



**ARC Research Network on
Intelligent Sensors, Sensor Networks
and Information Processing
(ISSNIP)**

**Annual Report
(October 2004 to December 2005)**

www.sensornetworks.net.au

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1. Introduction

Sensor networks with a large number of diverse sensors interconnected via a low data-rate communication network have the potential to make a huge impact on many areas. The area of sensing technologies and sensor networks is now considered by international funding agencies such as the European Commission, DARPA and NSF to be one of the top five emerging technologies that will shape the future of human kind.

The Sensor Net research network will harness the great strengths of its highly qualified multi-disciplinary participants in a national co-operative effort which will:

- Provide an urgently needed national focus and identity for Australian research in the rapidly emerging and highly significant area of sensor networks;
- Provide Australian researchers with strong linkages and exchange opportunities with the major international sensor networks research efforts in the USA and Europe;
- Link Australian industry with world class research programs covering all the critical facets of the highly multi-disciplinary sensor network science and technology base;
- Significantly enhance the relevance and quality of Australian post-graduate training in the broad area of sensor networks;
- Provide a framework for guiding and supporting young Australian researchers in the area of sensor networks;
- Build a national collaborative framework to grow and support the essential industry/research co-operation needed to fully exploit advances in sensor network science and technology to address major national social challenges in the areas of health, environment and security.

The scientific challenges which must be overcome in order to realize the enormous potential of sensor networks are substantial and multidisciplinary in nature. The Sensor Net research network will provide an exciting environment for effective collaboration amongst a multi-disciplinary team of world class researchers with outstandingly successful existing research programs covering all the core disciplines required for the successful development and exploitation of sensor networks. These disciplines include bio and nano sensor science and manufacture, large scale system optimization, data and information processing, wireless networks and computer communications, electronics and mechatronics. Sensor Net participants will be linked with many of the very best overseas

researchers in these core disciplines and to the world's best sensor networks research groups.

Sensor Net participants will generate new collaborative multi-disciplinary proposals for ARC Centres of Excellence, and Linkage/Discovery grants in a major national collaborative effort to solve the key underlying scientific problems facing sensor networks and provide Australian industry with the opportunity to exploit and apply sensor network technology in the socially and commercially important areas of security, health care and the environment.

Sensor Net provides an unprecedented opportunity for Australia to become a world leader in sensor networks by supporting and assisting co-operation and collaboration amongst existing world class research activities in relevant disciplines.

Sensor Net strategies are driven by a vision to create the collaborative research foundations which support a world leading Australian sensor networks industry. The Sensor Net vision will be realized through five strategic priorities:

1) National collaboration and identity

- To build a fertile and effective national collaborative environment for undertaking innovative multi-disciplinary research in sensor networks and to create a strong Australian sensor networks research identity.

2) Industry linkage

- To work with Australian sensor network researchers and relevant industry sectors to explore opportunities for the application of sensor network technology.

3) International linkages

- To create opportunities and an environment for linking Australian sensor network researchers with the premier sensor networks research groups around the world.

4) Education

- To actively pursue the expansion of sensor networks related post-graduate student research opportunities in Australian Universities and raise the public awareness of the emerging sensor networks science and explore undergraduate and secondary school educational opportunities.

5) Future funding

- To build co-operative multi-disciplinary research teams and industry linkages that will generate a future stream of collaborative multi-disciplinary research activities including new multi-disciplinary proposals for research funding.

Through these 5 Strategic Priorities Sensor Net was intended to lay the foundations for a major national collaborative effort to solve the key underlying scientific problems facing sensor networks and provide Australian industry with significant opportunities to exploit and apply Australian sensor network technology in the socially and commercially important areas of security, health care and the environment. Keeping the focus on the above strategic priorities, we present here the research network annual report for the period **October 2004 to December 2005**. The combined report is due to the fact that the funding agreement between The University of Melbourne and the ARC was

completed several months after the initial announcement. There were also substantial delays in completing agreements between the University of Melbourne and all the Partner Institutions. Substantial progress has been achieved in the Research Network's strategic priorities as detailed in the report. Having successfully completed the first stage in establishing the ARC Research Network in ISSNIP, the RN now embarks on next stage in building upon the strong foundations already laid in each of the Strategic Priority areas.

2. Governance

The governance of the ARC Research Network on ISSNIP is based on the outline given in the proposal.

2.1 ISSNIP Executive Board:

A high level Executive Board, with extensive management and leadership experience was formed. The ISSNIP Executive Board is chaired by Dr. D. Nandagopal who is the Deputy Chief Defence Scientist, Australia and a highly experienced manager and research leader. The members of the board included A/Prof. M. Palaniswami, Prof. M. V. Srinivasan (ANU) and Prof. I. Petersen (ADFA-UNSW). The executive board meeting was held on 15th August 2006 in Canberra and the committee approved the report leaving the financial statement to the University of Melbourne. The executive board endorsed the convener's idea of generating more funds for projects leveraging the networking opportunity created by the ARC RN. The committee was appreciative of the initiatives taken by the network members in obtaining new grants particularly the DEST-ISL grant. The next meeting is scheduled to be held in December 2006.

