals, and contributed to international standard organizations and industry led consortia. She is the author of "Coexistence in Wireless Networks: Challenges and System-level Solutions in the Unlicensed Bands," published by Cambridge University Press (2006).

1:30 PM

An Institutional Biomedical Device Information System: Integrating Clinical Devices, Location-based Services (RFID) and Targeted Communications

Presenter: Paul Frisch, Chief, Biomedical Physics and Engineering and Assistant Attending in the Department of Medical Physics, Memorial Sloan-Kettering Cancer Center

Abstract: The deployment of new wireless and network technologies coupled with advanced clinical applications and devices have significantly increased the quality and the quantity of patient diagnostic and monitoring information. Increasing workloads and reduced staffing have revealed difficulties in effectively prioritizing and handling this information and have resulted in increased equipment-related errors, patient dissatisfaction, the potential for patient injury, and an increasing overall concern for patient safety. Concerns about this trend have prompted the Joint Commission to established seven patient safety initiatives geared to the patient environment of care. These include establishing methodologies and protocols to reduce the probability of errors, and providing an enhanced level of communications.

This presentation focuses on the requirements, development methodology, and deployment criteria of an integrated institutional biomedical information systems solution, exploiting the institution's network backbone and wireless infrastructure.

Bio: Paul Frisch is currently an Assistant Attending in the Department of Medical Physics and the Chief of the Biomedical Physics and Engineering service at Memorial Sloan-Kettering Cancer Center. Specific areas of research include electromagnetic field induced gene expression, robotic surgery, and clinical applications of wireless technology, such as RFID. Previous experiences include research in human biodynamics investigating human response to transitory acceleration, such as crash-impact and aircraft ejection and robotic applications in pharmaceutical development.

Paul Frisch has a doctoral degree in bioengineering from the State University of New York at Binghamton and master's and bachelor's degrees in electrical engineering from the State University of New York at Stony Brook.

2:00 PM

WiTAT Smart Band-Aid: A Wireless Temporal Artery Thermometer

Presenter: Stan Zwierzchowski, Department of Electrical and Computer Engineering, University of Calgary

Abstract: A research team at the University of Calgary, headed by James Haslett, has developed a wireless vital signs monitor (WVSM) for measuring patient core temperature – the WiTAT smart bandage. This work was done in conjunction with the Ward of the 21st Century initiative at the Foothills Medical Center in Calgary. The WiTAT is the first step in the development of WVSM devices based on the smart bandage concept. The method for determining core temperature employed in the WiTAT bandage is a proprietary scheme based on conduction heat flow measurement through an array of sensors and for which a patent application is in process. The patent is currently at the stage of submission of the response to the first examiner's action. Looking very much like a common household first-aid bandage, the WiTAT smart bandage is applied over the temporal artery on the forehead from where it determines and transmits core temperature readings. Future vital sign monitoring to be incorporated in the WiTAT platform includes pulse-blood oxygen measurement.

The WiTAT smart bandage is currently undergoing a clinical trial in the Intensive Care Unit at the Foothills Medical Center in Calgary with Dr. Tom Stelfox as the Principle Investigator. In this clinical trial, the performance of the WiTAT device is being investigated and is compared against the standard for core temperature measurement—that being a temperature sensing Foley bladder catheter. Preliminary trial results look promising and will be discussed. Also, a brief discussion of the process of obtaining approvals, supporting the trial and liability considerations, since this can be instructive to engineers involved in developing wireless medical devices, will be given.

Bio: For over three decades, Stan Zwierzchowski has had a very broad career in technology development. This career has spanned industry, academia, and research. Stan was Vice-President and Chief Operating Officer for a publically traded aerospace company that designed and developed, manufactured and installed navigation systems for aviation. He worked as a management consultant providing hands-on leadership in engineering, manufacturing and organization to a number of technology companies leading their technology development projects.

In academia, Stan's teaching career has been equally diverse. Over the years, he has taught many courses at the University of Calgary ranging from microelectronics, digital communications, RF circuits to project management, engineering law and ethics.

Past research work included investigations in ultra-wideband communications and high temperature electronics

2:30 PM

Break

2:45 PM

Wireless Body-area Networking Standardization

Presenter: Maulin Patel, Senior Member, Wireless Communication and Networking, Philips Research North America

Abstract: Wireless Body-area Networking (BAN) is an emerging technology that has potential to unleash the wave of innovative applications. BAN is seen as a key technology that enables unified connectivity among in, on and around the body devices. BAN can support an evolutionary set of applications in health care (e.g., deep brain stimulation, camera pills and implanted drug delivery), lifestyle (e.g., ambient intelligence), gaming and entertainment that can improve the quality of life in an unprecedented way. The wide range of BAN applications and corresponding stringent requirements bring a new set of research challenges such as energy efficiency, scalability (in terms of data rate, power consumption, duty cycle, security and number of devices), integration of in and around the body networking, interference mitigation, coexistence, QoS and security. Developing a single unifying BAN standard that addresses these core sets of technical requirements is the quintessential step to unleash the full potential of BAN. In this talk, Dr. Patel will outline the emerging BAN applications and highlight the core set of technical requirements that must be addressed for BAN to become ubiquitous and pervasive technology.

