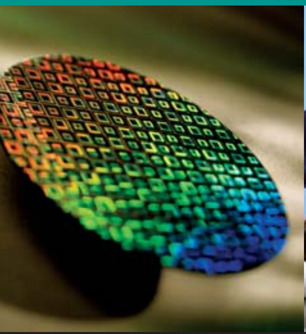
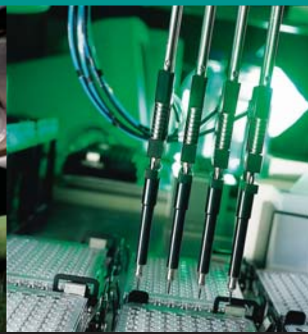
NMS Innovation News

Incorporating the former MET Newsletter

2008 | issue 03







ADVANCED MATERIALS | MEDICAL | COMMUNICATIONS | ENERGY | MANUFACTURING

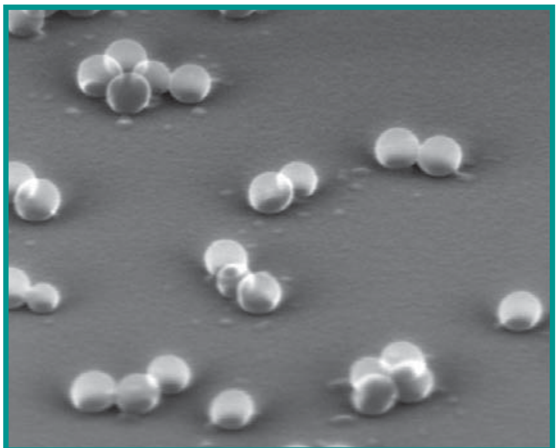
NPL Sizes-up Nanoparticles

Nano-scale materials frequently exhibit properties that differ from those of materials in the bulk state. These properties maybe exploited in new products or to optimise existing ones - for example, the greatly increased surface to volume ratios of nanoparticles is used to boost the efficiency of powder-based catalysts. Other current commercial applications of nanoparticles include highly concentrated suspensions in the ink industry, drug delivery agents for the pharmaceutical industry, and novel composite materials for the transport industries. However, well-documented toxicological concerns highlight the need for strict and well-defined standards to be applied.

The nanomaterials team at NPL is working to improve the reliability of nanoparticle-based products and is developing the essential underpinning metrology needed for quality control. Characterisation and standardisation of nanoparticles are absolutely critical for regulatory purposes and to sustain innovation.

Currently no recognized traceable calibration of nanoparticles exists below 50 nm, and as nanoparticle properties are strongly dependent on size, new metrological capabilities are required in order to ensure consistency in quality and innovation. The NPL nanomaterials team has recently developed the metrology expertise to measure nanoparticles (dry or in liquid suspension) in the size range between 0.5 nm and 1 µm using techniques such as transmission electron microscopy, atomic force microscopy and dynamic light scattering measurements for nanoparticles. The team is also coordinating a European project involving 8 National Measurement Institutes to provide new traceable standards and procedures to determine the size, shape and distribution of nanoparticles, with an accuracy of better than 1 nm. This will be correlated with preparation methods and the end-product environments (on a surface or in suspension), and will be offered as a new measurement service to industry.

Nano-scale materials currently dominate the markets for nanotechnology products, representing around 70% of sales. In 2001 these markets were equivalent to worldwide sales of around £22 billion, with approximately 33% being associated with nanoparticles. By 2010 overall nanomaterials sales are expected to approach £88 billion, with nanoparticles accounting for over 40% of this figure. Better characterisation methods will help to support this market growth, particularly for the highly engineered, high added value materials market.



Scanning electron microscopy image of 50 nm polystyrene beads

For further information please contact Alexandre Cuenat at NPL on 020 8943 8627 or e-mail: alexandre.cuenat@npl.co.uk

A Confident Future for Wireless Sensor Networks

MicaZ node - part of the NPL wireless sensor network testbed

Overview

March 2008 saw the completion of the Measurement for Emerging Technologies project: *Effective wireless sensor networks with context identification and communication.* This three-year project brought together collaborators including NPL, Oxford University, Invensys and BT to identify and tackle the key measurement issues facing the emerging area of wireless sensor networks. The project has succeeded in addressing many of these and identifying areas and capabilities which will require further development to fully exploit this new and exciting technology.