2.2 ISSNIP Research and Industry Committee:

The ISSNIP Research-Industry was set up to play a defining role in establishing and supporting new collaborative projects. Prof. Subhash Challa from UTS, Australia and M Palaniswami are co-chairs of this committee. Their extensive links with industry have helped the research network to form new collaborations in the form of the DEST-ISL grant. Several companies were brought on board as part of the DEST-ISL project on Distributed Sensor Networks. The Road Traffic Authority of NSW, a government based organisation was also brought on board within the first year of the formation of this committee. The committee members include Slaven Marusic, UNSW; Raj Buyya, University of Melbourne; N. Mani, Monash University.

2.3 ISSNIP International Scientific Advisory Committee (ISSNIP-ISAC):

ISSNIP has established an International Scientific Advisory Committee consisting of the world's top researchers and research leaders in the area of sensor networks and its core disciplines. ISSNIP-ISAC has already met twice in Australia (2004 and 2005). The objective of setting up the committee was to overview ISSNIP research activities and to advise on research directions. The meetings

were held alongside international conferences (ISSNIP 2004 and ISSNIP 2005). The members presented seminars and short courses/tutorials. The first ISSNIP-ISAC meeting was attended by the following people:

1. Chair - Dr. Srikanth Kumar (DARPA, USA)
2. A/Prof. M Palaniswami (University of Melbourne, Australia)
3. Ulrich Ramacher (Infineon, Germany)
4. Prof. Vittal Rao (NSF, USA)
5. Dr. Feng Zhao (Microsoft Research, USA)
6. Prof. Erol Harvey (Swinburne, Australia)
7. A/Prof. Mohan Kumar (UT Arlington, USA)
8. A/Prof. Dinesh Kant Kumar (RMIT, Australia)
9. A/Prof. Paul Havinga (University of Twente, The Netherlands)
10. Dr. Pubudu Pathirana (Deakin University, Australia)
11. A/Prof. Arcot Sowmya (UNSW, Australia).

This meeting was more of a welcome meeting and the plan for a new project based proposal was discussed in detail. The DEST-ISL grant which was received the following year was a result of this meeting. It was also decided that the annual conference should be held in early December to enable more overseas participation.

The second ISSNIP-ISAC meeting was held at Langham Hotel alongside the Second ISSNIP conference. The second ISSNIP-ISAC meeting was attended by the following people:

1. Chair: A/Prof. M Palaniswami (University of Melbourne, Australia).
2. Prof. Stuart Milner (University of Maryland, USA)
3. A/Prof. Mohan Kumar (UT Arlington, USA)
4. A/Prof. Arcot Sowmya (UNSW, Australia)
5. Prof. Subhash Challa (UTS, Australia)
6. Dr. Danyl Prokorov (Toyota, USA)
7. Prof. Vittal Rao (NSF, USA)
8. A/Prof. Paul Havinga (University of Twente, The Netherlands)
9. Dr. Stefan Dulmann (University of Twente, The Netherlands)
10. Dr. Pubudu Pathirana (Deakin U, Australia)
11. A/Prof. Ian Atkinson (James Cook University, Australia)
12. Dr. Raj Buyya (University of Melbourne, Australia).

The main outcome of the meeting was to implement an Australian Sensor Network Testbed. As a result, a large test bed was planned with the support of

an ARC LIEF Grant application for which the decision is awaited. This will be implemented in collaboration with Australian Institute of Marine Science (AIMS), VPAC, and the timber authority. Universities include The University of Melbourne, Deakin, University of Queensland, James Cook University and UTS. The next meeting is scheduled for November 2006 in Townsville under the agenda "**Environmental Sensor Network**".

2.4 The ISSNIP Education Committee:

This was set up under the leadership of A/Prof. Arcot Sowmya and intended to coordinate the education outreach program for around 50 post graduate students directly involved with ISSNIP through their supervisors. It also intended to groom young researchers to take up active leadership role. Two postgraduate workshops were held in UNSW on Image and Signal Processing. In the later part of the year A/Prof. Dinesh Kant Kumar came on board as co-chair of the committee. Under his leadership, student workshops were held on sensor networks (more details in the activities section) and later on signal processing for sensor networks. The two co-chairs have met the convener during the two conferences to discuss the progress. The local organising secretaries of the two conferences were PhD students (Jayavardhana Gubbi and Daniel Lai,) under A/Prof. Palaniswami. The second ISSNIP also saw greater involvement from the students. Post graduate students including Dr. Alistair Shilton (currently post-doc in UniMelb) and Ms. Sophie Kaplantzis (PhD student, Monash University) arranged a parallel student program to enhance student networking. Several undergraduate projects in sensor networks have been initiated in various nodes of the network.

3. Network Activities

The primary network activities include the ISSNIP conference series and affiliated workshops. There were two external interdisciplinary activities (workshops) that were funded by the network. One of them was by Prof. Moshe Sniedovich in the area of interdisciplinary decision making and another in the area of Distributed Sensor Networks conducted by A/Prof. Dinesh Kant Kumar from RMIT University under the education focus of the Research Network.

