



# Annual Report FY2008

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## Productive and Rewarding

Overall, FY2008 has been a productive and rewarding year for I<sup>2</sup>R. We published 453 papers in prestigious journals and conferences; submitted 146 Technology Disclosures, filed 49 patents and were granted 27 patents. I<sup>2</sup>R and its staff won numerous awards including the IES Prestigious Engineering Achievement Awards 2008, Technology Review (TR35) 2008, Nokia Visiting Professor, as well as outstanding mentors and teacher advisors awards from MOE.

We had a number of significant breakthroughs and strong contributions to international standards. For instance, I<sup>2</sup>R's patented scheme had been successfully adopted in the China WPAN high rate UWB specification draft in the 11th C-WPAN plenary meeting. The schemes could enhance network throughput by as much as four times with only a slight increase in hardware complexity and provide a finer synchronization mechanism.

We also achieved significant results in various international benchmarking competitions. In particular, we were very happy that the Speech Group from I<sup>2</sup>R's Human Language Technology Department won overall first position in the 2008 National Institute of Standards and Technology Speaker Recognition Evaluation (Core Test Condition); I<sup>2</sup>R Brain-Computer Interface (BCI) team won No. 1 position (amongst the 35 international teams) in the BCI Competition IV, 2008, in all three electro-encephalograms (EEG) based non-invasive BCI categories; FCC test report on white-space device testing reported that the I<sup>2</sup>R device for sensing digital TV and wireless microphone was superior in an actual field trial; NUS-I<sup>2</sup>R team won first place in the liver tumor segmentation performance competition (in the semi-automatic category) organized by the workshop: 3D segmentation in the clinic, A Grand Challenge II, held in New York on Sept. 6-10 in the leading international medical imaging conference, MICCAI2008.



We received cash funding for 21 industry projects and we signed 26 new licensing deals. We seconded 7 RSEs through T-UP to the local Industries. We also licensed out numerous technologies to local and international companies. We initiated 9 new research collaboration projects with the local universities: NUS, NTU and SMU. We also initiated 12 research collaboration projects with international research organizations.

At the end of FY2008, we had 319 researchers, of which, 57% had PhD., 30% had Master and 13% had Bachelor degrees. In terms of our pipeline to industry, 17 RSE/RTS's left I<sup>2</sup>R to join the industry during this period.

We extended our outreach activities to involve some 731 secondary and JC students, up by 118 % from 336 in FY2007. The activities to inspire the young took the form of: "Meet the Scientist" talks; A\*STAR-MOE JCI Student attachment; A\*STAR Young Researchers Attachment Programme (YRAP); X-periments@ Science.08 Exhibition; Infocomm and Media Horizons; Youth Science Conference; Singapore Science & Engineering Fair, Research Exposure Program (REP) and such.

A handwritten signature in red ink, appearing to read 'Lye Kin Mun'. The signature is stylized and cursive.

**Professor Lye Kin Mun**  
**Deputy Executive Director (Research)**

# Mission and Vision Statements

With the continuing importance of Info-Comm and Media (ICM) technologies to the economy of Singapore, I<sup>2</sup>R is well positioned to play a crucial role in knowledge creation, high-level manpower training, and supporting the local ICM industry to create economic impact for Singapore. To do this successfully, I<sup>2</sup>R must strive to attract and nurture the best team with the dedication and passion to excel and to yield the best outcomes that will earn a place for I<sup>2</sup>R in the annals of technical achievement globally.

**Our vision:**

*The Infocomm and Media value creator that keeps Singapore ahead*

**Our mission:**

*To be the globally preferred source of innovation in “Interactive Secured Information, Content and Services Anytime Anywhere”, through research by passionate people dedicated to Singapore’s economic success.*

As such we place our core values in:

- Integrity – we carry out our responsibilities in an honest and trustworthy manner
- Action – we are action-oriented and strive to excel in what we do
- Speed – we work swiftly and conscientiously to ensure no momentum is lost
- Teamwork – we build on each other’s strengths so that all can win
- Agility – we adapt our plans and actions to take into account changes
- Resolve – we are dedicated and determined to achieve our mission

To move us in the right direction, we need an environment that fosters *passion for innovation* and *dedication to excellence*. Incentives and recognition systems must be in place to encourage a “Dare to Dream” culture tempered with a balanced realization of practicalities and of the need to ensure that the fruits of our intellectual pursuits are pertinent to the needs of industry.

Quality processes are needed to monitor, assist and manage the knowledge creation activities aided by appropriate use of automation and IT. A transparent and well-administered performance-based system instils confidence and direction so that each and every staff strives to do his best.

# Organisation Structure

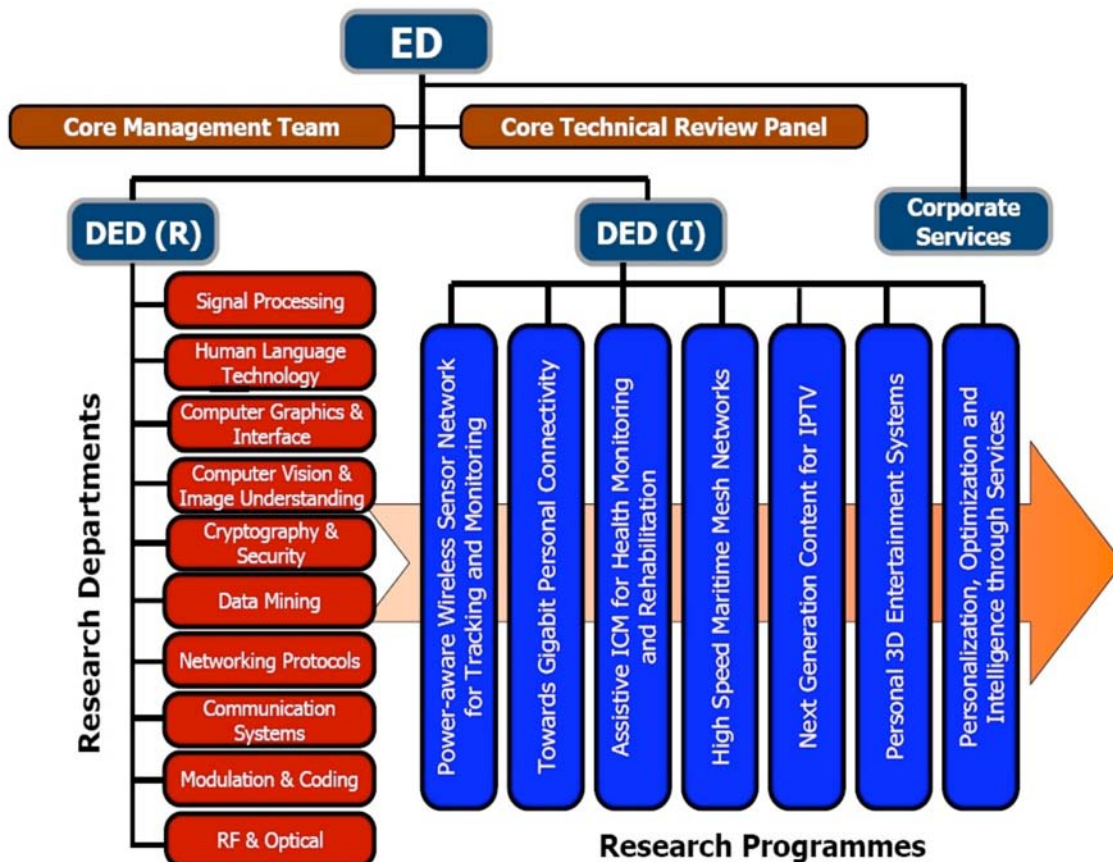


Figure 1: Organisation Chart

## Management Team

### Executive Committee

Chair:	Prof. Chong Tow Chong	(ED, SERC)
Members:	Prof. Lye Kin Mun	(DED, Research, I <sup>2</sup> R)
	Dr. Lim Khiang Wee	(DED, SERC)
	Dr. Raj Thampuran	(Director, SERC)

### Core Management Team

Prof. Lye Kin Mun  
 Mr. Budiman Sastra  
 Dr. Michael Chia Yan Wah  
 Dr. Susanto Rahardja  
 A/Prof. Tham Chen Khong  
 Dr. Ng See Kiong  
 Dr. Cheah Kok Beng

### **Programme Directors/Managers**

- Dr Michael Chia Yan Wah, Programme Director  
Power-aware Wireless Sensor Network for Tracking and Monitoring
- Dr Susanto Rahardja, Programme Director  
Personal 3D Entertainment Systems
- Dr Chin Po Shin Francois, Programme Manager  
Towards Gigabit Personal Connectivity
- Dr Guan Cuntai, Programme Manager  
Assistive ICM for Health Monitoring and Rehabilitation
- Dr Jaya Shankar s/o Pathmasuntharam, Programme Manager  
High Speed Maritime Mesh Networks
- Dr Yau Wei Yun, Programme Manager  
Next Generation Content for IPTV
- Assoc Prof Tham Chen Khong, Programme Manager  
Personalization, Optimization and Intelligence through Services

### **Department Heads**

- Mr Ashok Kumar Marath, Department Head  
Communication Systems
- Dr Bao Feng, Department Head  
Cryptography and Security
- Dr Chen Zhi Ning, Department Head  
RF and Optical
- Dr Huang Zhiyong, Acting Department Head  
Computer Graphics and Interface
- Dr Li Haizhou, Department Head  
Human Language Technology
- Dr Lim Joo Hwee, Acting Department Head  
Computer Vision and Image Understanding
- Dr Ng See Kiong, Department Head  
Data Mining
- Dr Susanto Rahardja, Department Head  
Signal Processing
- Dr Sun Sumei, Acting Department Head  
Modulation and Coding
- A/Prof Tham Chen Khong, Department Head  
Networking Protocols

# III. Significant Achievements for FY2008

## Achievements

I<sup>2</sup>R made significant achievements in FY2008 in the following areas:

- Creation of intellectual capital
- Development of human capital
- Transfer of technology and know-how to industry

In terms of creating new knowledge and technologies, I<sup>2</sup>R filed 146 technology disclosures, as well as published 453 research papers in leading and reputable journals and conferences (SCI/EI database). In addition, 27 of our earlier patent filings were granted during this FY.

