
**Strategies for Embedded Systems Research**

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**Deliverable**

# D3.3.1 Extra EU Activities

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## Objective

| Task 3.3 Extra-EU activities |
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| The project will look into Embedded Systems policies and programmes outside Europe. Of particular interest will be existing instruments and developments in the US such as those by DARPA and the NSF. Developments in other interesting countries (e.g. Korea, Japan) will also be monitored, summarized, and reported to Steering Group and/or Executive Committee. The information will be made available publicly at COSINE's web page and used in training workshops and other presentations. |

## Aims

This particular contribution, *Embedded Systems – In search of a common strategy* aims to compare recently published documents about current proposals for European Technological Platforms (ETP) and the ongoing programme Information Technology for European Advancement (ITEA) and it's follow up ITEA2 regarding their contents relating to Embedded Systems (ES).

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This report was compiled by

Ms Orsolya Dobán (BME MIT, doban@mit.bme.hu) and

Mr András Balogh (BME MIT, abalogh@mit.bme.hu),

and compiled and edited by

Mr Péter Hanák (NKTH, hanak@nkth.gov.hu).

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## Introduction

Embedded systems (ES) have become one of the most important research, development and innovation areas in information technology. Not surprisingly it is one of the focal areas in the quickly developing countries of Asia. This fact is well reflected in their recent information and communication technology (ICT) strategies. Good news that many countries have ICT strategies, these are well documented and published in English on the Web.

In the following sections the ICT strategies of a number of countries will be surveyed, with special emphasis on embedded systems. Please note the following:

- Since the main competitors of the EU member states in ICT are the United States and a bunch of Asian countries, the survey and analysis focuses on their policies and practices. In the frame of COSINE it would be impossible to significantly extend the survey to other regions.
- All the countries, surveyed in this report, refer in their policy documents to other countries' strategies in ICT, meaning that policy makers often learn from each other. In consequence, there are many similarities in these ICT policies and programmes, the main difference being in their extent and implementation ambitions. It can be assumed that the focal points of other countries' ICT policies do not differ significantly from those of the leading countries.
- Embedded and/or ambient systems are often called ubiquitous systems; the latter term is used almost exclusively in Japan.
- Some countries, first of all Japan and to a lesser extent Korea, make embedded, or ubiquitous, systems the core of their research, development and innovation activities in ICT, and build their R&D&I activities in other ICT-fields around these core activities.
- Other countries have more traditionally structured ICT-strategies, usually with special sections and programmes for embedded systems, e.g. the USA and Singapore.
- Further, some countries, e.g. India and China, have only traditional ICT strategies, without special reference to or programmes for embedded systems. However, even in these cases the need for embedded systems technologies and application developments is obvious from their ICT-strategies.
- The latter is exactly the reason why, to some extent, general ICT strategies will be surveyed below: even without special reference to embedded systems the reader will have an impression how important embedded systems technologies are in all countries surveyed.
- Finally, we also tried to survey ICT and in particular ES strategies of Russia. However, information about Russia is sporadic, especially in English but also in Russian. Even the Hungarian S&T attaché staying in Moscow could not find much text describing ICT and ES strategies which might conclude that such strategies and programmes do not exist in Russia. It may also be assumed that the situation is similar in other post-Sowiet countries, with the exception of the Baltic states.

It is also worth to mention that

- most ICT strategies explicitly mention the importance of international collaboration, and in particular agreements and joint events with the European Commission;
- the US National Science Fund has a regional office in Tokyo, Japan, see: http://www.nsftokyo.org.

**Other work**

Other reports and surveys on research, development and innovation activities that focus on or reference to embedded systems should also be mentioned here:

- CISTRANA, the European initiative for the Coordination of IST Research and National Activities, http://www.cistrana.org,
- Venture Development Corporation, a technology market research and strategy firm, USA, http://www.vdc-corp.com/embedded/index.html; White Papers: http://www.vdc-corp.com/embedded/white/index.html

## Content

# AUSTRALIA

Australia's information and communications technology (ICT) sector is one of the most highly developed and cost competitive ICT platforms in the Asia Pacific region. There is a strong local industry and many international ICT corporations have significant global operations based in Australia.

To support the growth of this important sector, the Department of Communications, Information Technology and the Arts[1] of the Australian Government administers a range of programmes and provides policy advice.

Data on the ICT industry in Australia is available from a number of sources, see e.g. the ICT industry information page.[2]

## ICT Framework for the Future

The ICT Framework for the Future[3] was announced by the Prime Minister at the World Congress on Information Technology in February 2002.

A Steering Committee, comprising leaders from the ICT industry and the research sector in Australia, was formed to develop the Framework. Chaired by the Minister for Communications, Information Technology and the Arts, the Committee was assisted by expert working groups in Mapping and Foresighting.

McKinsey & Company was commissioned to provide a report on the strategic perspective of the ICT industry in Australia in a global context, *Australia: Winning in the Global ICT Industry*. In the area of embedded systems, it was proposed that Australia specializes itself in *Mobile and Embedded Operating Systems.*[4]

The Framework report, *Enabling our Future*, was released by the Government on 15 April 2003. It focuses on broad strategic directions for the Australian ICT sector with recommendations in key areas impacting on the future development of an internationally competitive Australian ICT industry.

## National ICT Australia (NICTA)

National ICT Australia (NICTA), Australia's centre of excellence in ICT research, plays a major role in the Australian Government's policy to promote science and innovation.[5]

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[1] Department of Communications, Information Technology and the Arts, http://www.dcita.gov.au
[2] IST Industry Information, http://www.dcita.gov.au/ict/ict_industry_information
[3] ICT Framework for the Future, http://www.dcita.gov.au/ict/ict_framework_for_the_future
[4] McKinsey and Co. report, Chapter 3 on Software, http://www.dcita.gov.au/__data/assets/pdf_file/10358/The_McKinsey_and_Co_Report_Software.pdf
[5] National ICT Australia, http://www.nicta.com.au

In 2002 the Australian Government selected NICTA to establish and operate an enduring, world-class, world-scale ICT research and research training institute. NICTA will lift Australia's ability to generate breakthrough technologies, grow ICT businesses and spur the development of Australian industries creating jobs and wealth.