3.1 Conferences:

A conference series was initiated with several network Chief Investigators as part of the program committee with convener A/Prof. M Palaniswami as the general chair. Three conferences were already conducted and have proven to be very successful. The third one was held jointly with IEEE e-Science. The conferences attracted over 350 participants.

3.1.1 First International Conference on Intelligent Sensors, Sensor Networks and Information Processing, Melbourne, December 2004.

- The conference was held in The Grand Hyatt
- It was sponsored by IEEE Victoria Section, CSSIP, CENDS, DSTO and Raytheon
- The conference was technically co-sponsored by IEEE EMBS and ran in-cooperation with IEEE Computational Intelligence Society and IEEE Sensor Council.
- The conference was attended by over 200 delegates from different parts of the world.
- The conference was inaugurated by Marsha Thomson, Victorian ICT Minister and opening address was given by Dr. Nanda Gopal, Director, SSL Labs, DSTO, Australia.
- The conference had several top plenary and key note talks by eminent professors:
 1. Graeme Clark, Bionic Ear
 2. Srikanth Kumar, DARPA (Funded by ISSNIP)
 3. Feng Zhao, Microsoft Research (Funded by ISSNIP)
 4. M Srinivasan, ANU (Funded by ISSNIP)
 5. Rob Evans and Iven Mareels, University of Melbourne
 6. Hugh Durrant Whyte, University of Sydney (Funded by ISSNIP)
 7. Vittal Rao, NSF (Funded by ISSNIP)

8. Belur Dasarathy, USA (Funded by ISSNIP)
 9. David Fogel, Natural Selection (Funded by ISSNIP)
 10. Doug Cochran, DARPA (Funded by ISSNIP)
 11. Ulrich Ramacher, Infineon, Germany
 12. Terry Caelli, NICTA, Sydney (Funded by ISSNIP)
 13. Hynek Hermansky, Oregon University
 14. Mel Seigel, Carnegie Mellon University
 15. Paul Havinga, UTwente, The Netherlands
- There were four other invited talks by
 1. Prof. Yos Morsi
 2. Dr. Keith Hill
 3. Dr. Javaan Chall
 4. Dr. David O'Carroll
 - Four workshops ran in parallel on the last day and were well attended by delegates. This included DEST funded workshop on Sensor Networks, Machine Learning for Signal Processing, Bio-inspired Models and Unmanned Vehicle Systems. DEST funded workshop on Sensor Networks included eight fully funded participants from Europe (More information in workshop section).
 - The conference technical committee received about 185 papers for the conference. The committee selected top 105 papers (87 papers for oral presentation and 18 papers for poster presentation) which were published in the IEEE Proceedings.

3.1.2 Second International Conference on Intelligent Sensors, Sensor Networks and Information Processing, Melbourne, December 2005 (www.issnip.org).

See summary information below. A detailed review is provided in Appendix A.

3.1.3 First IEEE e-Science Conference, Melbourne, December 2005.

A new conference series was promoted by ARC RN on ISSNIP under its project on e-Science. The conference chair was Dr. Rajkumar Buyya who is a Chief Investigator in the RN application (Table 1 in ARC-RN Application)

Summary of Events 2 (ISSNIP 2005) and 3 (e-Science 2005):

- 6 Plenary speakers were fully funded
- 40 Post Graduate scholarships (Registration Fee Waiver) were offered
- 20 Researcher scholarships (Registration Fee Waiver) were offered
- Total attendance was approximately 350 including both conferences

- More information is provided in Appendix A.

3.2 Workshops:

The following workshops were held under the umbrella of ARC-RN on ISSNIP between October 2004 and December 2005.

3.2.1 International Workshop on Interdisciplinary Decision Making Opportunities and Challenges

Conducted in collaboration with Australian Mathematics and Statistics Institute, chaired by Moshe Sniedovich (University of Melbourne, Australia) and co-chaired by M Palaniswami and Baikunt Nath (University of Melbourne, Australia)

Type of Support: A\$2000 (Sponsorship of 20 graduate students) 21% of total expenditure

Dates: December 6-7, 2004

Attendance: 75

Post-Graduate Students: 32

Location: ICT Building, University of Melbourne

Main attendees and speakers:

Invited speakers:

Bob Bixby, ILOG Inc

Leon Sterling (University of Melbourne)

Moshe Sniedovich (University of Melbourne)

Bob Johnston (University of Melbourne)

Mark Wallace (Monash University)

Janos Pinter (PSC)

Mohan Krishnamoorthy (CSIRO)

Gary Froyland (UNSW)

Geoff Prince (AMSI)

Irv Lustig (ILOG)

Affiliations of attendees:

Australia post, BHP Billiton, CSIRO, DSTO, ILOG, Monash, Frontier Economics, Deakin, Hydro Tasmania, Optimization and Simulation Consulting, Pinter Consulting, University of Ballarat, University of Melbourne, UNSW, UWA, VUT, Swinburne University, AMSI, Wuhan University, Systemwide, Quantm, Whittle Consulting.