In terms of training students & researchers and sharing human capital, I<sup>2</sup>R trained 43 PhD students and 10 Master students, spun out 17 staff to industry and had 6 T-Ups to local firms.

In terms of technology-transfer, I<sup>2</sup>R had 26 new licensing deals and 21 industry projects.

In FY2007, the institute transformed from a Divisional Structure to a Matrix Structure (so as to better achieve the 3 major goals above). Thus, during FY2008, the institute continued adapting to the new structure and processes were further fine-tuned accordingly. This significant reorganization was undertaken to better respond to the changing technology landscape. Based on the experience thus far, the Matrix structure helped the institute to be more agile and responsive, while also providing more efficient use of staff time.

During FY2009, a significant new approach will be instituted for refreshing the existing Programmes as they are intended to reach end-of-life in mid-2010. The plan is detailed under Section IX and will be executed in FY2009.

In FY2008, I<sup>2</sup>R had a number of significant breakthroughs as R&D achievements and contributed significantly in international standards.

- The Speech Group from I<sup>2</sup>R's Human Language Technology Department won overall first position in the National Institute of Standards and Technology 2008 Speaker Recognition Evaluation (Core Test Condition). 44 international organizations participated in the benchmarking (core test condition). I<sup>2</sup>R team members comprised Haizhou Li, Bin Ma, Hanwu Sun, Donglai Zhu, Kong-Aik Lee, Khe Chai Sim, Changhuai You, Rong Tong, Ismo Kärkkäinen, Vladimir Pervouchine, Susanto Rahardja, and I<sup>2</sup>R interns Yijie Li (USTC, China), Chien-Lin Huang (NTU), Julien Epps (UNSW, Australia) and Qin Jin (CMU, USA).
- Two schemes proposed by I<sup>2</sup>R had been successfully adopted in China WPAN high rate UWB standard specification draft in the recent 10th CWPAN June 2008 plenary meeting in Nanjing, China. The schemes could enhance network throughput by as much as four times with only a slight increase in hardware complexity and provide a finer synchronization mechanism. This enabled higher efficiency in wireless UWB networks while minimizing capital investment. Staff involved: Xiaoming Peng, Ananth Subramanian and Francois Chin.

- The automatic run submission by Dr. Gao Sheng from Computer Vision and Image Understanding Dept. (CVIU), participated under the name of IPAL, emerged as 2nd (text modality), 4th (image modality) and 3rd (image+text modalities) among 25 participating research groups from Europe, Asia and North America, in the Photographic Image Retrieval Task (ImageCLEFPhoto) of ImageCLEF 2008.
- I<sup>2</sup>R FAMS Project (FAMS – An Intelligent Fish Activity Monitoring Technology to Ensure Water Quality) won the IES Prestigious Engineering Achievement Awards 2008. This was a joint project between I<sup>2</sup>R and PUB. The team comprised Eng How Lung, Chew Boon Fong, Lee Beng Hai, Myo Thida and Suryanti Yunita Anggrelly from Computer Vision and Image Understanding (CVIU) Dept.
- I<sup>2</sup>R's patented scheme has been successfully adopted in China WPAN high rate UWB specification draft in the recent 11th C-WPAN plenary meeting in China Hangzhou. The same scheme has also been successfully adopted in ECMA TC48 60GHz mmWave specification draft, which would be subsequently adopted by WiMedia high rate UWB Alliance. The scheme enables robust video / data transmission in dynamic and fast time varying scenarios via power control and rate control at the transmitter side. Staff involved: Ananth Subramanian, Peng Xiaoming and Francois Chin.
- FCC had officially released the test report on white-space device testing (spectrum sensing for cognitive radio). In addition, FCC was pleased with the test results and had recommended opening up TV spectrum for such secondary access. Our device's performance was superior in sensing digital TV and wireless microphone in actual field trial. They proposed to vote for such usage in their next commission meeting.
- NUS-I<sup>2</sup>R team won the first place in the liver tumor segmentation performance competition (in the semiautomatic category) organized by the workshop: 3D segmentation in the clinic, A Grand Challenge II, held in New York on Sept. 6-10 in the leading international medical imaging conference, MICCAI2008.
- A team of researchers from I<sup>2</sup>R Brain-Computer Interface (BCI) team won No. 1 position (amongst the 35 international teams) in the BCI Competition IV, 2008, in all three electroencephalogram (EEG) based non-invasive BCI categories. The results were announced on 12 December 2008, at the Neural Information Processing Systems (NIPS) conference in Vancouver, Canada.. The I<sup>2</sup>R team consists of Zhang Haihong, Ang Kai Keng, Chin Zheng Yang, Guan Cuntai, Wang Chuanchu, Phua Kok Soon, Brahim Hamadicharef and Tee Keng Peng.
- The team from CVIU Dept. (Li Liyuan, Luo Ruijiang, Dong Li, YuXinguo, Chin Tat Jun and Hoe Kah Eng, Jerry) in partnership with NUS reached the finals of the TechX Robot Competition. This was a competition on urban warfare robot organized by Mindef with a prize of S\$1 million. The team was one of the five (out of 9 teams) that passed the qualifying rounds to reach the finals. I<sup>2</sup>R's team was responsible for developing the robot vision system needed to identify objects, building and the surroundings.
- The IPTV programme had started collaboration with IDA since mid May to jointly explore the feasibility of defining a reference design model for an IPTV open access Universal Set-top Box (USTB) to be used in the NBN, covering middleware and hardware.
- FAMS (Fish Activity Monitoring System) project was shortlisted for 2nd round selection as one of the final 8 to be presented on 23rd August for the IES Asean Outstanding Award/ IES Prestigious Engineering Achievement Award. The team comprised Eng How Lung, Lee Beng Hai, Chew Boon Fong, Myo Thida and Suryanti Yunita Anggrelly.

# IV. Core Research and Technology Areas

**Using the matrix organization structure, our core research areas are grouped into 10 Research Departments and 7 Research Programmes:**

## Research Departments

### **Department: Communications Systems**

The department aims to pioneer new systems and communication needs of the future, by identifying and developing core technologies, and integrating them to form total system solutions to solve communication problems. Technologies are examined from the viewpoint of potential applications, and systems defined to put solutions in place.

The Department also introduces system engineering concepts in the execution of complex projects, striving for modularity, scalability and reusability in our systems. It defines methodologies and architectures which enable it to achieve optimum solutions, integrating new research outputs with past results.

The Department focuses on real time software and embedded system design and development, to translate research outputs to functional prototypes. Using the latest development tools and most relevant design methodologies, it aims to implement concept-proving prototypes in a timely manner. This systems approach is further extended to cover end-to-end user applications.

### **Key Competencies**

- Development of communication systems
- Provision of architectural design, embedded systems and real time software design at the systems level

### **Department: Computer Graphics and Interface**

Researchers from the Computer Graphics and Interface department engage in theoretical and practical research in the areas of computer graphics, brain-computer interfaces and context awareness computer interfaces.

### **Key Competencies**

- High performance P300-based brain-computer interfaces
- Accurate motor imagery detection and classification
- A trusted, spontaneous, scalable middleware to support the ad-hoc interactions between previously unseen devices and environment or services
- 3D modelling, rendering, animation and imaging

### **Potential Applications**

Research outputs from the department are particularly relevant for assistive ICT systems for monitoring and rehabilitation for the elderly and Personal 3D entertainment systems.

### **Department: Computer Vision and Image Understanding**

Visual data dominates our daily perceptual and cognitive activities. With advances in image acquisition technology and socio-economic proliferation of imaging behaviours, more and better quality images and videos are being generated from static surveillance cameras, digital image and video cameras, camera phones, medical imaging devices and so on.

Computer-assisted image understanding tools and systems can help organise the voluminous production and archives of image data and media content, providing invaluable assistance in security enforcement, query and retrieval, and decision making.

The department possesses sound technical competence in computer vision, and an outstanding track record in international publications, international benchmark competitions, international standards, and industrial applications. It leverages on these strengths to create intellectual properties related to image understanding, and to apply the results of R&D towards addressing real world problems.

### **Key Competencies**

- Image and video retrieval
- Object, scene and event recognition
- Human identity and activity modeling
- Active and passive media authentication
- Statistical methods and learning
- Performance evaluation

### **Potential Applications**

The department focuses on developing solutions related to visual pattern analysis for decision making, such as medical image analysis for disease screening, image-based information access for mobile searches, and human behaviour tracking for elderly care. It also provides solutions for security enforcement based on biometrics, video surveillance, and media authentication, as well as for the entertainment industry, such as interactive television and 3D gaming interaction.

### **Department: Cryptography and Security**

The department explores cryptography and its applications in network security and digit management security, with five groups working on projects in these areas.

The department aims to be a world-class security research centre, providing cutting edge security technologies and solutions that serve national objectives, and to generate IP and training manpower in ICT security sector to benefit local industries.

### **Key Competencies**

- Cryptography - design and analysis of cryptosystems
- Defending malware - protect mobile devices from virus and worms
- Digital rights management - digital copyright protection by software obfuscation
- Network security - defending DDoS, sensor network authentication and encryption
- Privacy protection - security and privacy of e-commerce and data mining
- RFID security - fighting physical counterfeit by secure RFID data chaining
- Security protocols - authentication, fair exchange, e-payment, key agreement

**Department: Data Mining**

The department focuses on the effective mining of complex patterns from large sets of data by using a combination of techniques to discover new knowledge for a wide range of application domains. Its objective is to discover patterns and rules to guide decisions about future activities.