NICTA conducts research, provides research training, commercializes research and collaborates with private sector research organizations, major companies, small to medium size enterprises (SMEs) and public sector agencies.

NICTA will be one of Australia's largest ICT research organizations when fully established in 2006-07. It will run 17 research programmes and have more than 300 research staff, 75 research engineers and programmers and more than 100 post-graduate students.

NICTA's headquarters is at Australian Technology Park, Redfern, Sydney. It also has research laboratories at the Australian National University in Canberra and the University of NSW in Kensington, Sydney.

NICTA was initially funded with AUD 129.5 million over five years (from 2001-2006) under the Australian Government's innovation action plan - *Backing Australia's Ability*. In 2004, a further funding commitment of AUD 251 million over five years (from 2006-2011) has been provided through the Australian Government's companion science and innovation plan[6].

NICTA funding is jointly administered by the Department of Communications, Information Technology and the Arts (DCITA) and the Australian Research Council.

One of NICTA's research programmes is the Embedded, Real-Time, and Operating Systems (ERTOS) programme.[7] ERTOS focuses on *reducing the cost and improving the reliability and trustworthiness of embedded systems software.* They use microkernel technology to enable the application of software-engineering techniques and formal methods to the development of embedded software.

[6] Backing Australia's Ability - Building Our Future Through Science and Innovation, http://backingaus.innovation.gov.au
[7] Embedded, Real-Time, and Operating Systems, http://ertos.nicta.com.au

# CHINA

It follows from China's high population and the lately noticeable modernization in the country that nowadays China belongs to the world's largest consumer markets in the field of:

- personal computers (10M PCs sold / year),
- telecommunication (60M Internet subscribers, 360M cellular phones, 400M wired-line telephones),
- household appliances (80M Cable TV Users, 300M TV Sets, 40M VCD Players, 20M Learning Machines),
- private cars (in 2010 10M cars are expected to be sold) which means a large market and big opportunity for embedded in-car devices,
- semiconductors (China's aim is to be the second largest semiconductor market in the world).

Data related for China and in particular for Shanghai can be read in the presentation of Prof. Ju Dehua.[8]. Excerpts:

The software market increase is 30% pro year with a volume of USD 10 billion ($10^9$). Demands for embedded software development are growing explosively, in 2001 China's embedded software sales exceeded USD 580 million, which was approx. 14.5% of total software sales. According to a latest survey, 30% of software companies are being involved in embedded software development, additional 20% are planning to engage in.

The Chinese government places special emphasis on boosting the IT industry, and to turn software industry into a new pillar industry in the 21st Century.

Now, China has 7,000 software companies and nearly 400,000 professionals, and, in addition, more than 300,000 IT applications staff. From these, about 60% are employed by private enterprises and 10% are at foreign vendors. Approx. 66% of the software companies are small start-up businesses with fewer than 50 employees and a short history, possibly less than 5 years. Approx. 29% have 50 to 200 employees. There are at least 18 key software enterprises with more than 1000 employees and over USD 60 million revenue per year, like CS&S, [9] UFSoft Group,[10] Founder,[11] NEU-Alpine, etc.

Programmes which may increase the demand for embedded systems:

- Golden Projects Series

[8] http://www.bitkom.net/files/documents/Presentation_1_SSIA_Prof_JU_Dehua.pdf
[9] http://www.css.com.cn/enhome.php
[10] http://www.ufsoft.com.cn/english
[11] http://www.founder.com.cn/EnglishSite

- City Funded Information Port or Digital City Projects
- e-Government
- e-Enterprise, e-Business / Reformation Of Traditional Industry
- High-Tech Projects: Development of Embedded Systems as One of Key Areas (863 and 973 Programmes) and Major Projects for State Innovation Grants

**National High-Tech R&D Programme (863 Programme)[12]**

In line with national objectives and market demands, the programme addresses a number of cutting-edge high-tech issues of strategic importance and foresight during the 10th Five-year Plan period. They are:

1) *Develop key technologies for the construction of China's information infrastructure.* It aims to accelerate the national socio-economic development, drive industrialization through informatization, and enable China to approach or catch up with international pioneers in selected fields by the year 2005.
2) *Develop key biological, agricultural and pharmaceutical technologies to improve the welfare of the Chinese people.*
3) *Master key new materials and advanced manufacturing technologies to boost industrial competitiveness.* The 863 Programme attaches importance to developing nano-material and other new materials, along with related technologies for the development of aviation, the maglev (i.e. magnetically levitated) train, information storage and access, in order to meet major demands of national security and economic development by utilizing China's characteristic resources, environment, and technical strength.
4) *Achieve breakthroughs in key technologies for environmental protection, resources and energy development to serve the sustainable development of our society.*

At present there are totally eight fields and 20 subjects within the 863 programme, in which the Ministry of Science and Technology is responsible for organizing implementation in the six fields of biology, information, automation, energy, materials and marine technologies[13].

<u>The areas of the 863 programme:</u>

- Information Technology
  - *Computer Software and Hardware Technology*
    In 2002, 68 projects were initiated under this subject field covering 10 aspects such as high-performance CPU chip, network computer (NC) and its application, mass storage, system technology and integration, domain-oriented application middleware platform and its application, application component base system and its application, middleware key technology and integration etc.
  - *Communication Technology*

[12] http://www.most.gov.cn/eng/programmes/programmes1.htm
[13] http://english.gov.cn/2005-08/12/content_21701.htm

In 2002, 37 projects were initiated under this subject field covering 3 aspects including new generation information network technology, fiber optics technology and personal communication technology.