3.2.2 DEST funded Australia-EU Joint Workshop on Signal Processing in Sensor Networks

Chaired by A/Prof. M Palaniswami, A/Prof. P Havinga (Uni Twente, The Netherlands) and Prof. E. Oja (Helsinki University, Finland). The Research Network also succeeded in getting another grant to conduct a Joint European Australian Workshop on Signal Processing in Sensor Networks. This provided support for 12 researchers from Europe to visit Australia for this event. It was a well attended seminar exploring opportunities for collaboration between Australia and Europe.

Type of Support: Logistical Support held in conjunction with First ISSNIP.

Dates: 17 December 2004

Main Supporting Body: DEST-Australia for inviting twelve European speakers (List provided below)

Attendance: 50 national and international participants

Post-Graduate Students: At least 20

Location: Grand Hyatt, Melbourne

Main Attendees and Speakers:

1. Danny Ralph, Cambridge University, UK
2. Erdal Cayirci, Istanbul Technical University, Turkey
3. Hynek Hermansky, Oregon Institute of Technology, USA
4. Ian Oppermann, University of Oulu, Finland
5. Kay Roemer, ETH Zurich, Switzerland
6. Lodewijk Van Hoesel, University of Twente, The Netherlands
7. Paul Havinga, University of Twente, The Netherlands
8. Philippe Dallemagne, Switzerland
9. Ralf Kernchen, University of Surrey, UK
10. Ron Lawes, Imperial College London, UK
11. Stefan Dulman, University of Twente, The Netherlands
12. Tim Nieberg, University of Twente, The Netherlands
13. Ulrich Ramacher, Infineon Technology, Germany
14. Subhrakanti Dey, University of Melbourne, Australia
15. M. Hedley, CSIRO, Australia
16. Pubudu Parthirana, Deakin University, Australia
17. Palaniswami M, University of Melbourne, Australia
18. Subhash Challa, UTS, Australia
19. Slaven Marusic, UNSW, Australia
20. Thomas Hanselmann, University of Melbourne, Australia

3.2.3 Unmanned Vehicle Systems

Type of Support: Logistical Support held in conjunction with First ISSNIP

Date: 17 December 2004

Attendance: 60 national and international participants

Post-Graduate Students: At least 30

Papers Presented: 2

Location: Grand Hyatt, Melbourne

Main Attendees and Speakers:

Chair: Anthony Finn, DSTO

Mel Siegel, Carnegie Mellon University, USA

Javaan Chahl, University of South Australia, Australia

3.2.4 Machine Learning in Sensor Networks

Type of Support: Logistical Support held in conjunction with First ISSNIP

Date: 17 December 2004

Attendance: 40 national and international participants

Post-Graduate Students: At least 20

Papers Presented: 8

Location: Grand Hyatt, Melbourne

Main Attendees and Speakers:

Chair: Arcot Sowmya, UNSW, Australia

Terri Caelli, NICTA, Australia

3.2.5 Bio-inspired models

Type of Support: Logistical Support held in conjunction with First ISSNIP

Date: 17 December 2004

Attendance: 40 national and international participants

Post-Graduate Students: At least 20

Papers Presented: 8

Location: Grand Hyatt, Melbourne

Main Attendees and Speakers:

Chair: David Grayden, Bionic Ear Institute, Australia

David O'Carroll, University of South Australia, Australia

Hynek Hermansky, Oregon Institute Technology, USA.

Graeme Clark, The Bionic Ear, Australia

3.3 Education Workshops

3.3.1 Workshop for mobile devices to develop wireless sensor networks

The focus of the three day workshop was on distributed sensor networks using mobile phone technology. This workshop was organised at RMIT and run by Professor Weghorn from Germany. The workshop incorporated theoretical and practical components. It involved an interactive workshop where the participants participated in hands-on programming of mobile devices, providing a unique perspective of how existing and easily available mobile devices could be used for developing complex sensor networks that could use blue tooth or satellite communication technology.

Type of Support: ISSNIP supported the hotel accommodation of Professor Hans Weghorn worth approximately \$400. The balance of approximately \$3500 that includes the airfares and other expenses were paid by other sources.

Attendance: 21

Post-Graduate Students: 15

Location: RMIT, School of Electrical and Computer Engineering.

Affiliations of attendees: RMIT, Melbourne University, Victoria University of Technology and industry.

Invited Speakers:

Prof Weghorn, University of Stuttgart, Germany.

3.3.2 Workshop on 'applications of signal processing'

The Workshop on 'applications of signal processing' was run by Associate Professor Dinesh Kumar at Stuttgart, Germany. There were 28 attendees, most of these were sponsored by IBM, Germany, and HP-Germany. The three day interactive workshop offered participants hands-on experience in identifying means of reducing data transfer between multiple sensors for remote monitoring.

Type of Support: All expenses covered by other sources.

Attendance: 28

Post-Graduate Students: 28

Location: Department of Information Technology, University - Stuttgart, Germany.