Having started out as a bioinformatics group, the department excels in cross-disciplinary data mining research, and is extending its success in bioinformatics to other challenging domains such as financial data analysis, business analytics, and social network mining.

Its mission is to put Singapore on the knowledge highway by developing advanced data mining systems to address the increasing volume, variety and velocity of data analysis today with greater flexibility, precision and automation for today's knowledge economies.

**Key Competencies**

- Data mining
- Machine Learning
- Text Mining
- Graph Mining
- Semantic web technologies
- Privacy-preserving data mining
- Bioinformatics

**Potential Applications**

Data mining is critical for companies which need to analyse complex information for business intelligence and decision support. With competent data mining that can handle both structured and unstructured data, a company can improve its level of service and performance, discover new opportunities and profit on data. It can also help detect fraud, waste and abuse, as well as assist in the sharing of sensitive information.

**Department: Human Language Technology**

The department's mission is to lead state-of-the-art research directions for language technologies that drive the development of new applications and services. Led by a group of established scientists and engineers, the department specialises in automatic speech recognition, speaker and language recognition, text-to-speech, statistical and corpus-based natural language processing, machine translation, information retrieval, with special focus on Asian languages and multilingual computing.

The department's flagship technologies include patented text information agent, machine translation for South-East Asian Languages, and the Abacus multilingual speech recognition platform which have been deployed commercially in real-world applications.

Its vision is to facilitate and transform human communication through new language technologies.

### **Key Competencies**

- Large Vocabulary Continuous Speech Recognition (LVCSR) - automatic transcription, spoken document retrieval, voice surveillance
- Speaker and Language Recognition (SLR) - voice biometrics, spoken document retrieval, automatic call routing, rich transcription
- Multilingual modelling - machine translation, multilingual information management
- Cross-lingual information retrieval - business intelligence, information security and terrorism attack warning system, financial information gathering system

### **Department: Modulation and Coding**

The department focuses on algorithms development and proof-of-concept prototyping of advanced digital communication systems. Equipped with high performance workstations and design tools, the department is able to perform system level design and verification, FPGA prototyping and ASIC design. It also has a quick prototyping platform based on MATLAB SIMULINK and structure ASIC, which is useful for validating research outcomes in real-time. Besides the Matlab to FPGA design flow, it had also established design flow based on Synopsys Cocentric System Studio, and SystemC.

### **Key Competencies**

- Forward error correction coding
- Orthogonal frequency division multiplexing (OFDM)
- Multiple-Input Multiple-Output (MIMO)
- Modem algorithms
- Iterative turbo processing
- Multiple access and joint detection
- Cognitive Channel Sensing
- Resource allocation and link adaptation

### **Potential Applications**

The technologies developed by the department may be applied to many next generation communications systems, including high throughput wireless local area networks, Ultrawideband wireless personal area network based on WiMedia, wireless sensor networks, wireline communications systems, and next generation wireless local area network system beyond IEEE 802.11n.

### **Department: Networking Protocols**

The department focuses on communications and networking protocols for wireless, wired and optical networks, and distributed computing. Its areas of research include routing, mobile ad-hoc networks, mesh networks, sensor networks, Quality of Service (QoS), including robustness and fault-tolerance, cooperative and coordinated approaches in networking for enhanced performance, and next generation architectures for services.

It's R&D on adhoc and sensor networks cover maritime and underwater communications and sensing, monitoring and surveillance of outdoor spaces, and healthcare. The research objective is to develop optimized and highly survivable, integrated ad hoc and sensor networks to collect, distribute and process information to enable applications such as monitoring, surveillance and tracking.

In the area of next generation service delivery platforms, the department's R&D focuses on distributed systems with computational, content and data storage resources where performance guarantees are required in order to provide mission-critical services.

### **Key Competencies**

- Wireless ad hoc, mesh and sensor networking
- Architectures for mission-critical services, including control and management of optical networks
- Cooperative and coordinated networking
- Autonomic self-healing and robust networks

### **Department: RF and Optical**

The department focuses on R&D of advanced antenna, RF and optical technology. It aims to build up strong competencies in these areas by conducting long-term applied research and by providing quality training for researchers and engineers to meet demands of rapid development of wireless technologies.

### **Potential Applications**

The department's research into antenna technology focuses on novel design concept and new application of electromagnetic materials for antennas with high performance such as broadband/multiple-mode operation for modern wireless systems such as UWB, WLAN WiMAX, WiFi, MIMO, on-body/implanted communications.

The research in RF technology targets development of components, modules and sub-systems for emerging wireless systems such as phased arrays, UWB radar, UWB localisation, and RFID systems.

The research in optical fiber transmission aims to investigate optically amplified, high-speed, multi-wavelength optical signals in long-haul and metropolitan area networks, and develop RoF technology for picocell applications with low cost optical components.

The research into sensors based on optical fibre develops the new sensors which can perform measurements with distributed sensing and high level of immunity from interferences, like EM and RF interference.

### **Department: Signal Processing**

The department conducts R&D mainly in the areas of signal processing and its applications. It deals with the movement of bits and data, and aims for high quality and efficiency in signal transmission and data delivery. Current research efforts are focused on advanced coding of multimedia data for efficient storage and delivery in heterogeneous networks, post-processing of multimedia data, processing of signals as well as analysis of medical, sensory, and neural data from the healthcare industry to seamlessly integrate mobile healthcare solutions into the daily lives.

The department aims to revolutionise the human multimedia experience, using human perceptual audio and video quality metrics to achieve the highest quality in audio and video processing, while actively conducting R&D in the areas of interactive sound synthesis and multimodal game engine in parallel. This will result in technologies that are relevant to the needs of digital media industries, such as having an enabling natural interface for computer game using human gesture, which will greatly enhance the whole gaming experience.

### **Key Competencies**

- H.264 and SVC encoder, decoder and IP-based delivery; MPEG2-to-H.264 transcoding; video pre- and post-processing
- Audio signal processing, lossless audio compression, scalable audio coding
- Perceptual image and video quality measurements
- Natural interface for computer game using human gesture
- Scratched sound synthesis
- Cardiac signal processing, multimodal sensor data processing

### **Potential Applications**

- Live and on-demand video coding, scalable video archival/retrieval; heterogeneous video delivery over diverse wireline and wireless networks targeting video surveillance and entertainment applications
- Online music store, Internet radio, personal CD archive
- Automatic and objective image and video quality measurements, perceptually optimized image and video compression
- Computer game, Interactive advertisement, Interactive kiosk and information system
- Personalized mobile phone ringtones
- Mobile healthcare, Homecare for elderly, healthcare and medical devices

# Research Programmes

### **Programme: Assistive ICM for Health Monitoring and Rehabilitation (AIM)**

The programme aims to develop ICT for various healthcare applications. One of these is health monitoring, especially for cardiovascular patients and the elderly. Cardiovascular disease (CVD) affects about 20% of the population in developed countries.

The programme will explore scalable and flexible frameworks for remote and mobile monitoring for CVD patients. With an aging population in most developed countries, elderly care had become a significant social issue. It will develop solutions for behaviour and event detection to monitor safety and facilitate their daily living.

Rehabilitation is another main focus, where the programme will work closely with healthcare organisations and caregivers to develop new rehabilitation technologies and create value-added services for patients, elderly and healthcare sector.

### **Key Competencies**

- Activity and event recognition
- Bio-signal Processing
- Body area networks
- Brain-computer interfaces
- Context awareness
- Medical image analysis, indexing, and retrieval
- Multi-modal sensor data processing
- Object detection, tracking, and categorization
- Ontologies and event based reasoning
- Video understanding

### **Potential Applications**

The programme technologies are aimed at monitoring and assisting elderly care, through remote health monitoring, disease prediction and screening, rehabilitation, and cardiovascular patient examination and management. The technologies will also go towards enhancing assistive communication, control, and mobility of the elderly, as well as tele-medicine.

### **Programme: High Speed Maritime Mesh Networks**

The programme explores new scientific and engineering techniques for the development of new generation, high speed maritime networks for port-areas, above-sea and under-sea to support communications with improved bandwidth, reliability and pervasiveness.

The programmes focus is on four key areas. The first is related the development of practical distributed feedback (DFB) fiber laser array for all optical underwater sensing, particularly on the design of the fiber laser, grating methods and signal processing algorithms for a robust system that will be able to withstand high temperature and long distance operations.

The second area is related to the development of a high speed ship-to-ship/shore mesh network that is targeted for use in narrow water channels and traffic lanes that are close to the shoreline. The system is being built to complement existing satellite communications and the focus of the technology development is the design of the robust networking schemes for the ship-to-ship/shore mesh networks and the middleware to glue to the satellite system.

The third area is related to providing more robust communications for a school of submersibles, specifically focusing on providing robust networking and localisation protocols for use in accurate coordination and control of the distributed submersibles.

The fourth area is related to providing alternative communications based on electrical conduction for underwater data transmission but at a much higher speed than current acoustic communications.

### **Key Competencies**

- Above water ship-to-ship communications
- Underwater electric conduction
- Collaborative protocols for underwater SWARMS
- Optical fiber sensors

### **Potential Applications**

The programme's R&D is largely targeted towards applications in the oil and gas industry. Its technology development of DFB fiber laser array for all optical underwater sensing can be used in applications such as port security, waterfront security and seismic monitoring, while its R&D in communications for submersibles and underwater data transmission are targeted for applications related to geophysical survey.

### **Programme: Next Generation Content for IPTV**

IPTV is the next big thing to hit consumers, fuelled by the availability of gigabit bandwidth in homes and mobile devices. With IPTV, consumers can access global entertainment channels anytime, anywhere, and personalised to meet specific preferences. Real-time interaction with the program you are enjoying is now even a possibility.