- *Information Acquisition and Processing Technology*
  In 2002, 69 projects were initiated under this subject field covering 5 aspects including Spatial Information Grid (SIG) framework technology, high-resolution spatial information acquisition technology, spatial information processing technology, spatial information application and industry promotion, and spatial information acquisition & process leading technology.
- *Information Security Technology*
  In 2002, 52 projects were initiated under this subject field covering 5 aspects including basic core technology of information security, integrated defense key technology of information security, network environment secure application technology, new technology of information security and application demonstration of information security.

- Biotechnology & Advanced Agricultural Technology
- Advanced Materials
- Advanced Manufacturing & Automation Technology
  - Contemporary Integrated Manufacturing System (CIMS)
  - Technologies on Robots
- Energy Technology
- Resource & Environment Technology

An exemplar ES related project:

*Design of Very Large Scale Integrated-circuit*
The objectives of the project are to enhance the design and development capability in very large scaled integrated-circuit through focusing on the key technology breakthrough and highlighting the construction of related environment and service system, to develop a number of key IC products including CPU with domestic intellectual property rights, to cultivate professional teams for IC design and to foster a batch of IC design enterprises able to develop products with domestic intellectual property rights and explore the international market.

Further project descriptions can be read in the 863 programme annual report 2002[14].

Organization and Management

1) Expert Responsibility System
During the 10th Five-year Plan period, the Programme continues practicing an expert responsibility system to engage the full role of experts in technical decision-making and judgments of the high-tech development trend while further developing the decision-making role of the government. The system is tiered with expert committees (priorities) and expert panels (subjects). The former supervise, assess, and give advice on project implementation in relevant priority fields. The latter is responsible

[14] http://www.863.org.cn/english/annual_report/annual_repor_2002/annual_repor_2002.pdf

for technical decision-making on relevant subjects and their project process management.

2) Project Management
During the 10th Five-year Plan period, the Programme adopts a project management system which includes calculation of the full budget, total cost accounting, and a project leader responsibility system. To pool resource and focus on key issues, key projects are managed by the general expert panel. As for R&D budget management, priority projects are mostly financed by the government and adopt a project budget system. Meanwhile, local governments, industries, enterprises and the whole society will be encouraged to increase input into high-tech R&D.

Special funds are earmarked to facilitate the integration of the 863 Programme with the "Programme on Major International Cooperation Projects", and support and encourage the implementation of international cooperative projects within the framework of the 863 Programme.

**National Programme on Key Basic Research Projects (973 Programme)**

The National Basic Research Programme (also called 973 Programme) is China's on-going national keystone basic research programme, which was approved by the Chinese government in June 1997 and is organized and implemented by the Ministry of Science and Technology[15]. The 973 Programme is created on the basis of existing research activities and deployments made by the National Nature Science Foundation and major dedicated pre-studies, to organize and implement basic research to meet the nation's major strategic needs.

This programme has four main tasks.

1) The first is to conduct multidisciplinary comprehensive research and provide theoretic and scientific foundations for the settlement of the important scientific issues regarding the development of the national economy and society as well as the science itself in the fields of agriculture, energy, information, resource and environment, population and health, materials, etc.
2) The second is to deploy relevant, important and explorative forefront basic researches.
3) The third is to nurture a number of outstanding personnel with high scientific qualification and creative capability, who meet the requirements of development in the 21st century.
4) The fourth is to build a group of high-level scientific and technological assignments of the country, thus constituting some interdisciplinary scientific research centers.

***Organizing and Managing the 973 Programme***

The Ministry of Science and Technology has set up a high-level advisory committee through appointing eminent. This committee is responsible for offering consultation

[15] http://www.973.gov.cn/English/Index.aspx

advice, assessment and supervision on the stipulation of the National Key Basic Research Development Programme, and the organization and selection of the research projects of the 973 Programme. In the course of organizing and implementing projects within the 973 Programme, the Ministry relies on the experts and gives full play to them. A chief scientist is appointed to the projects of the 973 Programme, who is entrusted with full power of leadership.

There exists a consulting group, which appoints senior experts and scholars from relevant fields to conduct follow-up observation and research during the implementation of the projects.

For the funding of the projects of the 973 Programme, the Ministry adopted a new mode of "2+3", namely, a stage-by-stage funding. Two years after each project is implemented, a mid-term evaluation and inspection should be conducted. Based on the actual performance and the evaluating comments of a special expert group, the decision will be made on whether the preset tasks should be continued, or whether the preset amount of funding should be adjusted in the next three years.

In accordance with the international practice in the financial management of scientific and technological projects, a "subject management system" was introduced for funding the 973 Programme projects in China. Namely, they conducted the total fund budgeting by subjects calculation, process control and full cost accounting inside of the projects.

Some exemplar ES related projects from the *Information* area[16]:

- Basic research of novel devices and novel process of system on a chip
- Basic Research on Photonic Integrated Circuit for High Speed, High Capacity Information Network
- Theory and Method for Real-time Intelligent Control and Optimization of Complex Production Manufacturing Process
- Fundamental Investigation on Micro-Nano Sensors and Systems based on BNI Fusion

**PR China – EU cooperation**

According to the "Agreement for Scientific and Technological Cooperation between the Government of the People's Republic of China and the European Community", the European Community opens all the activities of research, technological development and demonstration in the First Activity of the Framework Programme under Article 130g of the Treaty, establishing the European Community, for the Chinese participation, and the Ministry of Science and Technology of the People's Republic of China opens the National Basic Research Programme for the European participation. This implementation regulation is established to encourage and promote the cooperation between the Chinese and the European scientists under the framework of the National Basic Research Programme[17].

[16] http://www.973.gov.cn/English/AreaItem.aspx?catid=03
[17] http://www.973.gov.cn/English/AreaCoop.aspx

## Software parks

To unite scattered strength and integrate advantageous resources, the Chinese government has established 21 nationwide **software parks** (within the 53 National Science and Technology Industrial Parks of China[18]), e.g. the ZhongGuanCun Information Base at Beijing[19] (called as the Silicon Valley of China, was established in 1988 with 73 Universities including Beijing University, Tienhwa Uiversity and 230 research institutes. It is the best up-to-date-technology center in China with over 4,500 high-tech related corporations and 100,000 technological workers), the Shanghai Software Park and the Shanghai Pudong Software Park[20], the Shenzen Software Park,[21] the Central China Software Park at Wuhan city, the Dalian Software Park,[22] and Xian Software Park, as well as Ningbo International Software Park.