Affiliations of attendees: 50% IBM sponsored and 50% sponsored by HP- Germany.

Invited Speakers:

Chair: A/Prof. Dinesh Kant Kumar, RMIT, Australia.

4. International out-reach and Value Addition

Many international visits were made as the result of Research Network. The Convenor A/Prof. Palaniswami visited Spain, India and Singapore for international collaborations in Sensor Networks. He also delivered invited/plenary talks at several conferences in Melbourne and abroad. At least 15 overseas researchers visited Australia for activities relating to the network. As a result of DEST funding, 15 European researchers visited Melbourne. In addition to these, 6 world leading overseas researchers delivered key-note lectures in ISSNIP 2004 and another 8 overseas researchers in ISSNIP 2005. Dr. Stefan Dulman and A/Prof. P Havinga made separate visits to Melbourne in connection with creation of sensor network test beds at the University of Melbourne and the Great Barrier Reef. As an indication of international recognition for Australian work, the convener of the network was invited by various forums abroad (see below)

1. Invited Talk, 14th International ADCOM Conference, Mangalore, Dec 2006
2. Keynote Talk, First IEEE e-Science Conference (Special Workshop Track), Melbourne, Dec 2005.
3. Plenary Talk, Ninth Knowledge Engineering Systems (KES-2005), Melbourne, Sep 2005.
4. Keynote Talk, 3rd International Conference on Informatics in Control, Automation and Robotics, Spain 2005
5. Keynote Talk, 2nd International Conference on Informatics in Control, Automation and Robotics (ICINCO), Spain 2005, discussing the latest developments of Sensors Networks.
6. Keynote Talk, International Conference on Sensor Networks, Singapore, Jun 2005.
7. Member of External Advisory Board, CRUISE Consortium, European 6th Framework funded centre, Denmark. (From 2006)
8. Member of NSF Review Panel for Sensor Networks, National Science Foundation, USA.
9. Publicity Chair, IEEE World Congress on Computational Intelligence, Vancouver, Canada, 2006.
10. Program Committee member for several sensor network conferences.

International outreach activities, showcasing some of the Australian expertise of the ISSNIP RN, by other network members included for example those of A/Prof D. K. Kumar. These include:

1. Chair & invited speaker, Workshop on 'applications of signal processing', Stuttgart, Germany (described earlier).

2. Invited program chair, the 2nd International Conference on Informatics in Control, Automation and Robotics (ICINCO), Spain 2005, for sensing and analysis of biosignals for sensing human movement.
3. Invited expert, BPC 2005, Barcelona, Spain, for emotive machine sensing.
4. Awarded scholarship from Johns Hopkins University for developing signal classification techniques for acoustic sensor networks. The work was carried out over three months at The University of California in San Diego, USA.

Without ARC-RN on ISSNIP being formed it would have been rather difficult to establish a series of conferences with so many top class international speakers visiting Australia. One of the plenary speakers who was invited (Dr. Danyl Prokorov) was so impressed that there is now a proposal for the 2008 INNS International Conference to be held jointly with ISSNIP.

It is obvious that the DEST-ISL funding was granted to supplement the Research Network activities. This funding is quite a substantial amount (\$1.1M only from DEST) and has created about 6 Research Associate positions and at least 12 overseas exchange activities annually. Another request of about a \$1M has been made to the ARC (LIEF Funding) for test bed preparation which will be the first of its kind in Australia. A new ISL application in e-Science has been submitted to DEST.

The convener is also an international partner in a new National Science Foundation (NSF) grant on SENSORS: Approximate Dynamic Programming for Dynamic Scheduling and Control in Sensor Networks. Dr. Ganesh Kumar Venayagamoorthy who is the principal investigator for this NSF grant is ISSNIP Partner Investigator.

Taking note of the international accomplishments, the convener strongly believes that the key-note talks and EU collaborations established during the past year is largely due to ARC RN on ISSNIP, having significantly raised the profile of Australian RN members around the world and promoting their associated expertise in the priority research areas of the RN.

5. Research Network Profile

The objective of the ARC RN on ISSNIP to continue to raise the profile of Australian researchers both locally and internationally was successfully achieved in these initial stages of the Network's operation. This was achieved through international media coverage of RN events as well as significant publications of ISSNIP research emanating from the Network, serving to demonstrate the expertise of RN participants. Added to these is the continually improving RN website, which is successfully serving as a primary interface and access point for ISSNIP RN activities. All of these items, while increasing the RN profile, simultaneously provide an opportunity for increased research collaboration. This objective will continue to be pursued by building on the momentum already generated in increasing the profile of the ARC RN, its activities and its participants.

5.1 Media coverage

1. RN team's work has received wide publicity in UniNews (14th November 2005) and The Australian (Nov 2005)
2. RN team's professional contribution was featured in the Indian Media (Both print and Television including The Hindu (4, 5, 7 Jan 2005; 15 Dec 2005), Indian Express (4, 7 Jan 2005; 15, 16 Dec 2005), News Today (6 Jan 2005), JTV during the conferences conducted between Jan 2004 to Jan 2006)

5.2 Publications

There were several publications in Books, Journals and Conferences with network members. Listed below are only some of the most significant book publications directly resulting from ARC Research Network activity.