The programme aims to leverage on the potential growth of IPTV by enabling content manipulation technologies to support IPTV trials in Singapore and new IPTV applications and services to be provided worldwide. The key focus is in interactivity and personalisation.

#### **Key Competencies**

- Scalable audio and video coding
- Content understanding in video
- Multilingual messaging and language translation
- Multimedia content search, indexing and retrieval
- Digital media security
- Biometrics
- Ultra-high-speed optical fibre & wireless transmission system (ONFIG)

### **Programme: Personal 3D Entertainment Systems (P3DES)**

The programme aims to create engaging entertainment systems through digital content creation, and developing core technologies that enrich the entertainment experience of such systems.

Ongoing R&D is conducted on speech/sound modelling and synthesis, 3D animation, human body and face modelling, interactive virtual reality, mixed reality, and multimodal game engine. To complement and enhance the fundamental building blocks of the programme framework, the P3DES programme also leverages on other existing core competencies in I<sup>2</sup>R such as speech and dialogue processing technologies and networking technologies.

The P3DES programme develops enabling technologies for interactive 3D digital media and state-of-the-art content creation tools that will seamlessly integrate with the predominant software used by content creators and graphic designers. These technologies will enable faster and more efficient generation of digital media content, and create unique interactive media access applications and services for sectors like healthcare, security and education.

#### **Key Competencies**

- 3D head and body tracking
- Gesture tracking
- Expressive text to speech
- Speaker identification and verification
- Human computer interaction

#### **Potential Applications**

The main application focus of technologies developed in P3DES would be for gaming, such as immersive and interactive games for home entertainment. These technologies will amplify applications for animation, voice-dubbing of movies, and services such as rehabilitation and training.

### **Programme: Power-Aware Wireless Sensor Network (WSN) for Tracking & Monitoring**

Recent enhancements in wireless technology has given rise to the development of wireless sensor networks (WSN) - an application with great potential for mass deployments in healthcare, home, enterprise and industry.

Some of the challenges facing WSN applications include interference, handling of large amounts of sensor data and security of sensor information. The WSN programme aims to address the challenges of WSN while leveraging on its potential to provide innovative solutions at affordable costs.

The programme also looks into different location estimation techniques based on RFID, Zigbee and UWB to suit the requirements of different wireless sensor applications. Technologies such as RFID and Zigbee help provide new intelligence to machines to automatically communicate meaningful information in a Machine-to-Machine communication environment.

#### **Key Competencies**

- RFID (Transceiver, Communication Protocols, Antenna, Security)
- Localization system (UWB, Zigbee)
- Networking protocols
- UWB Radar

#### **Potential Applications**

- Track & trace in Supply Chain Management
- Smart Shelves for Libraries and Retail
- Contact tracing
- Robot Navigation
- Exhibition Audio Guide
- Gaming
- Healthcare (breathing & heart-rate monitoring)
- Aerospace (Structural Health Monitoring)

### **Programme: Towards Gigabit Personal Connectivity**

The programme focuses on providing Ultra-high data rate (Gbps) in both wireless and wireline broadband networks with 'master-slave' and peer-to-peer connectivity. Such high speed personal connectivity is expected to create new usage models and market opportunities across PC, consumer electronics and mobile terminal segments.

Using state-of-the-art technology, the programme aims to deliver networks which offer low power consumption and costs with high spectrum efficiency and system reliability. The programme's mission is to push the frontiers of Gigabit connectivity technology.

### **Key Competencies**

- High data rate, spectrum efficient techniques
- MIMO and space-time-frequency modems
- Multipath robustness techniques
- Error control coding
- Low spectral density, high rate UWB communications
- Band Hopping OFDM
- Spread Spectrum & CDMA
- Channel modelling & propagation channel measurements
- Multiple access/interference suppression techniques
- Power efficient modulation & coding
- Power/cost/complexity efficient algorithms
- Beamforming/antenna array/antennas
- Signal processing architecture
- Hardware/software co-design
- Wireless/wired communication systems design
- Medium access control
- Interference avoidance
- Channel/spectrum sensing

### **Potential Applications**

- Short range power-efficient Gbps Data Exchange, e.g. high rate UWB for wireless USB applications
- Ubiquitous wireless bandwidth-efficient Gbps Data Access, e.g. 3GPP long term evolution for cellular applications
- Long Range Wire medium Gbps Coverage, e.g. UWB over coax/powerline for whole-home Gbps coverage

## Other Research Programmes and Initiatives

In FY2008, I<sup>2</sup>R continued to host the following important SERC Programmes and initiatives:

### **STARhome**

STARhome is an A\*STAR R&D technology testbed funded by SERC, providing a realistic platform to explore and demonstrate state-of-the-art smart home technologies from research outcome of SERC RIs, tertiary institutions and industry partners.

The broad objectives of the STARhome programme is to encourage and accelerate the transfer of research knowledge to industry; shorten time-to-market of products from promising technologies; promote public awareness of advances in future home technology as well as to create a high-level of synergy between research institutes and the industry.

The official launch of STARhome@KentRidge in Nov 2006 created an overwhelming response from the industry and media. More than 130 groups of high level visitors from foreign and local MNCs, SMEs, universities as well as government agencies had visited STARhome@KentRidge. Besides exploratory works, it had also attracted Intelligent Building and Smart Home systems integrators who are keen to bring these technologies to the local and overseas marketplace.

Following the success of the pilot phase of STARhome@KentRidge, a second phase for the STARhome programme named STARhome@Fusionopolis was initiated. The new Starhome is now housed within Fusionopolis, the national R&D hub with unprecedented convenience, excitement and vibrancy.

STARhome@Fusionopolis will continue to be a model smart home testbed transforming innovative technologies into live prototypes for testing and demonstration purposes. Over time, with the progress of HOME2015 research programme, more advanced technologies and research prototypes will be integrated into STARhome. It had successfully attracted more than 20 industry project partners and sponsors, including local and overseas SMEs and MNCs. More than 20 technology prototypes have been developed and integrated to demonstrate novel concepts and new business possibilities for the digital home industry.

With the transition to Phase 2, STARhome@Fusionopolis had expanded both in size and in scope. It is about twice the size of STARhome@KentRidge and a Green dimension had been included. With the aim to better understand the challenges facing developers of smart living environments, STARhome@Fusionopolis had also included a fully equipped usability testing facility which allows Human Factor Engineering (HFE) experts to undertake elementary studies on user interactions with technology prototypes in STARhome.

### **FusionWorld**

With its successful inception on 20 October 2008, FusionWorld was officially opened by the Minister of State for Trade and Industry, Mr. Lee Yi Shyan, and had been well-received by both the public and industry. Since its opening, close to 3,000 visitors, both local and international, have toured FusionWorld. FusionWorld remains a platform for A\*STAR RIs to market its technologies and innovations in practical yet creative concepts. It is therefore important to not only present the exhibits in a manner that will demonstrate industry relevance, attract attention and improve recall, but also ensure that it stays up-to-date and an inspiration for R&D. Feedback from visitors have been very positive, a motivation for the team and researchers to keep improving the FusionWorld experience, and refresh the showcase with state-of-the-art technologies and applications.

### **Home2015**

On 14 April 2009, HOME2015 Phase I officially came to a close. Achievements from the Phase I programme include:

- 31 technology disclosures
- 12 patent applications
- 77 papers submitted/published
- 42 RSEs trained

Below are highlights of cross-RI collaborations that resulted in cross-disciplinary technologies and innovations:

- Project 47: Urine sample protein detection
- Project 51: 2Gpbs data rate, mmWave wireless communication platform for home entertainment
- Project 48 – An accurate, low-cost system that monitors one's breathing and measures heart-rate in a non-invasive way.

Home2015 Phase II will leverage on the competencies that have been built in Phase I. It is now in the final stage of issuing its Call for Proposal.

# V. Intellectual Capital Development

## Research Collaborations with Local and International Research Community

I<sup>2</sup>R had actively sought research partnership with both international organisations and local universities.

In FY2008, a total of 12 joint R&D collaborations were initiated with international research organisations, 9 were initiated with local universities and another 10 SERC & RI-RI collaboration projects as inter-RI collaborations were also initiated.

## Creating Intellectual Property

For FY2008, in terms of IP created, I<sup>2</sup>R produced a total of 453 publications, 49 filed patents, 27 granted patents, and 146 submitted Technology Disclosures.

### **Patents granted in FY2008:**

#### ***Method and Platform of Term Extraction from Large Collection of Documents***

A method and platform for statistically extracting terms from large sets of documents were described. An importance vector is determined for each document in the set of documents based on importance values for words in each document. A binary document classification tree is formed by clustering the documents into clusters of similar documents based on the importance vector for each document. An infrastructure is built for the set of documents by generalizing the binary document classification tree. The document clusters are determined by dividing the generalized tree of the infrastructure into two parts and cutting away the upper part. Statistically significant individual key words are extracted from the clusters of similar documents. Key words are treated as seeds and terms are extracted by starting from the seeds and extending to their left or right contexts.

#### ***Spoken Language Identification Systems and Method for Training and Operating Same***

The invention is a novel technique for identifying spoken languages based on the use of a universal phonetic inventory and a “bag of sounds” technique for associating collections of phonetic symbols with particular spoken languages.

### ***System for Recognising and Classifying Names Entities***

Using the constraint relaxation principle, a pattern induction algorithm is presented in the training process to induce effective patterns. The induced patterns are then used in the recognition process by a back-off modelling algorithm to resolve the data sparseness problem. Various features are structured hierarchically to facilitate the constraint relaxation process. In this way, the data sparseness problem in named entity recognition can be resolved effectively and a named entity recognition system with better performance and better portability can be achieved.

### ***Time-Based Media Navigation System***

The invention relates generally to systems for media navigation. In particular, the invention relates to systems for navigating time-based media to which meta-data is linked.