Background

Wireless sensor networks (WSNs) are set to become a significant enabling technology in many areas of security, military, health and environmental monitoring. Potential applications range from monitoring machinery and environmental noise to care monitoring of elderly and vulnerable people in the home. It has been estimated that the world market in wireless sensors will increase from $150 million in 2004, the level at the start of this MET project, to over $7 billion in 2010 – a fifty-fold increase. There are two distinct stages to this expansion. The first, which is being seen in many currently deployed commercial applications, is as a replacement for wired systems. WSNs eliminate wiring and reduce installation costs (together making up to 80% of the costs of a conventional network) and have the advantage that any subsequent changes can be made easily and cheaply by replacing or repositioning the sensors. The other, longer-term driver is that these systems will allow a broad range of exciting functionalities that have hitherto been impossible using traditional systems. There is the opportunity to develop self-calibrating, self-validating intelligent networks, with distributed processing and collaborative sensing. Functionalities such as localization and ad-hoc networking allow quick deployment in a range of hard-to access locales, and allow networks to adapt and remain robust to changes in the system or environment.

Key Issues

With these new capabilities and opportunities comes a range of challenges, which must be addressed if these systems are to be adopted for applications with any level of criticality. The overarching issue is the uncertainty, or confidence in the output of the system. Without knowledge of the accuracy and reliability of the output of a system, it is impossible to make educated actions based on that output. This would also prevent potential users from being able to perform a risk and cost-benefit analysis of employing the system and hence would pose a barrier to adoption. The complexity in establishing the output confidence depends on the complexity and level of autonomy of the system, but there are generalized issues, which must be accounted for (to a varying extent) in all wireless sensor-networking applications (see Key Themes Box).

Key Themes

[1] Data link uncertainty: *Data loss, latency or corruption*

[2] Data Fusion and Propagation of uncertainty in networks: *May have many levels of processing to consider*

[3] Metrology using un-scaled data: *How to make use of qualitative data*

[4] Uncertainty in Data Visualization: *How the information is presented to the user*

[5] Outputs high up the information hierarchy: *How to aggregate large volumes of data into meaningful and useful information*

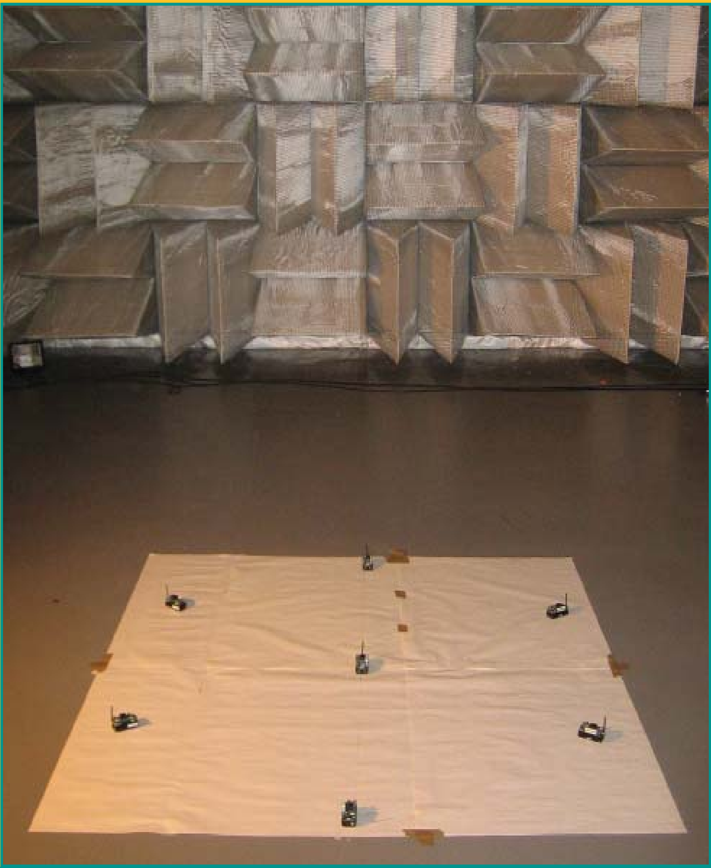
[6] Network calibration and self-calibration: *How to calibrate numerous, dispersed sensors*