1. PALANISWAMI M & KRISHNAMACHARI B. Guest Editors, International Journal on Distributed Sensor Networks. Taylor and Francis 2005.
2. PALANISWAMI M, PATNAIK LM, VENUGOPAL K, RAJ KANNAN, RAJEEV KHOSLA, Editors, IEEE Proceedings of Third International Conference on Intelligent Sensing and Information Processing, 2005.
3. PALANISWAMI M, PAUL HAVINGA, ARCOT SOWMYA, SUBHASH CHALLA, Editors, IEEE Proceedings of Second International Conference on Intelligent Sensors, Sensor networks and Information Processing, 2005.

4. PALANISWAMI M, CHANDRASEKHAR C, RAMASUBBA REDDY, RAVINDRAN B, HEMA A. MURTHY, Editors, IEEE Proceedings of Second International Conference on Intelligent Sensing and Information Processing, 2005.
5. PALANISWAMI M, EROL HARVEY, ARCOT SOWMYA, SUBHASH CHALLA, BHASKAR KRISHNAMACHARI, Editors, IEEE Proceedings of First International Conference on Intelligent Sensors, Sensor networks and Information Processing, 2004.
6. PALANISWAMI, M, CHANDRASEKHAR, B., VINAYAGAMURTHY, G.K, KHANTSALA, M., AND MOHAN, (Editors). IEEE Proc. International Conference on Intelligent Sensing and Information processing, IEEE Press, NY, 2004.

The following list of publications is but a sample of those emanating from collaborative research enabled by the RN.

1. BEGG RK, PALANISWAMI M & OWEN B, Support vector machines for automated gait recognition. IEEE Transactions on Biomedical Engineering, 52, 828-838, 2005.
2. LAI, D., SHILTON, A., MANI, N. AND PALANISWAMI, M. - A convergence rate estimate for the SVM Decomposition Method in Proc. of the International Joint conference on Neural Networks, Montreal, August 1-4, 2005, page 931-936., 2005
3. BEGG RK, LAI D, TAYLOR S & PALANISWAMI M, SVM models in the assessment of balance impairments. The Third International Conference on Intelligent Sensing and Information Processing, December, Bangalore, India. (Best paper award), 2005.
4. BEGG RK, HASSAN, R, TAYLOR, S & PALANISWAMI M, Artificial neural network models in the assessment of balance impairments. Proceedings of the International Conference on Intelligent Sensing and Information Processing, (IEEE Press), January, Chennai, India, 2005.
5. BEGG, RK, PALANISWAMI, M, OWEN B, TAYLOR S & DELLORO L - MFC Histogram and Poincar Plot Images for Automated Gait Detection. Proceedings of the International Conference on Intelligent Sensing and Information Processing, IEEE Press, Jan 4-7, Chennai, India. Page(s): 368-372, 2004.
6. Lai, D., Mani, N. and Palaniswami, M. An Extrapolated Sequential Minimal Optimisation Algorithm for Support Vector Machines, In Proc. of International Conference on Intelligent Sensing and Information Processing, IEEE Press, Jan 4-7, Chennai, 2004.
7. Begg, R., Palaniswami, M., Owen, B., Taylor, S., and Delloro, L. - MFC Histogram and Poincar Plot Images for Automated Gait Detection, in Proc. of International Conference on Intelligent Sensing and Information Processing, IEEE Press, Jan 4-7, Chennai, 2004.
8. W. H. WANG, M. PALANISWAMI AND S. H. LOW, "Application oriented flow control: fundamentals, algorithms and fairness", IEEE/ACM Transactions on Networking, to appear in 2006.

5.3 Research Network Webpage

The network website is www.sensornetworks.net.au. Totally the current web hits are more than 10,000. We are modifying the web and making it more interactive based on valuable feedback we received last year.

6. Grant applications

In keeping with the RN objective of attracting further research funding for Australian researchers to conduct work in the priority areas of the Network, significant progress has been made. A number of applications for funding have been successful with more in preparation:

1. DEST EU-Australia Joint workshop on Distributed Sensor Networks, December 2004.
2. DEST-ISL (DEST-International Science Linkage) grant of \$1.1M (Total \$2.3M including partner contributions) for projects complementing ISSNIP network themes. This involves international researchers from European Union and the US, June 2005.
3. NSF Grant on SENSORS: Approximate Dynamic Programming for Dynamic Scheduling and Control in Sensor Networks (Ganesh Kumar Venayagamoorthy, Derong Liu, M Palaniswami)
4. A new ARC LIEF grant proposal is under preparation for creating a large Wireless Sensor Network test-bed (BigNet) in The University of Melbourne and in the Great Barrier Reef (St. Davis Reef).
5. A new ARC Linkage grant in association with other research networks has been submitted.
6. Associate Professor D. K. Kumar submitted an application to Baden-Wurttemberg to fund the exchange of students working on the topics related to Sensor Networks and Biosignal analysis.
7. DEST-ISL application on e-Science has been submitted.