## Embedded software and systems[23]

A dozen of **embedded operating systems** with own IP rights have been developed in China. Almost all of these products have strong research and application background, and been successfully applied to practical systems and applications.

- Some overseas OS brands have still some dominance on the Chinese embedded market, mainly like Wind River's VxWorks, Windows CE and Embedded Linux.
- The Chinese OS will share more percentage in the future. They have been widely applied into many current hot applications, such as mobile phones, personal digital assistants, eBooks, eDictionaries, set top boxes, stock trading machines, information appliances, in-car devices etc.
- Chinese embedded developers always need more hard works, because they must face with simultaneously both battlefields; platform and application development. However, as a return, it will give them more skills and experiences in embedded development.

To meet the needs of domestic market, China has imported a number of **IC production lines** in recent years.

Shanghai is widely acknowledged as one of the major semiconductor centers in China. The concentration of semiconductor expertise in the city and the adjoining regions is unequalled. The neighbor delta of the Yangtse River is also an intensive area for the electronic industry creating an exceptional condition for the development of the embedded industry. Shanghai is dedicated to be one of world's largest base of IC chip production by 2015. By 2005 there will be more than 10 IC production lines with the annual outcome about USD 10 billion. It will be doubled by 2010 and there will be 30-40 production lines by 2015.

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[18] http://www.chinatorch.gov.cn/eng/ejym/Park.htm
[19] http://www.zhongguancun.com.cn/en/default.asp.htm
[20] http://www.spsp.com.cn/SoftparkEnglish/portal/index.jsp?tid=8&pid=8
[21] http://www.szsoftwarepark.com/english/home.htm
[22] http://www.dlsp.com.cn/english/index.asp
[23] http://www.asti.com.cn/doc/EmbSW.ppt

Shanghai has established its own IC design center, and IC design is one of the most important topic for research projects.

Through more 3 years research efforts, Beijing University has successfully developed a co-design platform and, as a breakthrough, released the first own-designed RISC-based embedded CPU chip in 1999, and in 2001 produced more 16- and 32 bits CPUs JBCore 32. So far at least 5 chips has been developed and produced by Chinese researchers.

## Major actors in ES in China

*Nokia* entered into China in 1985. So far it has invested about USD 2.7 billion in China, set up more than 20 offices, 8 joint ventures and 2 R&D centers. As a return, Nokia achieved more than USD 3 billion sale in China in 2001. China became Nokia's second largest market in the world.

For a long-term success in technology development and innovation, *Motorola* just unveiled its new five-year development plan in China, expressed in a short form "2+3+3":

- The '2' means building China into a world-wide manufacturing and R&D base.
- The first '3' means 3 new growth areas.
- The second '3' stands for 3 X USD 10 billion:
  1) annual production value to reach USD 10 billion by 2006,
  2) accumulated investment to reach USD 10 billion by 2006,
  3) local procurement to reach USD 10 billion by 2006 in China.

*DENSO Create Inc.*, a subsidiary of DENSO Japan, established DENSO Create Shanghai Inc., on June 27, 2002. The company develops software for DENSO-related products such as control systems and information system products for automobiles.[24]

Some overseas OS brands have still some dominance in current Chinese embedded market, mainly like *Wind River's VxWorks*, *Windows CE* and *Embedded Linux*. The Chinese OS will share more percentage in future market. They have been widely applied into many current hot applications, such as mobile phone, PDA, eBook, e-Dictionary, STB, Stock trading machine, information appliance, in-car devices etc.

*CoreTek*[25] -- the first company in China to provide an Integrated Development Environment (IDE) for embedded software, which includes operating system DeltaOS, DeltaCore, integrated development tool LamdaTool, testing tool

[24] http://www.denso.co.jp/en/newsreleases/030324-01.html
[25] http://www.esmertec.com/press/2005/050202_pressrelease_CoreTek_Acqusition_E.pdf

GammaRAY, auxiliary embedded components as well as DeltaWAP for wireless application development.[26]

The *Eurotech Group* announced the official opening of the Eurotech Nanjing University of Technology (NJUT) Research Center, as well as the sponsorship of a new university course on the design of embedded computing systems.[27]

**Further useful links**

- National Software Export Base: http://www.tnseb.com.cn/english.asp
- Reference to Chinese Software, Hardware, and Computing Web Sites: http://www.chinasite.com/Technology/Chinacomp.html
- China's IT resource website: http://www.iturls.com/English/Default.asp

[26] http://www.embedded.com/showArticle.jhtml?articleID=59300651
[27] http://www.eurotech.it/main/news.asp?2M=50

# INDIA

The Indian software and services export is estimated at Rs. 78,230 crore[28] (USD 17.2 billion) in 2004-05, as compared to Rs. 58,240 crore (USD 12.8 billion) in 2003-04, an increase of 34% both in rupee terms and dollar terms[29].

The total number of IT professionals employed in India has grown from 284,000 in 1999-2000 to over 1million in 2004-05, growing by over 160,000 in the last year alone.

Unprecedented growth of telecom subscribers have occurred during the year 2004. As many as 22.18 million subscribers have been added during the year 2004. A tele-density of 8.62 per 100 persons in the country has consequently been achieved by December 2004, crossing 92 million mark. An interesting observation is that 19.50 million mobile subscribers were added during the year, taking the total of this category to 48 million, and thus wireless phones overtook fixed wireline connections.

### Initiatives in the Information Technology Sector

The importance of e-Governance has been recognized in the **National Common Minimum Programme**[30]. Three important elements of the National e-Governance Plan, which form the core infrastructure for the effective service delivery paradigm are Data Centres, State Wide Area Networks (SWANs) and Common Services Centres (CSCs).