[7] Localization: *How sensor nodes may locate themselves and their neighbours*

[8] Timing and synchronization: *How to keep the nodes synchronized for data fusion and networking functionalities*

MET Project Achievements

The initial, crucial output of the MET5.1 project: *Effective wireless sensor networks with context identification and communication* was to identify the key measurement issues facing the emerging area of wireless sensor networks, and in doing so, develop a strategy for the NMIs in this area. Of the key themes identified, this project focused on data fusion and propagation of uncertainty in networks. Data fusion and analysis at node, network and system level is required for many of the future applications of WSNs.



MicaZ nodes deployed in an acoustically anechoic chamber carrying out ranging and localisation measurements

This work was carried out through targeted case studies, looking at a number of applications.

In collaboration with BT, the project team developed data fusion algorithms and uncertainty propagation techniques for an assisted living application. A testbed of sensors was set up by BT to monitor an elderly person in their home. The aim was to observe a variety of worktop, water tap, door and infra-red sensors over a 6-month period in order to ascertain the day-to-day behaviour, and hence wellbeing, of the client. The challenge was to extract meaningful information from over half a million sensed events from twenty-seven sensors. Through the development of clustering and pattern searching algorithms, the project team was able to identify specific activities of the client, which could then be fed into a higher-level process to quantify the well being of the subject. The confidence in such an output is vital to a potential end user, and they would want to be assured of sufficiently low false positive and negative levels if they were to rely on such a system for the safety and wellness of an infirm patient.

Invensys and Oxford University have developed a tank gauge system. This combines a number of pressure, flow and level meters to produce a "self-validating" gauge, which can give a user information on the status of the sensors and uncertainty of the measured quantity (in this case the volume of liquid transferred from one tank to another). This application highlights the advantages of a collaborative measurement approach, enabled by WSNs. Data processing techniques developed within this application have also been applied to an acoustic ranging application using the NPL WSN testbed.

These, and other applications investigated within this project have allowed the key measurement issues to be investigated within the context of whole, integrated systems. The highly imbedded nature of WSNs means that it is often necessary to consider the interactions between all the system components, making it difficult to investigate any single issue in isolation. A tutorial website has been developed to assist potential users in understanding the metrology of WSNs. Please visit http://www.npl.co.uk/wireless_communications.

Publications

The project has resulted in the following publications:

- *"Effective wireless sensor networks with context identification and communications"* NPL open report
- *"Testing the reliability and accuracy of a preventative telecare system"* Telemedicine and e-Health 2008, American Telemedicine Association
- *"Self-validation in a multi-sensor system: tank gauge case study"* NPL open report
- *"Aggregating measurement data influenced by common effects"* Metrologia 2007
- *"Data fusion in wireless sensor networks, an acoustic ranging case study"* MSET online presentation (http://mset.globalwatchonline.com/)
- *"The application of self-validation to wireless sensor networks"* Measurement Science and Technology 2008

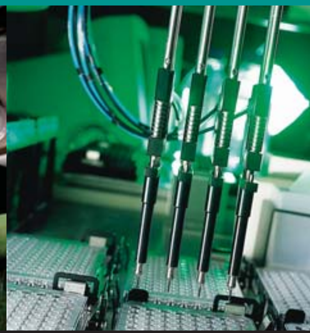
The future for wireless sensor networks

This project has put NPL in an excellent position to facilitate the development of WSNs for a broader range of more intelligent and critical applications. From 2010 onwards, ideas that are currently at the design stage will start to be deployed in test environments such as nuclear reactors and wearable health monitoring. Devices will be smaller but the amount of data generated will be larger. There will be more on-board intelligence and processing, self-calibration and self-validation within smart nodes/sensors, and ad-hoc networks of heterogeneous devices. Control applications will be increasingly important. NPL and the NMS will need to be able to demonstrate how traceability of measurements can be achieved in these new types of networks through successful solution of real-world mission-critical Wireless Sensor and Control Network problems, and to be firmly positioned as sources of expertise and advice in WSNs. This is already underway, with confirmed collaborative projects on structural health monitoring, acoustic emissions testing, WSN synchronization and mission critical data fusion for disaster situations.