7. National benefit

The development of a world class national research and industry capability in sensor network technology is of great national importance. Sensor networks provide the ability to gather information cheaply, accurately and reliably over both small and vast physical regions ranging from inside a human body to across a whole country. This amazing property of sensor networks opens up previously unforeseen opportunities especially in the areas of environment, security and health.

The nature of the activities undertaken by ISSNIP clearly advances Frontier Technologies. The collection of expertise aiming to solve the underlying scientific problems associated with sensors and sensor networks will provide the technological breakthroughs to put Australian industry in a position to fill niche markets.

The DEST-ISL grant has enabled the ISSNIP group to deploy sensor networks for environment monitoring. Efforts are underway to deploy sensors in Davies Reef of the Great Barrier Reef, a region that attracts significant tourism in Australia. The collaboration with DSTO on geo-location is intended to enhance the Australian Defence capabilities in surveillance and monitoring of Australia's vast borders. Already a number of research publications have been made related to this area in international conference and book chapters. In the area of health, efforts are underway to initiate an industry-linkage program for online monitoring of patient's health. This will be made possible by low cost sensors for monitoring ECG, BP and other vital parameters, while addressing the key challenges of security and privacy.

Overall, the activities of the convener and other participants in the research network are firmly on the path to make Australia one of the key players in Sensor Network Technology. In less than 18 months the research network has been able to build new collaborations and obtain new grants in the area. The RN has conducted conferences and several workshops to train young Australians and post graduate students in the area. The participants have given several international lectures demonstrating the capabilities of Australian researchers. It has put Australia on the international map in sensor network technology through media coverage in Australia and overseas.

8. Research Network Membership and Collaboration

8.1 Active and New Participants

At the time of applications there were 50 primary participants including the international researchers, and up to 148 total participants (including affiliated researchers and post-graduate students). The research network has attracted many more researchers including Rezaul Begg (Victoria University), N Mani (Monash University), C Manzie, M Duckham, BN Vo (All from the University of Melbourne), I Atkinson (James Cook University), B. Pailthorpe (QPSF, University of Queensland) and Pubudu Pathirana (Deakin University). Priyan Mandis, Convenor of another research network is a new active participant of the network. In December 2004 and in December 2005, research network meetings were held with most senior participants and several junior participants. The meetings intended to establish strategies to increase network activities via conferences, workshops and courses, and to attract more funding for projects.

8.2 New Collaborations

The DEST-ISL grant brought together several new members. A/Prof. P Havinga (UTwente) is an active member from the European Union. We are using sensor nodes contributed from Ambient System Sensor for some of our research. Prof. Havinga and Dr. Dulman have made separate visits to Melbourne and the Great Barrier Reef as a result of this project. At the national level, there is new collaboration between Prof. Pailthorpe, Dr. Atkinson, Mr. S Kininmonth (AIMS) and A/Prof. Palaniswami in creating an infrastructure framework to deploy sensors in the Great Barrier Reef for environment monitoring. The new collaborations between industries like Decisioneering Systems (environmental monitoring), Road Traffic Authority (NSW), and Iomniscient (Visual Surveillance systems) have enhanced the Research-Industry Program.

8.2.1 Funded Visitors

Several visits were made by international researchers as a network activity. The visits included University of Melbourne, La Trobe University, Monash University, James Cook University, University of New South Wales, University of Technology, Sydney, Australian Institute of Marine Science and RMIT University. The following were the funded researchers (Figures are indicative only):

1. Kingsbury, Cambridge University, UK (\$11,000) – 2 Visits
2. Havinga, UTwente, The Netherlands (\$6,920) – 2 Visits
3. Venkateswarulu, A-Star, Singapore (\$1,750)
4. Liu, Harvard University, USA (\$4,000)

5. Dulman, UTwente, The Netherlands (\$8,000) – 2 Visits
6. Marshall, University of Kent, UK (\$4,000)
7. Oja, Helsinki, Finland (\$4,000)
8. Milner, University of Maryland, USA (\$4,000)
9. Prokhorov, Toyota, USA (\$4,000)
10. Kumar, DARPA (\$4,000)
11. Zhao, Microsoft Research (\$4,000)
12. Dasarathy, USA (\$4,000)
13. Fogel, Natural Selection (\$4,000)
14. Cochran, DARPA (\$4,000)

8.3 Research Network Participants

(List of primary participants as of 31st March 2006)