### ***Methods of Processing Biological Data***

The invention describes a new method to discover many diversified and significant rules from high dimensional medical gene expression, or other types of data.

### ***Method for Transmitting Data, Method for Receiving Data, Transmitter, Receiver, and Computer Program Products***

A method for transmitting data comprising a plurality of bits is described wherein the data is mapped to a plurality of modulation symbols, each modulation symbol comprising at least one more significant bit and at least one less significant bit, at least one parity bit is generated for the plurality of bits and the plurality of bits are mapped to more significant bits of the plurality of modulation symbols and the at least one parity bit is mapped to at least one less significant bit of the plurality of modulation symbols.

### ***Compact multi-tiered plate antenna array***

An antenna array having a plurality of array elements is disclosed. The antenna array comprises a first array element having a first suspended radiator and a first ground conductor, the first suspended radiator being displaced from the first ground conductor. The antenna also comprises a second array element being adjacent to the first array element, the second array element having a second suspended radiator and a second ground conductor, wherein the second suspended radiator is displaced from the second ground conductor. In the antenna the first ground conductor is adjacent to and displaced from the second ground conductor and the first ground conductor is disposed on a first tier and the second ground conductor is disposed on a second tier to form an at least two-tiered ground conductor.

### ***A Method and a Device for Computer Based Processing a Template Minutia Set of a Fingerprint and a Computer***

A template minutia set of a fingerprint comprising template minutiae and a template interest region is provided. Further, an input minutia set comprising input minutiae and an input interest region according to an input fingerprint is provided. The input minutia set is matched with the template minutia set. All matching template/input minutiae are determined. Furthermore, an updated template minutia set is determined dependent on the matching template/input minutiae and the non-matching template/input minutiae, and dependent on whether the template minutiae are inside the input interest region or outside of it and whether the input minutiae are inside the template interest region or outside of it.

***Process and device for determining a transforming element for a given transformation function, method and device for transforming a digital signal from the time domain into the frequency domain and vice versa and computer readable medium***

A fast algorithm for integer DCT-IV was invented. The total rounding number of this method is only  $2.5N$  ( $N$  is block size). As a result, its approximation error to floating point DCT-IV is far less than that of the directly converted integer transforms. At the same time, its complexity is maintained very low.

***Method for Performing a Domain Transformation of a Digital Signal from Time Domain into the Frequency Domain and Vice Versa***

The transmission spectrum consisting of multiple wavelength peaks produced by injecting an athermal Mach-Zehnder interferometer with a broadband source can be used as wavelength reference which is able to calibrate nonlinear devices such as a fiber Fabry-Perot tuneable filter.

***Method for Transforming a Digital Signal from the Time Domain into the Frequency Domain and Vice Versa***

The transmission spectrum consisting of multiple wavelength peaks produced by injecting an athermal Mach-Zehnder interferometer with a broadband source can be used as wavelength reference which is able to calibrate nonlinear devices such as a fiber Fabry-Perot tuneable filter.

***A shared storage network system and a method for operating a shared storage network system***

The Globally Addressable Storage (GAS) system is proposed with an optical network as the interconnection network to support a shared storage system over a large scale distributed network at low cost.

***A Method and transmitter, receiver and transducer systems for Ultra Wideband communication***

A transmitter for transmitting data as a pulsed ultra-wide band signal comprises a serial-to-parallel converter for converting the signal to be transmitted to a parallel sequence, a modulator to convert the parallel sequence to a parallel stream of impulse trains. A delay unit delays the parallel streams of impulse trains by different time intervals within the same pulse repetition period. The delayed pulse streams are combined so that the pulses in the streams occur within the pulse repetition period of a single pulse. An antenna is used to transmit the combined signal. A receiver comprises an antenna for receiving a transmitted pulsed ultrawide band signal having two or more interleaved pulse trains with equal pulse repetition periods, the pulse repetition period being greater than the pulse spacing in the interleaved signal. A matched filter filters the received signal, the filter being matched to the pulse shape of the received signal. A low-pass filter is coupled to the matched filter and an analogue-to-digital converter is coupled thereto. A sampling unit is coupled to the converter to sample the digital signal at a rate greater than the pulse repetition frequency of the received signal. A signal processor is coupled to the sampling unit to produce an output signal representative of the received data.

***A Variable Spreading Factor-Orthogonal Frequency and Code Division Multiplexing (VSF-OFCDM) System, a Receiver for use therein and a Method of Processing Received signals in such a system***

A variable spreading factor-orthogonal frequency and code division multiplexing (VSF-OFCDM) system and receiver for use therein had a sequence extension remover for removing a predetermined number of chips from the received signal to form a modified signal, and a first converter for converting the modified signal from a serial sequence to a parallel sequence. A despreader is coupled to the first converter for despreading the parallel sequence to derive a group of symbols. An orthogonal transform block, such as a Fast Fourier Transform block is coupled to the despreader to transform the symbols from the time domain to the frequency domain. An equalizer block is coupled to the transform block for equalizing the transformed signal to reduce channel distortion. A deinterleaver block is coupled to the equalizer block to form a deinterleaved signal. The deinterleaved signal is then converted from a parallel sequence to a serial sequence.

***Method of Generating UWB Pulses***

A method produces UWB pulses using a differentiated clock signal as a pulse input, and a data signal to modulate the pulse input. The mixed signal is then differentiated a second time to produce high frequency broad band UWB signals. A differentiating system which comprises a biased transistor, a lowpass filter on the output of the transistor, the output of the lowpass filter negatively feedback to the input of the transistor, whereby the output of system had a high voltage swing capable of being matched to an antenna without further need of amplification, and the system is capable of implementation in an IC chip.

***Method and apparatus for melody representation and matching for music retrieval***

This invention discloses a method for melody representation and matching which is robust against pitch and speed variations in the query input. The essence of the invention had two aspects: one is to represent melody by a sequence of data points, which is invariant to the speed or tempo of the melody; and the other one is a data point sequence matching technique, which is effective and efficient for music retrieval.

***A Control Device and a Method for Controlling an Optical Data Transmission, and a Shared Storage Network System***

A control device for controlling the optical data transmission in an optical burst switching mode between a source computer and a destination computer, the control device being connected to the source computer and to the destination computer and being adapted such that in case of a burst to be transmitted from the source computer to the destination computer, the length of the burst is determined based on a parameter indicating an available buffer size of the destination computer, and a predetermined timeout value parameter indicating a time after which improper burst transmission is assumed to have been occurred. After the burst length is determined and the traffic starts to be accumulated, a proposed burst reservation and transmission scheme, namely random burst eligibility time method, is used to deliver the burst.

***A Protein Interaction Extraction System***

The present invention relates to the field of research, particularly the searching, scanning and/or analysis of a voluminous amount of information available in databases where the latest scientific discoveries are often lodged and first reported online and are accessible by scientists worldwide. Most particularly, the present invention relates to the research undertaken and reported related to the biotechnology and pharmaceutical industries.

**Method for encoding at least one digital picture, encoder, computer program product**

It is a new prediction scheme for the inter-layer prediction of SVC. There can be 2 base layers for an enhancement layer. The coding efficiency can be improved.

**Fast Method and Receiver for CDMA Joint Detection**

Joint detection will be employed to effectively combat the Inter-Chip Interference (ICI) and Multiple Access Interference (MAI) in CDMA system. The joint detection combines the knowledge of all users that share one time slot into 1 large system of equations. The resulting system of equations can be very large and thus algorithm must be developed to exploit its special structural characteristics. Current approaches to solve the complex equations are based on the block – Toeplitz structure of the coefficient matrix. However, if the decision feedback is introduced to the joint detection algorithm, the data detection sequence will be re-ordered according to the received power. Correspondingly, the coefficient matrix will also be re-scheduled. The resulting matrix becomes a Toeplitz block structure. The invention exploits the structure of Cholesky factor of the coefficient matrix and proposes an approximate computation method which can significantly reduces the computation complexity

**Method and System for Video Quality Measurements**

This invention pertains to video processing system and more particularly, the invention relates to method and apparatus for automatically estimating objective digital video quality based on emulation of perceived human visual subjective ratings.

**Image and Video Quality Measurement**

The invention encompasses four new no-reference image/video-quality features and their applications in no-reference objective digital image and video quality measurement systems have been proposed. The proposed image/video-quality features and its corresponding no-reference objective digital image and video quality measurement systems can be used for monitoring and quality control for in-service operations in the digital image/video industry without requiring the use or availability of a reference undistorted image/video.

**Systems and methods for scalable encoding and decoding data Technology: MPEG-4 SLS; Low Energy Mode detector**

In this invention, a hybrid scalable non-scalable (HSNS) approach is proposed to improve the coding efficiency of a scalable coding system for multimedia signal. The HSNS approach tries to identify the perceptual irrelevant components of the multimedia signal input in a transform domain, and improve the overall performance of the coding system by coding those perceptual irrelevant components.

**Method for Synthesizing a Minutiae Template and Increasing Reliability of Fingerprint Matching Using a Fingerprint Sensor with Small Sensor Area technology: Biometric; Fingerprint sensor**

The patent describes a method to combine several representations of a fingerprint (called the template) obtained using a sensor with a small touching area but which is cheaper so that the combined representation would be similar to the one obtained using a sensor with a larger touching area. The patent also takes advantage of the proper sequence and position of the finger used in the combination process to derive a codeword which adds to the security level of the system.

### ***A virtual grid***

A software solution is applicable to sensor fields of arbitrary regions. The (thickness) of row & column in the grid is software controlled, and thus providing a mechanism to trade off energy efficiency & data robustness.

### ***Method and System for Event Detection in a Video Stream***

A novel method to automatically detect events and event semantics from live sport video. Main technical components include event detection from web-casting texts automatic time detection from broadcast video and automatic alignment of text event and video event.