A Centre of Excellence in Wireless Technologies (CEWiT)[31] has been set up in Chennai, with the seed capital provided by the Department of Information Technology through Media Lab Asia, as a public-private partnership initiative to undertake research and development in the fast developing area of fixed/mobile wireless technologies, and work on creating newer technologies and solutions in the area of next generation wireless communication.

**Media Lab Asia**[32] was set up as a not-for-profit Section 25 Company with an aim to research and innovate Information and Communication Technologies (ICT) relevant for the common man and to promote deployment of research projects in rural and remote areas to serve the poor and other needy population.

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[28] Rs. = rupees, One Indian crore = one hundred million; a unit in the traditional number system in India, Pakistan and Bangladesh, The same name with a different meaning was also used in Persia (Wikipedia).
[29] Department of Information Technology, Ministry of Communication and Information Technology, Annual report 2004-2005, http://www.mit.gov.in/annualreport2004-05.zip
[30] http://nac.nic.in/ncmp.htm
[31] http://www.cewit.org.in
[32] http://www.medialabasia.org

The Media Lab Asia works with the academic/research institutions, industry, non-governmental organizations (NGOs), and government to bring these innovations for the benefit of the masses.

Media Lab Asia applies a project-based, multi-stakeholder approach to research. In doing so, it transmutes research into widely-distributed, on-the-ground projects with strong industry support.

Media Lab Asia consists of regional laboratories and participating grassroots communities. Every regional laboratory is formed around several core projects, each involving academic, industrial, and village community partners. Each regional laboratory has a small permanent senior research staff that is independent of the associated academic institutions, and researchers who have short-term appointments of three to five years; students; and researchers from sponsoring organizations, including companies and NGOs.

Media Lab Asia's research projects may be divided into three technical initiatives:

- *Bits for All:*
  This aims at bringing digitally enabled services to even the most remote locations by creating disruptive technologies, bicycle computers ("Infothela") and other cost effective methods.
- *The World Computer*
  Build affordable smart devices and computers for underserved communities, children, illiterates, etc.
- *Tomorrow's Tools:*
  Development of low-cost instrumentation and fabrication facilities to empower rural innovators and entrepreneurs to transform traditional handicrafts, agriculture education and health care.

Exemplar ES related projects are:

- *A replicable model for IT based health system at grassroots:* Handheld device based data collection methods are being developed and tested.
- *Polysensors:* research will prototype a water testing device that can be taken into remote areas. A sensor for a medical parameter (glucose) will also be developed.

More information about these and further projects can be read on the Media Lab Asia website[33].

These ideas are developed in two ways: through research laboratories that generate and prototype new concepts, and through field projects that develop, test and evaluate these laboratory prototypes.

There are further ES related ongoing projects in Media Lab Asia:

[33] http://www.medialabasia.org/index.php?option=content&task=view&id=34&Itemid=43

***Ad-hoc Networks***[34]

An ad-hoc network is a dynamically changing unpredictable network that is created by the mobile nodes when needed for their own communication purposes. Under the project at IIT Delhi, a test implementation of IEEE 802.11b WiFi standard based self-configurable network with PCs and Hand Held Computers (iPAQs) has been developed on Linux. Further, a temperature sensor network has been designed and tested. Other than measuring the temperature, the sensor is able to schedule measurements and communicate the same to a 'collator'. The collection of collators, in turn, forms an ad hoc network, discover the central 'temperature management station' and communicate all collated information to the temperature management station.

*System-on-Chip for Messaging Terminal as an Access Device*

MeTel Plus is a low cost messaging terminal. It is targeted for applications in rural areas, in conjunction with a connectivity solution such as the CorDect wireless system. The aim of the project is to provide a terminal for simple web-browsing, email, chat, SMS, stock quotes and market price checks, etc., over a wireless connectivity. The prototype is being made using Field Programmable Gate Arrays (FPGAs).

*A Mobile Health Care Delivery System*

A mobile healthcare system typically consists of mobile units equipped with computers and diagnostic devices. These units are supported by specially developed software and hardware for health screening, health education, information dissemination, patient data acquisition, and communication with doctors for diagnosis, prescription and treatment.

The **Department of Information Technology** of the Ministry of Communication and Information Technology has been giving importance to promote research and development in the field of Information Technology and Electronics in the country and provides financial support for undertaking research and development. The projects which were completed during the years have led to setting up of *four Centers for Development for Advanced Computing (C-DAC).*

C-DAC is a multi-locational, multiactivity organization spread out at 10 locations with 14 laboratories and has a work force of about 1800 employees.

Some exemplar C-DAC focus areas are:

- High Performance Computing (HPC) and Grid Computing

[34] http://www.medialabasia.org/index.php?option=content&task=view&id=50&Itemid=59

- Power Electronics, Agri-Electronics, Real Time Systems, *Embedded Systems* and VLSI Design[29]
  - development of a Remote Inspection Device (RID),
  - Trouble Call Registration and Management System,
  - power supply module for Mirage Aircrafts, and so on.
- Broadband, Wireless and Internet Technologies
- Health Informatics

C-DAC website[35] contains detailed information about their ongoing projects.

***R&D Groups***

1. *Convergence, Communication, Internet and Broadband Technologies (CCIBT)* group.

   The following are important developments in progress, as example projects:
   - Research in broadband wireless access technologies and deployment of Wi-Fi protocol based campus network
   - Digital Connectivity through Amateur Radio to assist in Disaster Management
   - Wireless Communication for Underground Mines (including Trapped Miner Communication)
   - Secure Hybrid Network (wireline and wireless) and Managed Security System

   Technologies that were successfully developed and commercialized during the last 5 years, are described on the webpage.[36] Some examples :

   - Set Top Box technology for Internet access via Cable TV / DTH
   - Bluetooth short range wireless communication adapters
   - Portable X-Ray baggage system
   - Satellite based vehicle tracking and management systems
   - Electronic Stethoscope
   - GPS receivers for defense applications

   The focus of development in the coming years will be on the following:
   - Next generation wireless technology based communications
   - Low cost communication and computing access devices
   - Wi-Fi, Wi-Max, Hybrid Network deployments for important applications
   - Developments in VOIP technology and IPv6 protocol software tools
   - Security devices.