Bio: Dr. Patel received the MS in Computer Science and a PhD in Telecommunications Engineering from the University of Texas at Dallas in 2002 and 2006, respectively. Since 2006, he has been a senior member of the research staff at Wireless Communication and Networking Department of Philips Research North America where he does research on body-area networking. His current research interests include energy-efficient protocols for body-area networks and sensor networks. He actively contributes to IEEE 802.15.6 Body-area Network Task Group. His research has been published in many leading journals and conferences.

3:15 PM

Software Infrastructure for Applications: Leveraging Tracking and Other Wireless Sensors in Hospitals

Presenter: Binay Sugla, Chairman & CEO, Mobile Matrix Inc.

Abstract: Hospitals present a unique environment where there is a very high degree of mobility of personnel and assets all geared to deliver timely, life-critical care. This patient care environment also demands a very rich set of medical sensors. Intuitively, use of wireless technologies in hospitals could potentially deliver great benefits to administrators, care providers and patients.

However, these gains can only be obtained if these technologies can be leveraged effectively through the design and use of appropriate applications. This presentation models the tracking technologies and wireless sensors that are involved, identifies the applications that are needed, and describes software functionality and requirements common to all these applications. Finally, delivery, implementation and integration issues are also discussed.

Bio: Dr. Binay Sugla is Chairman and CEO of Mobile Matrix Inc. Dr. Sugla serves on the board of several other companies and also is an advisor to Signal Lake Ventures. In 2004-5, Binay was the Executive Director of the NSF-funded Wireless Internet Center for Advanced Technology (WICAT), which is a multi-university industry cooperative research center. In 2002, he served as the President and CEO of DSET, where he was instrumental in driving a strategic reorganization that led to increased revenues and new markets in a newly merged company. Before joining DSET, Dr. Sugla was a founder of ISPsoft (a Lucent Technologies funded company) and served as the company's President and Chief Executive Officer. He has also been a Director of Research and Development at Bell Laboratories where he conducted extensive research in the areas of networking, telecommunications and parallel processing systems. He has published numerous papers, holds several patents and has co-authored an IETF RFC.

3:45 PM

Modeling and Analysis of Energy-harvesting Nodes in Body-sensor Networks

Presenters: Alireza Seyedi, Assistant Professor, Department of Electrical and Computer Engineering, University of Rochester and Biplab Sikdar, Associate Professor, Department of Electrical, Computer and Systems Engineering, Rensselaer Polytechnic Institute

Abstract: Body-sensor networks (BSNs) are envisioned to revolutionize many fields such as health monitoring and personal health care. In this talk, we will describe the result of our recent research into modeling and analysis of energy harvesting BSNs. We provide a unified model that combines the energy model and the traffic model for the energy-harvesting nodes. Using this model which describes the state of the system by including both the harvesting state as well as the remaining energy supply of the node, we provide an analysis of the loss probability due to energy run-out as well as average time to energy run-out. The former gives us insight into the performance and the design criteria of the system, and the latter can be used as a vulnerability metric for various harvesting aware techniques at different protocol layers.

Bio: Alireza Seyedi is an Assistant Professor (Research) in the Department of Electrical and Computer Engineering at the University of Rochester. He has been with the department since September of 2007. Prior to that, he was a senior member of the research staff at Philips Research North America. He received his PhD and MS degrees from Rensselaer Polytechnic Institute, both in electrical engineering, in 2004 and 2000, respectively. He received his BS degree, also in electrical engineering, from Sharif University of Technology, Tehran, Iran, in 1997. His current research areas include body-sensor networks and cognitive radios.

Bio: Biplab Sikdar received a BTech in Electronics and Communication Engineering from North Eastern Hill University, Shillong, India, a MTech in Electrical Engineering from Indian Institute of Technology, Kanpur and a PhD in Electrical Engineering from Rensselaer Polytechnic Institute, Troy, NY, in 1996, 1998 and 2001, respectively. He is currently an Associate Professor in the Department of Electrical, Computer and Systems Engineering at Rensselaer Polytechnic Institute. His research interests

include wireless MAC protocols, network routing and multicast protocols, network security and queuing theory. Dr. Sikdar is a member of IEEE, Eta Kappa Nu and Tau Beta Pi.

4:00 PM
Continuous Vital Sign Monitoring via Wireless Sensor Network

Presenters: Baozhi Chen, PhD Candidate; Ivan Marsic, Associate Professor; and Dario Pompili, Assistant Professor; Department of Electrical and Computer Engineering; Rutgers, The State University of New Jersey

Abstract: Continuous, seamless, and reliable vital sign monitoring is crucial for making efficient and error-free decisions in pre-hospital settings. Currently, the pre-hospital environment lacks effective methods for prioritizing information streams, evaluating time-dependent trends, managing incomplete data, and providing effective alerts. To address these challenges, a new wireless sensor network system based on body-area network (BAN) for patient health care monitoring is proposed.