### ***Automatic Video Event Detection and Indexing***

The invention provides a method for automatic detection and indexing of video events based on a notion of audio-visual keywords that characterize consistent audio-visual spatio-temporal patterns between low-level features and semantic events. Characterized by low-level features such as motion, colour, texture, and audio etc, these audio-visual keywords are learned and created from video shots (or shotlets, or in general time windowed video frame sequence of suitable length). On the other hand, these audio-visual keywords serve as probabilistic spatio-audio-visual keywords from low-level features and construction of semantic video events from created audio-visual keywords.

### **Top papers published in FY2008:**

A research paper entitled “A Compact Planar Dipole Antenna with Ultra-Wide Band Performance” by Low Xue Ni, FYP student from NTU, was selected as an “HONORABLE MENTION” paper from the 175 Student Paper Contest papers associated with the 2008 IEEE International Symposium on Antennas and Propagation to be held in San Diego, CA from July 5-12, 2008.

A paper titled “Joint Source-Channel-Authentication Resource Allocation and Unequal Authenticity Protection for Multimedia Over Wireless Networks”, was selected for the 2008 issue of the Best Paper Award by the Multimedia Communications Technical Committee of the IEEE Communications Society. The paper was authored by Zhi Li, Qibin Sun, Yong Lian and Chang Wen Chen, and published in IEEE Transactions on Multimedia, Vol. 9, No. 4, June 2007, pp. 837-850.

A paper titled “Performance Analysis of Data Delivery Schemes for a Multi-sink Wireless Sensor Network” had received the ‘Highly Commended Paper’ award in the IEEE 22nd International Conference on Advanced Information Networking and Applications (AINA2008), Mar 25- 29, 2008, Okinawa, Japan. It was authored by Hwee-Pink Tan, Adriana F. Gabor, Winston K.G. Seah, and Pius W.Q. Lee, and published in the Proceedings of the IEEE 22nd International Conference on Advanced Information Networking and Applications (AINA2008).

A paper co-authored by Kong Peng Yong and Tham Chen Khong from Networking Protocols Dept, and A\*STAR International Graduate Scholar (IGS) Ghasem Naddafzadeh Shirazi, entitled “A Cooperative Retransmission Scheme for IR-UWB Networks” won the Best Student Paper Award at IEEE International Conference on Ultra-Wideband (ICUWB2008), Hannover, Germany.

One paper titled “Wideband Reconfigurable Rolled Planar Monopole Antenna”; co-authored by Dr Chen Zhining, won the CST University Publication Award 2008.

At the 19th International Conference on Pattern Recognition (ICPR), Tampa, December 8-11, 2008, Bappaditya Mandal's paper entitled "Verification of Human Faces Using Predicted Eigenvalues", which he co-authored with Xudong Jiang and Alex Kot of NTU, received the Best Biometrics Student Paper Award.

At the 19th International Conference on Patter Recognition (ICPR), Tampa, December 8-11, 2008, Dr. Karthik Nandakumar's paper entitled "Securing Fingerprint Template: Fuzzy Vault with Minutiae Descriptors", which he co-authored with Abhishek Nagar and Anil K. Jain of Michigan State University, USA, received the Best Scientific Paper Award for the Biometrics track.

One paper co-authored by Liang Ying Chang from Modulation and Coding Dept was listed as one of the January 2008 list of the ten most popular articles published in ComSoc periodicals viewed online, based on PDF views through IEEE Xplore. The detailed information of the paper is as follows: L. Zhang, Y.C. Liang and Y.Xin, Joint beamforming and power allocation for multiple access channels in cognitive radio networks, IEEE Journal on Selected Areas in Communications, Special Issue on Cognitive Radio: Theory and Application, vol 26, No. 1, pp 38-51, January 2008.

# Commercialising Intellectual Property

In FY2008, I<sup>2</sup>R continued to work closely with Exploit Technologies (ETPL) to commercialise its market ready research and development outcomes.

## VI. Industrial Capital Development

### Collaborating in R&D with the Industry

I<sup>2</sup>R continued to engage industry partners in its R&D to drive relevance in its research.

In FY2008, we initiated a total of 21 new collaborative R&D projects with industry cash funding.

### Sharing Human Capital with Industry

In FY2008, I<sup>2</sup>R continued promoting GET-Up activities, which included the secondment of our RSEs to industry (T-Up scheme).

There were a total of 7 T-UP secondees to industry.

In FY2008, I<sup>2</sup>R conducted an Operations and Technology Roadmap Workshop with a local SME to roadmap the requirements of the company as it seeks to venture into the media and communications business.

The objective of the road mapping exercise was to develop the 'first cut' technology roadmap for the setting up of the company's business with a time frame of about 5 years.

### Sharing R&D Resources with the Industry

In FY2008, I<sup>2</sup>R undertook five service related projects (consultancy services) with industry cash funding.

# VII. Human Capital Development

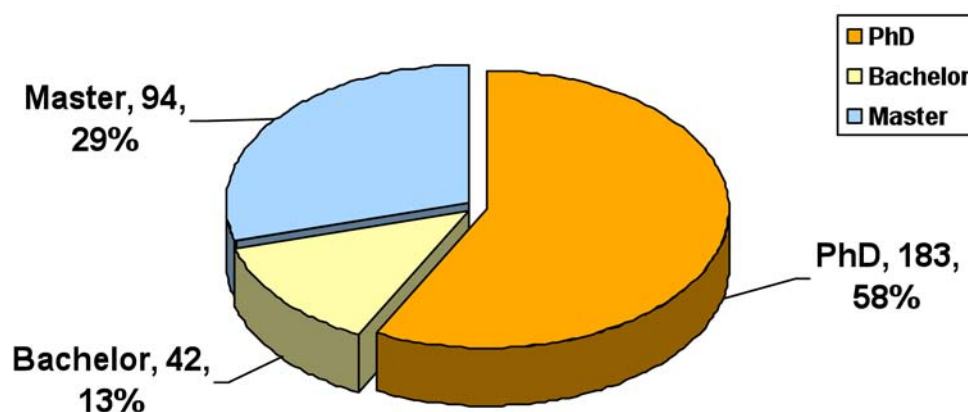
As at end FY2008, I<sup>2</sup>R had 319 core researchers of which, 57% were Ph.D. degrees, 30% had Master degrees and 13% had Bachelor degrees. In terms of our pipeline to industry, 17 RSE/RTSs left I<sup>2</sup>R to join industry in FY2008.

In the following section, statistics were presented on FY2008 update on nationality and qualification of the staff. The statistics are based on data as of 31st March 2009.

The following charts show the qualification profile of Research Staff, Post-Docs and Non-Research Staff:

	PhD	Master	Bachelor	Total
<b>Research Staff Qualifications (RSE/RTS+Post-Docs)</b>	183	94	42	319

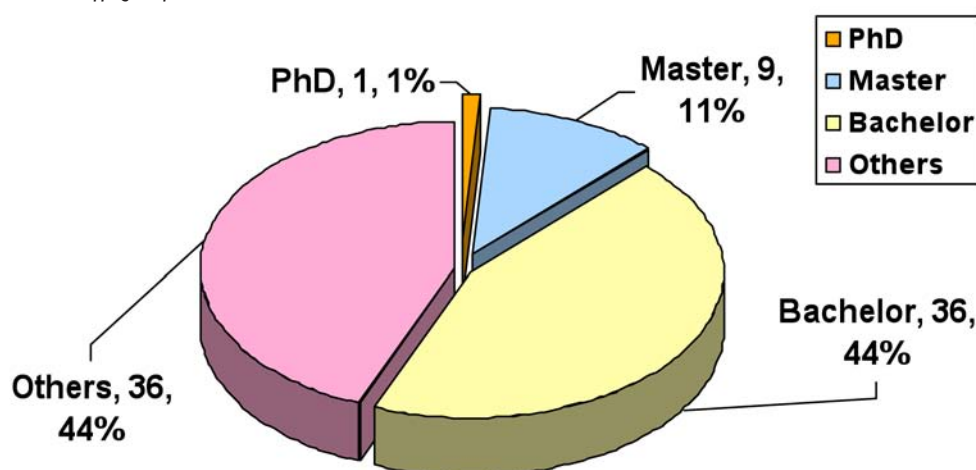
**Table 1:** Research Staff Qualifications (RSE/RTS + Post-Docs)



**Figure 2:** Research Staff Qualifications (RSE/RTS + Post-Docs)

	PhD	Master	Bachelor	Others	Total
<b>Non-Research Staff Qualifications</b>	1	9	36	36	82

**Table 2:** Non-Research Staff Qualifications



**Figure 3:** Non-Research Staff Qualifications

# Training Graduates and Post-Docs

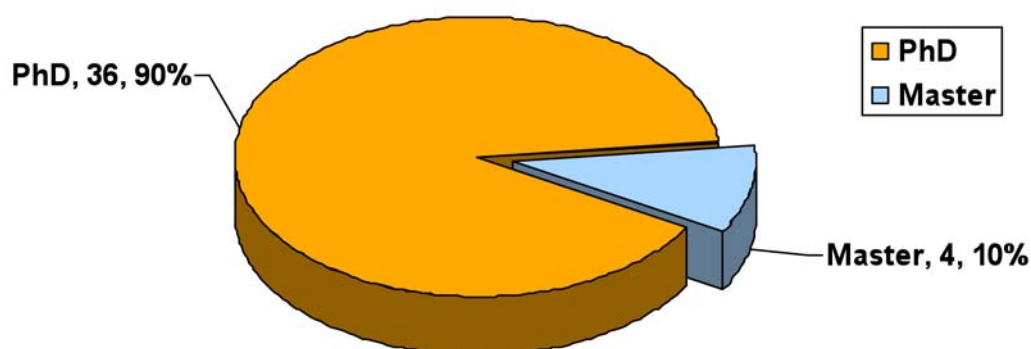
## Related KPIs achieved:

- No. of Master's research students trained: 10
- No. of PhD Students trained: 44
- No. of PhD Students registered: 10
- No. of post-doctoral (within 3 years of Ph.D.) researchers hired: 10

The following table and chart show the breakdown of students based on Qualification:

	PhD	Master	Total
<b>Students Qualification Profile</b>	36	4	40

**Table 3:** Students Qualification Table



**Figure 4:** Students Qualification Profile

# Training RSEs

## Staff Upgrading

There were 6 research staff pursuing PhD part-time. All were Singaporeans.