2. *R&D Group in Electronics*

[35] http://www.cdac.in
[36] http://www.mit.gov.in/ccibt.asp#2

The areas assigned to the Group cover: Electronic Materials and Components, Microelectronics, Photonics, Medical Electronics, Industrial Applications, and Promotion of Electronics/IT Hardware manufacturing.[37]

### *Smart Card Initiative*[38]

The Department has financially supported the development of core technologies for a Smart Card Operating System for Transport Applications (SCOSTA) standard. Two projects, namely 'Development of an OS for Smart Cards' and 'Testing Tools for and Extensions of SCOSTA', have been successfully completed.

### International Cooperation

As part of the International Cooperation with other countries under the Protocols signed by the Department of Information Technology of the Ministry of Communications and Information Technology projects proposed to be supported under Indo-EU Cooperation under the 6th Framework Programme have been prepared in the areas of ERNET/GEANT connectivity, Quality Of Service for 4G Mobile Networks and IPv6 tools.

Under the Indo-European programme 'Collaboration in the area of IT', the Department has proposed to connect GEANT, the Academic and Research Computer Network of the European Union, with ERNET, the Education and Research Network of India. The proposed connectivity would facilitate Indian universities, colleges and other educational institutions connected on ERNET to log into the network of their counterparts in Europe to share information and also undertake collaborative research and development. The European Union has proposed to provide funds for the implementation of the project to the extent of 50% of the total cost of bandwidth connectivity between ERNET and GEANT.

The European Union under the IST Programme has offered to fund R&D in the area of Communication including e-communication, Internet2, 4G Mobile, etc. The project proposal would be executed by ERNET along with further Indian institutes.

### Department of Information Technology Annual Plan 2005-06 (Rs. Crore)

| SCHEME | Budgetary Support |
|---|---|
| I. R&D PROGRAMMES | |
| 1 SAMEER | 20.00 |
| 2 Microelectronics & Nanotech Development Programme | 40.00 |
| 3 Technology Development Council | 17.00 |
| 4 Convergence, Communication & Strategic Electronics | 6.00 |
| 5 Components & Material Development Programme | 10.00 |
| 6 C-DAC | 60.00 |

[37] http://www.mit.gov.in/R&D/projects/rndelectronics.asp
[38] http://www.mit.gov.in/smartcard/overview.asp

| | |
|---|---|
| 7 Electronics in Health | 14.00 |
| 8 Technology Development for Indian Languages | 7.00 |
| 9 IPR Promotion Programme | 1.00 |
| 10 E-Commerce & Info-Security | 8.00 |
| 11 IT for Masses (Telemedicine) | 8.00 |
| 12 Media Lab Asia | 1.00 |
| R&D Sub-Total | 192.00 |
| | |
| II. INFRASTRUCTURE DEVELOPMENT | |
| 13 Vidya Vahini & Gyan Vahini Programme | 1.50 |
| 14 STQC | 42.00 |
| 15 STPI & EHTP | 4.00 |
| 16 Digital DNA Park | 10.00 |
| 17 Electronic Governance | 300.00 |
| 18 IT Act / Certification & Network Security | 7.00 |
| 19 Community Information Centres (CIC) | 50.00 |
| 20 Setting-up of Megafab | 10.00 |
| Infrastructure Sub-Total | 424.50 |

**Embedded software and systems**

With a worldwide market estimated at USD 21 billion, embedded software represents “a huge opportunity for Indian companies,” said Arun Kumar, chairman of India's National Association of Software and Service Companies (Nasscom).

Telecommunications, computing and datacom applications account for 34% of the world's embedded-software market, according to Nasscom. That's followed by consumer electronics (20%), industrial automation (19%), automotive (10%) and office automation (8%).

“Applicability of embedded systems is increasing in key user industries,” said Nasscom's Kumar. “In the automotive sector, for example, major advances such as automatic braking systems, telematics and engine control are all powered by embedded software.”

Software will also play a key role as both a technology enabler and a differentiator in such appliances as smart phones, camera phones and PDAs, said Shyam Kodavarthi, general manager of business development at Sasken.

A key challenge is imposed by such limits as memory, Mips and power, Kodavarthi said.

Startups like Ittiam Systems focus on embedded systems for digital signal processing. „We estimate the market for DSP-based embedded systems design to be around $1 billion,” said Srini Rajam, chairman and chief executive officer of Ittiam. „The key market segments we address are audio-speech, image video, wireless and wireline.”

Embedded software development constituted „a significant percentage" of the $1.2 billion in revenue India's software industry obtained from the R&D and technology sector in 2001-2002, said Nasscom president Kiran Karnik.[39]

## Further useful links

- http://www.indianngos.com/government/websites.htm
- http://www.mit.gov.in

[39] http://www.embedded.com/showArticle.jhtml?articleID=9901147

# JAPAN

Japan has developed an integrated IT strategy that started with the e-Japan programme[40] in 2001. The main goal of this initial plan was to create a "knowledge-emergent" society where everyone can utilize information technology and fully enjoy its benefits. The programme tried to make Japan the world's most advanced IT nation by 2006. The key points of this strategy are:

- Building ultra-high speed Internet network and providing constant Internet access at the earliest date possible
- Establishing rules on electronic commerce
- Realizing an electronic government
- Nurturing high-quality human resources for the new era

The coordinator of the main IT projects and programmes in Japan is the Strategic Headquarters for the Promotion of an Advanced Information and Telecommunications Network Society[41] (IT Strategic Headquarters) which was established in 2001 within the Cabinet. Besides this organization, most of the ministries in the country have its own projects for IT-related research and developments.