For more details on this work, and other projects in this area at NPL, please contact michael.collett@npl.co.uk or david.adamson@npl.co.uk.







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If you would like further information on any aspect of NMS Innovation R&D Programme, see www.metprog.org.uk
National Physical Laboratory | Teddington | Middlesex | United Kingdom | TW11 0LW
Helpline: 020 8943 6880 | Fax: 020 8614 0446 | E-mail: enquiry@npl.co.uk

Better Diagnostics at the Point of Care

Point of Care Testing (POCT) diagnostics is a rapidly evolving area with the potential to revolutionise the way patients and clinicians interact with primary healthcare services. Novel biosensor technologies will form the basis for these diagnostic systems and require a comprehensive set of tools for successful evaluation/development and commercialisation.

The current POCT marketplace is dominated by diagnostic systems such as blood gas analyzers and glucose testing devices. These devices provide diagnostic services at the point of clinical need rather than through centralised laboratory testing. POCT systems are generally limited to measuring simple biological analytes or physiochemical characteristics and do not test for complex macromolecules such as nucleic acids and proteins.

A MET programme collaborative project, led by LGC, was initiated in response to the healthcare and industry need to evaluate novel biosensor technologies for use in POCT diagnostics. The project was concerned with providing a metrological basis for the evaluation and development of novel biosensor technologies and focussed on comparing a selection of next generation POCT technologies (electrochemical and Surface Enhanced Raman Spectroscopy detection) to current 'gold standard assays' (ELISA and fluorescent probe-based real-time PCR) using either

DNA or protein-based model assays:

- DNA model – sexually transmitted infection (STI) assay targeting Chlamydia trachomatis
- Protein model – assay targeting cardiac biomarkers

Research was conducted in coordination with industrial collaborators (Atlas Genetics and Oxonica) to compare the performance characteristics such as sensitivity, specificity and matrix effects that are associated with the diagnostic systems and successful outputs fed back into commercial development activities. A successful collaboration with St. George's Hospital, University of London, provided STI clinical samples for in-house diagnostic testing at LGC. This, in turn, has led to further research opportunities outside of the current programme via both participation in the UKCRC Translational Infection Research Initiative and a successful application for a Strategy Development Grant which is looking at developing POCT devices for sexually transmitted infections.

The healthcare sector, and specifically patients, will benefit from the outputs of this project by encouraging the uptake of novel POC technologies and their integration into devices that deliver faster diagnosis and more accurate testing of clinical conditions.

For further information on this work at LGC please contact neil.harris@lgc.co.uk

Forthcoming Events

NPL Optical Technologies and Measurement (OTM) Network Annual Meeting

25 - 26 June 2008
NPL, Teddington
Contact: npl_clubs@npl.co.uk
http://www.npl.co.uk/server.php?show=ConWebDoc.2114

UKSAF Summer Meeting Surface Analysis Forum

2 July 2008
University of Ulster
http://www.uksaf.org

Micro and Nanoscale Characterisation of Fibres

3 July 2008
University of Ulster
http://www.npl.co.uk/server.php?show=ConWebDoc.2440

FOToN – 39th Meeting of the Fibre Optic Technology Network

17 July 2008
NPL
http://www.npl.co.uk/server.php?show=ConWebDoc.2649

"Nanomolecular Analysis for Emerging Technologies III" and "Surface Science of Biologically Important Interfaces 10"

5 – 6 November 2008
NPL, Teddington
http://conferences.npl.co.uk/nmaet/

NPL Training level 1 courses:

For information on training courses being run
contact helen.white@npl.co.uk
or see http://www.npl.co.uk/training

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