## Staff Training & Development

In FY2008, I<sup>2</sup>R conducted a total of 62 conferences, workshops and seminars. The FY2008 target was 60.

In FY2008, I<sup>2</sup>R continued to step up staff training and development by implementing a series of training programmes for specific target groups:

## Core Training programme for Researchers

- Project Management Course

### **In-House Training Courses (including those organized by A\*STAR)**

- Leadership Styles & Teambuilding Skills
- Crisis Communication
- Critical Thinking & Decision Making Skills
- Communication for Success
- Team Effectiveness (organised by A\*STAR)
- Personal Profile Analysis (organised by A\*STAR)
- Effective Presentation Skills Course for all staff (organised by A\*STAR)
- Scientific Presentation Skills Course for RSEs/RTSs (organised by A\*STAR)
- Scientific Writing Skills Course for RSEs/RTSs (organised by A\*STAR)
- A\*STAR Scientific Conference (organised by A\*STAR)

### **New Staff Orientation Programme**

- I<sup>2</sup>R Induction Programme - Intro@Work
- A\*STAR Induction Programme

### **Overall Training Man-days for I<sup>2</sup>R Staff**

Our staff received an equivalent of 6064 training hours from the above training programmes and external training arranged individually by our staff and the overseas/local conferences attended by the researches. This translated into an average of 11.6 training hours per staff.

## Science Outreach

I<sup>2</sup>R provided opportunities for undergraduates, polytechnic, Junior College, and secondary students to be attached and supervised by our researchers.

### **The Science Mentorship Program (SMP)**

In this program, students from various schools were attached to mentors in I<sup>2</sup>R from Jan 08 to Jul 08. The projects given to the students were structured to develop interest and talent in scientific research. The program provided opportunities for the pupils with interest and aptitude in science to deepen their knowledge in a particular area of their choice; to learn about the latest research developments; to be challenged by the intellectually stimulating process of scientific research and to nature values and positive attitudes towards scientific inquiry and competitions. From feedbacks received, the students enjoyed themselves and some showed interest in wanting to work in I<sup>2</sup>R after completing their studies.

### **X-Periment Carnival**

The 2008 X-Periment carnival was held at Marina Square Shopping centre from 15th to 17th August. I<sup>2</sup>R showcased 2 items, the social robot and a quick reaction game suitable for children. The carnival was to encourage the youths to inquisitive about science. The social robot could understand speech, recognize objects, pick them up gently and navigate its own way around a room. While the children were interested in playing the game, many adults and youths were fascinated by the robot. They experimented with the robot and were intrigued by the response of the robot. The robot was a hit that Mediacorp Channel 8 interviewed the team. The carnival was an excellent platform to showcase our technology and encourage students to take up science and engineering as a career.

### Meet the Scientist

Every year, I<sup>2</sup>R nominates 2 scientists to give talks at the Science Centre and 2008 was no exception. The two scientists were Dr. Tan Yeow Kee and Dr. Manjeet Singh. Dr. Tan spoke about his work on social robotics and Dr. Manjeet explained the concepts of game theory. Both talks were well attended by the public and schools. The feedback was very encouraging and positive. These talks allowed the students and Singapore Science Centre visitors to interact with real-life scientists, and know more about interesting scientific research topics, as well as what motivates scientists to be passionate about their work.

### Research Exposure Program (REP)

I<sup>2</sup>R played host to 25 upper secondary school students. During the programme, the students were treated to various talks and demonstrations. The students were clearly fascinated by the technology and work done at I<sup>2</sup>R. Many thought that scientists did boring work and got their hands dirty in the process. The program allowed the students to interact with the researchers, and know more about interesting scientific research topics, as well as what motivates researchers to be passionate about their work.

### TechFest 2008

The above activity was held in Fusionopolis on 22nd November. Students were invited to view the latest technologies developed by I<sup>2</sup>R. It was a great platform to showcase our emerging technologies and innovations. The students were exposed to the latest research and intermingled with various researchers and scientists to learn the latest advances in science and engineering. On display were various technologies with the potential to enhance information systems, accelerate computation and extend devices to new applications. Instead of the usual boring talks, this activity showed completed products that truly fascinated and inspired the students.

### Related KPIs

- No. of events organised for (or participated by) primary/secondary schools and JCs.: 22
- No. of Undergraduate/Poly/JC/Scholars students attached : 206

Types of AI Programmes	Total No. of Students in FY2008
Undergraduate Final Year Project Attachment (NTU and NUS including Honours Year Project)	62
Undergraduate Industrial Attachment (Including NUS Vacation Internship Programme, NUS/NTU local IA/ NUS / NTU Industrial Attachment Programme, NUROP, UROP, ISM, Local student from Overseas University)	36
Science Mentorship Programme	36
Polytechnic Students Attachments (Including A*STAR Polytechnic Students Research Programme)	64
A*STAR-MOE JCI Students Attachment / A*STAR Young Researchers Attachment Programme (YRAP)	1
A*STAR Pre-departure / Summer Attachment Programme	7
<b>Total</b>	<b>206</b>

**Table 4:** Types of AI Programmes

# VIII. Scientific Advisory Board

## **The I<sup>2</sup>R's Scientific Advisory Board (SAB), as at end of FY2008, included:**

- Prof. Jean Vuillemin, Ecole Normale Superieure (Chairman)
- Prof. Randy Howard Katz, University of California, Berkeley
- Prof. Richard Lipton, Georgia Tech
- Dr. Hamid Ahmadi, InQvest
- Dr. Stuart Card, Palo Alto Research Center
- Dr. Bernard S. Meyerson, IBM
- Dr. Henry Tirri, Nokia Research Centre

Of these, Dr Ahmadi and Dr Tirri were new members that had joined after the end of FY2007. Prof. Vuillemin was appointed as the new Chairman, taking over from Prof. Katz.

The SAB next visited the institute from 15th to 17th October 2008. I<sup>2</sup>R provided an overview of both the current research efforts and industry engagements. Following the overview, the SAB were shown demos of ten technologies developed within the institute.

During the visit, the SAB also took part in a discussion on the upcoming Services Programme. The session was attended by the SAB members and about 20 researchers from DM, NP, C&S, SP, CVIU and HLT departments working on services-related areas. DED (I), Budiman Sastra, chaired the session. SAB was supportive of the areas of focus and approach of the Services Programme and advised that I<sup>2</sup>R should engage big players in the field instead of engaging just one of them or competing with them.

The SAB comments and recommendations over the 3 days were invaluable in helping I<sup>2</sup>R understand better its strengths and weakness, to explore methods to improve the way it manages R&D and to consider various approaches and directions of technical pursuits.



# IX. Other Significant Events, Awards and MOUs

## **Corporate Events**

I<sup>2</sup>R was involved in 61 events, involving external participation, in FY2008. These conferences, seminars, workshops, talks and other adhoc events were part of the Institute's contribution towards expanding knowledge areas with those in the infocomm industry and academia in Singapore.

Industry players such as Accenture, Intel Research, NVidia Corporation, HP Labs were also featured highly in delivering industry insights to researchers.

International conferences organized by the Institute included Cognitive Radio Oriented Wireless Networks and Communications (CrownCom 2008), 4th ACM SIGGRAPH International Conference on Virtual-Reality Continuum (VRCAI 2008) and 10th International Conference of e-Health, Networking Applications & Services (Healthcom 2008).

Besides participating in CommunicAsia 2008, Ocular Imaging Symposium, Official Opening of Fusionopolis and SIGGRAPH Asia 2008, I<sup>2</sup>R also organised the annual Infocomm and Media Horizons seminar and TechFest.

Staff of the institute were also extensively involved in 2008 IEEE 67th Vehicular Technology Conference (VTC2008 - Spring), World Cities Summit, A\*STAR-Fulbright Global Conference themed "Futuropolis 2058: Creating Sustainable Urban Environments through Innovation", the week-long opening of Fusionopolis and the multimedia search engine competition - The Star Challenge 2008 in conjunction with FusionFest activities.

The Institute also organised SinFra '09 - Singaporean-French IPAL Symposium that aimed to strengthen existing research collaborations between French and Singapore scientists. I<sup>2</sup>R also organized the SEACOOOP Consortium Meeting held in conjunction with CommunicAsia 2008 and Commissioner Viviane Reding's visit to Singapore.

## **Visits**

Followings were some notable visits to I<sup>2</sup>R:

### ***1st Apr 2008, IDA,***

- RADM (NS) Ronnie Tay, CEO, IDA
- Mr. Leong Keng Thai, DCE, IDA
- Dr. Geok Leng Tan, CTO, IDA
- Mr. Ramakrishna Purushotaman, DD - Industry Development, IDA

### ***28th May 2008, Kenwood Corporation (Japan) R&D division***

- Mr. Shimada, GM for Kenwood Corporation (Japan) R&D division
- Mr. Henry, GM for Kenwood Singapore (KETS)
- Mr. Hida, KETS R&D Division Head
- Mr. Kadowaki, KETS R&D Chief Engineer
- Mr. Thenarasu, KETS R&D Manager.