In 2003, Japan announced the e-Japan strategy II[42] that evolved the main idea of the original e-Japan programme ("IT infrastructure development") to a higher level: "Effective IT Utilization". By this time, Japan had built a high speed network infrastructure, connecting more than 7 million households by DSL, and more than 30 million households by other high speed internet connections. The e-Government and e-Commerce infrastructure of the country was also very extensive.

The new strategy aimed at the better utilization of this existing infrastructure by integrating as many services as possible (including the socioeconomic system). The prerequisite for this is that they have to first strategically unlock the full potential of the Japanese people for the task at hand and then implementing the necessary policies for the effective utilization of IT. The main strategic points of this programme are the following:

## *E-Japan strategy II: Effective IT Utilization*

### Realizing an energetic, worry-free, exciting and more convenient society through the effective IT utilization

[40] The e-Japan programme, http://www.kantei.go.jp/foreign/it/network/0122full_e.html
[41] Strategic Headquarters for the Promotion of an Advanced Information and Telecommunications Network Society, http://www.kantei.go.jp/foreign/policy/it/index_e.html
[42] The e-Japan II strategy, http://www.kantei.go.jp/foreign/policy/it/0702senryaku_e.pdf

The definition of a Japanese society that is suitable to the 21st century is one which is vibrant and more convenient and where people can lead safe and stimulating lives. First and foremost, for the society to be convenient the economy must be strong. Through the active use of IT individuals will reach the limits of their potentials through the worry-free access and exchange of a wealth of knowledge and information. In this way, as individuals expand their potential; the global competitiveness of the domestic industries will also be stimulated and strengthened by the flowering of this new culture.

**Effective IT utilization strategy: structural reforms and the creation of new values**

To create this new society, first and foremost, Japan needs to carry out structural reforms. This means cutting out wasteful or redundant aspects of the existing system and to better manage resources. If this is done, the private business sector will then be capable of re-building a lucrative base, at the same time the government will be able to re-organize the system to better maximize cost efficiency. Japan has various management resources that it can boast to the world, such as high-tech technology, and elaborate social infrastructure, and a sophisticated population and culture.

However, in most cases, these resources are not being effectively managed. What is needed is not just introducing computers into the workplace or into schools, but rather to remove any barriers that hinder the free-flow of information. By going beyond the existing organizational framework and re-defining the business process, Japan can then revitalize its economy, regaining its competitive edge.

**The point of view of the individual and new international relations**

In order to implement the above reforms, Japan, on the one side, must take into account the logic of the service and suppliers' side, and, on the other side, must also understand the point of view of the individual. The task, then, is to consider to what extent the private industry and the government can advance utilizing IT, and at the same time to consider what effects these technical advances will have on medical, labor and other such activities of "the individual."

## *The u-Japan programme*

E-Japan Strategy II ends in 2006. The new vision of Japan is the *u-Japan programme,* where u stands for "ubiquitous" or "ubiquitous systems".[43] This is the main motivation of the current programmes and strategy of Japan for the coming years (Figure 1).

[43] Information and Communications in Japan, White Papers from 2001 to 2005, yearly, http://www.johotsusintokei.soumu.go.jp/english

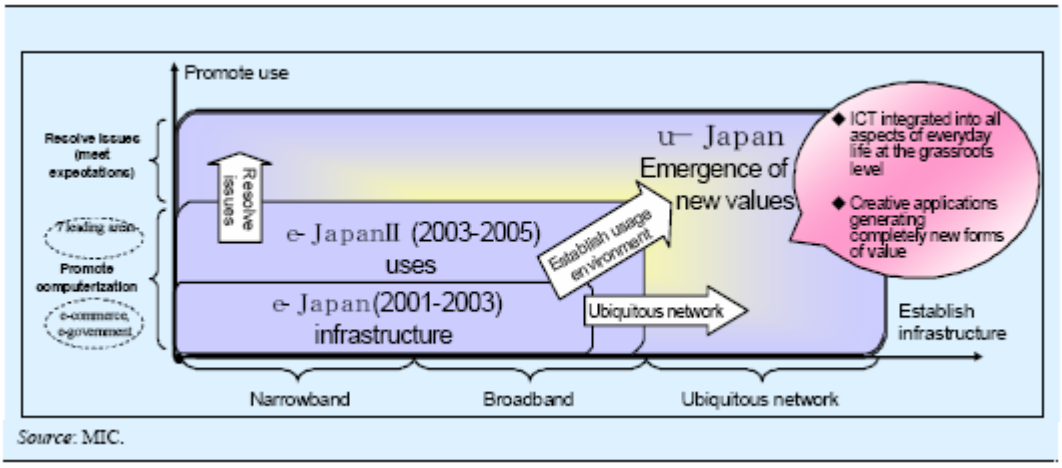



**Figure 1 From e-Japan to u-Japan[44]**

Ubiquitous systems is the Japanese term for embedded and ambient systems. One of the best known Japan IT experts, Professor Ken Sakamoto defined ubiquitous systems as follows:

*"I envisioned that the microprocessor, which had appeared in [the] 1970s and had become more powerful each year, would be embedded in many things. It was already obvious that industrial equipment like assembly line controllers and robots would have embedded computers, but I thought common objects like sunglasses and furniture could benefit from embedded computers."*

*„Ubiquitous computing, or calm technology, is a paradigm shift where technology becomes virtually invisible in our lives. Instead of having a desk-top or lap-top machine, the technology we use will be embedded in our environment."*

This shows that this term is nearly identical with the term of embedded/ambient systems.