Bio: Baozhi Chen received his BS in Information Engineering from Beijing University of Posts and Telecommunications, Beijing, China, in 2000. He received his MS in Electrical Engineering from Columbia University in New York in 2003. He is now a PhD student at Rutgers, the State University of New Jersey—New Brunswick. His research interests lie in wireless communications and networking, with emphasis on cross-layer optimization in wireless ad hoc networks and wireless sensor networks, wireless body-area networks, wireless health care networks, and underwater communications and networking. He is an IEEE student member. He has been a reviewer for conferences such as IEEE VTC, WCNC, MASS, ICC, WICON, and journals such as *Elsevier Ad Hoc Networks*, *Elsevier Computer Networks*, *ACM Transactions on Embedded and Computing Systems*, and *ACM Transactions on Parallel and Distributed Systems*.

Bio: Dario Pompili joined the faculty of the Electrical and Computer Engineering Department at Rutgers University as Assistant Professor in Fall 2007. He received his PhD from the Georgia Institute of Technology, where he was awarded BWN-Lab Researcher of the Year for "outstanding contributions and professional achievements". He is author of many influential papers in ad hoc and sensor networks, underwater acoustic communications, wireless sensor and actor networks, and network optimization and control.

4:15 PM
Panel Discussion: Unsolved Problems, Research Opportunities

Moderator: David Goodman, Professor Emeritus, Polytechnic Institute of NYU
Panelists: Kurt Becker, Satyen Mukherjee, Steven Lascher

David Goodman is Professor Emeritus as NYU-Poly. Before retiring in May 2008 from his position of Professor of Electrical and Computer Engineering, he was Director of WICAT, the Wireless Internet Center for Advanced Technology. Prior to joining NYU-Poly in 1999, he was a Professor at Rutgers and Founding Director of WINLAB, the Wireless Information Networks Laboratory. From 1967 until 1988, he was at Bell Labs where he was head of the Radio Research Department.

Kurt Becker is Associate Provost for Research and Technology Initiatives and Dean of Sciences and Arts at Polytechnic Institute of NYU. Dr. Becker has held tenured faculty positions at Lehigh University, the City College of CUNY, and most recently at Stevens Institute of Technology. At Stevens, he was the Head of the Department of Physics and Engineering Physics in 2000 and in 2003, he was also Associate Director of the Center for Environmental Systems (CES), a joint center between the Schools of Engineering and Science.

Dr. Becker's background is in atomic, chemical, and plasma physics. He holds a PhD from the Universitaet Saarbruecken in Germany. He is a Fellow of the American Physical Society and has worked extensively on experimental and theoretical studies of electron-driven processes and on low-temperature plasmas. He has published more than 180 peer-reviewed articles and edited or co-edited seven books. Dr. Becker's research has been funded by the NSF, DOE, NASA, ARO, AFOSR, ONR, DARPA, and through contracts from industry. He has also served on numerous review panels for federal funding agencies such as NSF, DOE, and NASA. He holds seven patents on the generation and maintenance of atmospheric-pressure plasmas and their application (six of those patents are joint patents with Provost Erich Kunhardt). In 2001, Becker was a co-recipient (with Erich Kunhardt) of the Thomas A. Edison Patent Award of the Research and Development Council of New Jersey.

Satyen Mukherjee is currently a Chief Scientist and Senior Director for Research Strategy in North America. Prior to this, he was the AD Interim Managing Director of Philips Research North America. Dr. Mukherjee has served as Department Head, Microelectronic Devices, Circuits and Systems at Philips Research, Briarcliff Manor, New York, where he has conducted research in a number of semiconductor technologies, circuits and systems including applications in lighting, energy management, consumer devices, ultrasound imaging, wireless communications and displays. Prior to joining Philips, Dr. Mukherjee worked on non-volatile memory devices at intel Corporation and Exel Microelectronics in San Jose, California. Dr. Mukherjee holds a PhD from Carleton University, Ottawa, Canada (1981) and a BTech from the Indian Institute of Technology, Kharagpur, India (1976), where he was awarded the President of India Gold Medal for top ranking in all branches of engineering.

Steven Lascher is an alumnus of Polytechnic and is Vice President for Research at Saint Vincent Catholic Medical Centers of New York, where he founded the Office of Research and Clinical Trials six years ago. Prior to that, he was the staff Clinical Epidemiologist at the American College of Physicians in Philadelphia, and a U.S. Public Health Fellow in Epidemiology at the FDA. He also practiced as an equine veterinarian in Saratoga Springs, NY. In addition to his DVM, Dr. Lascher has a Master of Public Health in Epidemiology and Biostatistics and a PhD in Health Services Research, both from Johns Hopkins.

5:00 PM
Refreshments and Adjournment

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