### ***4th Jun 2008, US Army***

- Major General Fred Robinson, Commander of US Army Research Development Engineering Command (RDECOM) & delegation

### ***20th Jun 2008, European Commission***

- Commissioner Viviane Reding & delegation

**1st Dec 2008, Ministry of Defence**

- Minister Teo Chee Hean

**5th Dec 2008, Ministry of Health**

- Minister Khaw Boon Wan

**3rd Mar 2009, NECTEC**

- Prof. Dr. Pairash Thajchayapong (Chairman) & delegation

**5th Mar 2009, Duke University**

- Prof. Bennet A. Zelner & delegation of MBA students

**13th Mar 2009, Delegation Office of the European Commission**

- Mr. Moumem Hamdouch
- Mr. Pierre Herges

**31st Mar 2009, Boeing**

- Ms. Susan Ying, (Director)
- Ms. Kjell Carlsen (Senior Manager)
- Mr. Keith Young (Senior Manager)
- Mr. Ming-Yuh Huang (Program Manager)
- Mr. Sidney Ly (Associate Technical Fellow)
- Mr. Al Salour (Program Manager)

## Awards

**International awards won include:**

- The Board of Nokia Foundation awarded the honour of “Nokia Visiting Professor” of the year 2009, with a grant of 10,000 Euros to Dr Li Haizhou, HLT Dept. Head. The Finnish researchers in his field nominated him for this award to recognize his contributions to Speaker and Language Recognition research. This honour had been given to distinguished professors. Formal announcement was made by the Chairman of Nokia in the Nokia Awards Ceremony in Helsinki on November 18, 2008.
- Dr. Lim Joo Hwee from Computer Vision and Image Understanding Dept. (CVIU) received a letter (dated 18 July 2008) from the French Embassy on his award as Chevalier (Knight) of the French Ordre des Palmes academiques, together with a certificate (dated 28 April 2008) endorsed by the Ministre de l’Education Nationale.
- Dr Victor Tong Joo Chuan, from Data Mining Department, had been conferred the “TR35 Award” for his research work on Personalized Vaccine Design. He is one of the 35 top innovators in science and technology under the age of 35 honoured by MIT’s Technology Review magazine this year.

- Dr Susanto Rahardja and Dr Huang Zhiyong were elected as the President and Vice President of SIGGRAPH Singapore Chapter (SSC) and Southeast Asia Graphics (SEAGRAPH) society in the AGM, 11 March 2009. SSC and SEAGRAPH were initiated and established by ACM SIGGRAPH as the interdisciplinary communities to networking the professionals and enthusiasts in computer graphics and interactive techniques (CGI). The leadership would allow I<sup>2</sup>R to make a greater coordinated effort to distinguish I<sup>2</sup>R in ACM SIGGRAPH and other international CGI communities.
- The Speech Group from I<sup>2</sup>R's Human Language Technology Dept. won overall first position in the National Institute of Standards and Technology 2008 Speaker (core test condition). I<sup>2</sup>R team members comprised Haizhou Li, Bin Ma, Hanwu Sun, Donglai Zhu, Kong-Aik Lee, Khe Chai Sim, Changhuai You, Rong Tong, Ismo Kärkkäinen, Vladimir Pervouchine, Susanto Rahardja, and I<sup>2</sup>R interns Yijie Li (USTC, China), Chien-Lin Huang (NTU), Julien Epps (UNSW, Australia) and Qin Jin (CMU, USA).
- The automatic run submission by Dr. Gao Sheng from Computer Vision and Image Understanding Dept. (CVIU), participated under the name of IPAL, emerged as 2nd (text modality), 4th (image modality) and 3rd (image+text modalities) among 25 participating research groups from Europe, Asia and North America, in the Photographic Image Retrieval Task (ImageCLEF Photo) of ImageCLEF 2008.
- FCC had officially released the test report on white-space device testing (spectrum sensing for cognitive radio). In addition, FCC was pleased with the test results and had recommended opening up TV spectrum for such secondary access. Our device's performance was superior in sensing digital TV and wireless microphone in actual field trial. They proposed to vote for such usage in their next commission meeting on 4th Nov.
- NUS-I<sup>2</sup>R team won the first place in the liver tumour segmentation performance competition (in the semiautomatic category) organized by the workshop: 3D segmentation in the clinic, A Grand Challenge II, held in New York on Sept. 6-10 in the leading international medical imaging conference, MICCAI2008.
- A team of researchers from I<sup>2</sup>R Brain-Computer Interface (BCI) team had won No. 1 position (amongst the 35 international teams) in the BCI Competition IV, 2008, in all three electroencephalograms (EEG) based non-invasive BCI categories. The results were announced on 12 December, at the Neural Information Processing Systems (NIPS) conference in Vancouver, Canada.. The I<sup>2</sup>R team consists of Zhang Haihong, Ang Kai Keng, Chin Zheng Yang, Guan Cuntai, Wang Chuanchu, Phua Kok Soon, Brahim Hamadicharef and Tee Keng Peng.

**Local Awards won include:**

- The team from CVIU Dept. (Li Liyuan, Luo Ruijiang, Dong Li, YuXinguo, Chin Tat Jun and Hoe Kah Eng, Jerry) in partnership with NUS reached the finals of the TechX Robot Competition. This was a competition on urban warfare robot organized by Mindef with a prize of S\$1 million. The team was one of the five (out of 9 teams) that passed the qualifying rounds to reach the finals. I<sup>2</sup>R's team was responsible for developing the robot vision system needed to identify objects, building and the surroundings.
- I<sup>2</sup>R FAMS Project (FAMS – An Intelligent Fish Activity Monitoring Technology to Ensure Water Quality) won the IES Prestigious Engineering Achievement Awards 2008. This was a joint project between I<sup>2</sup>R and PUB. The team comprised Eng How Lung, Chew Boon Fong, Lee Beng Hai, Myo Thida and Suryanti Yunita Anggrelly from Computer Vision and Image Understanding (CVIU) Dept.

- Deployed scholar Tony Quek from Modulation and Coding Department won this year's Philip Yeo Prize Award for Achievement in Research. The Award was inaugurated in 2007 to recognize note-worthy achievements and contributions of A\*STAR scholars. The prize was open to all incumbent NSS (BS), NSS (PhD), MBBS-PhD, AGS (Overseas, Local) as well as deployed scholars. The selection was based on the quality of first or main authored papers in premium journals and/or significant achievements/contributions.
- Chin Zheng Yang, Manjeet Singh Rikhraj, Li Te and Vladimir Pervouchine received outstanding mentors and teacher advisor award by MOE. They were nominated by students under the SMP project, organised by MOE GEB (Gifted Education Branch).

## Directions and Strategies

Following the FY2007 transformation of the institute from a Divisional Structure to a Matrix Structure, FY2008 was a period of adjustment to the new structure and fine-tuning of processes. Over the course of FY2008, the institute adapted to the requirements and demands of the Matrix structure and enjoyed significant benefits from the change. This significant reorganisation was undertaken to better respond to the changing technology landscape and the evidence from FY2008 showed that the Matrix structure does help the institute be more agile and responsive, while also providing more efficient use of staff time.

In FY2008, the Services Programme, aka POISe (Personalisation, Optimisation & Intelligence through Services) was initiated. POISe is intended to focus on creating value through services, with an initial focus on Healthcare. Services is an important new field of focus for the institute and was thus begun as a dedicated programme.

Also in FY2009, I<sup>2</sup>R will facilitate a new programme, Infuse, which is a SERC initiative. Infuse is envisioned as a networking and funding platform for researchers and scholars to generate and test out research ideas and innovations, which might not fall neatly within existing RI research programmes.

Infuse is not meant for deep-domain research but rather, a platform for A\*STAR researchers and scholars to generate and experiment rapidly with wild ideas, focusing on the promising ones, through e.g. feasibility studies, mock ups, demos and/or prototypes, which will result in paradigm shifts.

Concurrently in FY2009, a significant new approach will be instituted for refreshing the Programmes. It is intended to provide a top-down and bottom-up innovation approach, where good ideas are welcomed from all staff. Staffs who submit proposals will be the Champions for their respective proposals and, if interested, will be involved with the Programme, if and when approved. In some cases, the management may appoint an alternative Programme Manager but the Champion will be encouraged to see his vision through and contribute to the final output of the new Programme.

The institute's current programmes and departments (refer Section IV for details) are well aligned with the EDB sub-clusters within the overall area of Infocomm and Media. As of 2009, the sub-clusters are Telecom & Networks, Infocomm Products, Media & Digital Entertainment and Software & IT Services. The institute had been traditionally strong in networking technologies and media processing which are relevant to and contribute to the first 3 clusters. And the recently begun Services programme expands the institute's competence into the 4th cluster.

# X. Concluding Statements/Remarks

Indeed, FY2008 had been an eventful and productive year for us. We continue to improve the research environment to enable our researchers to attain their highest potential. We had introduced the matrix structure to enable multidisciplinary projects and efficient resource management to create impact on research projects. At the same time, we also strived to improve the general work environment by strengthening our business processes and our efforts in work health promotion. We believe we had in place a vigorous R&D environment where researchers sense passion for innovation and a desire for excellence. This had been demonstrated through the strong R&D deliverables in FY2008, as well as various accolades through awards and peer recognitions won within and outside Singapore.

We will strive to continuously improve the R&D environment within the Institute with the refinement and adoption of quality best practices, both in terms of R&D and corporate governance. In particular, with the introduction of a rigorous matrix based research management regime, we anticipate this will strengthen research governance across the Institute.

In addition, we will look into mechanisms to enhance both internal and external partnerships and synergies, leveraging on the diversity of competencies that are available. Understanding the importance of nurturing both internal talent and developing a sustainable pipeline of talent, we will continue to work closely with schools, junior colleges, polytechnics and universities.

The achievements in FY2008 had demonstrated the core strength, resilience and relevance of the combined technical teams. We envisage that creative and innovative endeavours will continue to grow and to make an impact on Singapore's economy and advancement.