Title	First Name	Last Name
Professor	Adrian J	Baddeley
Professor	Peter	Bartlett
Associate Professor	Natashia	Boland
Professor	Abdesselam	Bouzerdoum
Professor	Rajkumar	Buyya
Professor	Subhash	Challa
Professor	Ron	Chen
Dr	Vaughan	Clarkson
Professor	Stuart	Crozier
Associate Professor	Subhrakanti	Dey
Dr	Gamini	Dissanayake
Professor	Hugh F	Durrant-Whyte
Professor	Rob J	Evans
Professor	Muralidhar K	Ghantasala
Professor	Doug	Gray
Professor	Erol C	Harvey
Professor	Cliff	Hooker
Professor	S. Sitharama	Iyengar
Dr / Professor	Lindsay	Kleeman
Professor	Rao	Kotagiri
Professor	Mohan	Krishnamoorthy
Professor	Vikram	Krishnamurthy
Associate Professor	Dinesh	Kumar
Professor	Steven	Low
Professor	Iven	Mareels
Professor	Bill	Moran
Dr	David C	O'Carroll
Professor	Ian	Petersen
Associate Professor	Himanshu Roy	Pota
Dr	Daniel	Ralph
Associate Professor	Predrag	Rapajic
Professor	Alex	Rubinov
Professor	Andrey	Savkin
Dr	Len J	Sciacca
Professor	Aruna	Seneviratne

Professor	Kate A	Smith
Professor	Arcot	Sowmya
Dr	Mandayam A	Srinivasan
Dr	Mandyam V	Srinivasan
Professor	David	Suter
Associate Professor	David	Tay
Professor	Svetha	Venkatesh
Associate Professor	Brijesh	Verma
Professor	Geoff	West
Professor	Lang	White
Professor	Abdelhak M	Zoubir
Professor	Moshe	Zukerman
Professor	Yianni	Attikiouzel
Associate professor	Rezaul	Begg
Dr	Nallasamy	Mani
Associate Professor	Ian	Atkinson
Professor	Bernard	Pailthorpe
Dr	Pubudu	Pathirana
Associate professor	Priyan	Mandis
Dr	Ba-Ngu	Vo
Dr	Chris	Manzie
Dr	Mark	Duckham

9. Strategies for the coming year (Jan 2006 – Dec 2006)

9.1 Strategic Priority 1- national collaboration and identity

- To conduct a workshop in Townsville (**Great Barrier Reef**) where the sensors are being deployed. This would give participants a good understanding of the problem and assist them in designing superior algorithms.
- A new website is being created which will be more interactive.
- A new journal is being planned.

9.2 Strategic Priority 2- industry linkage

- Industry Linkage grants/DARPA grant applications in 2006.
- Initial talks with Iomniscient Pty Ltd are underway for a Linkage Grant on Visual Sensor Networks

9.3 Strategic Priority 3- international linkages

- The Third International Conference on ISSNIP will be held in Melbourne during November 2007
- International Workshop on Biomedical Informatics along side International Conference on Intelligent Sensing and Information Processing (www.icisip.org)
- A new Indo-Australian group is being formed to leverage the recently announced (by DEST) grant by prime Minister John Howard to build collaborative research
- EuroSSC 2006 is partially funded by ISSNIP which is to be held in the Netherlands during October 2006
- DEST-ISL program in grid computing and e-science is being sought for 2006.

9.4 Strategic Priority 4- education

- A PhD student workshop is being planned. Another workshop on Middleware for Sensor Networks will be held in Melbourne in December 2006
- Local school (Ringwood Public School) is engaged for creating awareness among students about sensor networks
- Several undergraduate sensor network projects are to be integrated to support the UG course curriculum and to raise the collaborative levels of the undergraduate students.
- Sensor Networks course development is underway
- Additional workshops with the following focus are also being planned:
 - Security in mobile devices based sensor networks to be organised in Melbourne.
 - Telehealth applications for distributed systems to be organised in Stuttgart.
 - Bio-classification workshop in Melbourne.
 - A series of seminars related to different issues on sensors and signals.

9.5 Strategic Priority 5- future funding

- A new ARC LIEF grant proposal is being prepared. This would enable the RN to create test-beds for simulation and testing of algorithms off-site.
- Discussions on a new proposal for European Framework are underway.
- Proposal for a new Indo-Australian collaborative project on Sensor Networks for healthcare and rural sector is underway

10. Glossary

ADFA-UNSW	Australian Defence Force Academy UNSW
AIMS	Australian Institute of Marine Science
AMSI	Australian Mathematical Sciences Institute
ANU	Australian National University
ARC	Australian Research Council
CENDS	Centre of Expertise for Networked Decision Systems
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSSIP	Cooperative Research Centre for Sensor Signal and Information Processing
DARPA	Defence Advanced Research Program Agency
DEST	Department of Education Science and Training
DEST-ISL	DEST International Science Linkages Programme
DSTO	Defence Science and Technology Organisation
EuroSSC	European Conference on Smart Sensing & Context
IEEE	Institute of Electrical and Electronics Engineers
IEEE EMBS	IEEE Engineering in Medicine and Biology Society
ISSNIP	Intelligent Sensors, Sensor Networks and Information Processing
JCU	James Cook University
LIEF	Linkage—Infrastructure, Equipment and Facilities
NICTA	National ICT Australia
QPSF	Queensland Parallel Supercomputer Facility
RN	Research Network
UNSW	University of New South Wales
UQ	University of Queensland
UTS	University of Technology, Sydney
UWA	University of Western Australia
VPAC	Victorian Partnership for Advanced Computing