### Large IT-projects supported by the Japanese government[45]

Table 1 and 2 list the large projects in the IT sector that are sponsored by the Japanese government in the fiscal years 2004-2005 and 2005-2006, respectively. As the tables show ubiquitous technologies and their applications have been given preference in these projects.

| | PROJECT | Ministry | JFY2005 Budget | JFY2005 Request | JFY2004 Budget |
|---|---|---|---|---|---|

[44] Ubiquitous Network Societies: The Case of Japan, Page 22, http://www.itu.int/osg/spu/ni/ubiquitous/Papers/UNSJapanCaseStudy.pdf#search='UNSJapanCaseStudy'

[45] Source: http://www.nsftokyo.org/trm.html

| | | | Yen Million | Yen Million | Yen Million |
|---|---|---|---|---|---|
| **A** | Ubiquitous sensor network | MIC | 400 | 500 | 0 |
| **A** | Asia ubiquitous platform technology | MIC | 330 | 600 | 0 |
| **A** | Ubiquitous network | MIC | 2 608 | 3 105 | 3105 |
| **S** | Highly efficient use of electronic tag | MIC | 629 | 699 | 699 |
| **S** | Basic technologies for supporting safe ubiquitous society | MEXT | 360 | 600 | 0 |
| **A** | Rationalization of supply chain with electronic tag | METI | 3 100 | 3 160 | 3000 |
| **A** | Autonomous move support project | MLIT | 490 | 500 | 480 |
| **C** | Public transportation real time system | MLIT | 0 | 13 | 0 |
| **S** | Next-generation backbone network for internet | MIC | 2 000 | 2 000 | 0 |
| **C** | Networking of digital home appliances | MIC | 0 | 300 | 0 |
| **B** | Shift of internet to IPv6 | MIC | 1 053 | 1 752 | 1752 |
| **A** | Joint use of high-level electric wave in mobile communication system | MIC | 7 842 | 11 288 | 0 |
| **A** | Basic research in wireless communication system with 6-30GHz | MIC | 7 842 | 11 288 | 0 |
| **A** | Wireless communication system with 30GHz and up | MIC | 7 842 | 11 288 | 0 |
| **B** | Narrower band for radar | MIC | 7 842 | 11 288 | 0 |
| **B** | Joint technologies for satellite communications and other communications | MIC | 7 842 | 11 288 | 0 |
| **B** | Next-generation wireless communication measurement technologies | MIC | 7 842 | 11 288 | 0 |
| **A** | Consolidation of digital information home appliances | METI | 1 500 | 2 500 | 0 |
| **B** | Advanced network identification technologies | MIC | 660 | 1 100 | 1040 |
| **A** | Early-stage caution for computer security | METI | 883 | 1 350 | 0 |
| **B** | Company/individual security countermeasures | METI | 921 | 1 800 | 0 |
| **B** | Next-generation image contents production/distribution | MIC | 170 | 380 | 0 |
| **C** | Environment-friendly image expression technologies | MIC | 0 | 107 | 0 |
| **A** | Basic software for e-Society | MEXT | 1 034 | 1 100 | 1100 |
| **A** | Industry-university cooperation software engineering | METI | 900 | 1 200 | 932 |
| **A** | Advanced social infrastructure software | METI | 612 | 1 000 | 0 |
| **B** | Verification of mutual usability of medical information system | METI | 449 | 600 | 0 |
| **B** | Asia OSS (Open Source Software) | METI | 343 | 500 | 0 |
| **B** | Network human interface: multi language voice translation system | MIC | 476 | 850 | 730 |
| **B** | Network human interface: Effect of optical stimulus on human body | MIC | 476 | 850 | 730 |
| **A** | Network human interface: Network robotics | MIC | 476 | 850 | 730 |
| **A** | Detective robots at Nuclear/biological/chemical accident sites | MIC | 106 | 200 | 200 |
| **B** | Urban earthquake disaster mitigation special project | MEXT | 997 | 1 334 | 1246 |
| **A** | IT-supported system development | MLIT | 156 | 158 | 158 |

| | PROJECT | Ministry | JFY2005 Budget | JFY2005 Request | JFY2004 Budget |
|---|---|---|---|---|---|
| | | | Yen Million | Yen Million | Yen Million |
| B | IT programme: Supercomputer network | MEXT | 355 | 502 | 752 |
| B | IT programme: Experiments on supercomputer network | MEXT | 355 | 502 | 752 |
| C | IT programme: Large-scale system, using IT | MEXT | 355 | 502 | 752 |
| A | Super high-speed computer network project (National Research Grid Initiative) | MEXT | 1 950 | 1 950 | 1950 |
| S | Technologies for future supercomputing | MEXT | 1 454 | 2 | 0 |
| A | Innovative simulation software | MEXT | 1 160 | 1 600 | 0 |
| A | Business grid computing | METI | 2 431 | 2 600 | 2501 |
| A | World advanced IT nation (IT programme) | MEXT | 1 598 | 1 998 | 2747 |
| B | Manufacturing technologies for advanced integrated circuits, including EUV (extreme ultra violet) light source | MEXT | 933 | 1 083 | 1140 |
| B | Next-generation high-speed communication equipment | METI | 2 619 | 2 700 | 2325 |
| B | Advanced personnel fostering with Industry-university cooperation: Intensive, advanced personnel fostering | MEXT | 0 | 1 703 | 0 |

Table 1 Large IT-projects supported by the Japanese government in 2004-05[46]

| | PROJECT | Ministry | JFY2005 Budget | JFY2006 Request |
|---|---|---|---|---|
| | | | Yen Million | Yen Million |
| | **Ubiquitous/Electronic Tag** | | | |
| A | R&D on ubiquitous network | MIC | 2 608 | 2 400 |
| C | Information technology for ubiquitous network society | MIC | 0 | 190 |
| B | Electronic tag technology development | METI | Part of 3 100 | 500 |
| A | Identification experiment for electronic tag | METI | Part of 3 100 | 550 |
| | **Network** | | | |
| A | Next-generation backbone | MIC | 2 000 | 2 100 |
| B | Advanced use of e-life | MIC | 0 | 250 |
| A | Advanced joint use of electric wave in mobile communication system | MIC | 3 254 | Part of 16 418 |
| A | Shift of wireless system to yet-to-be-used frequency areas | MIC | 2 058 | Part of 16 418 |
| B | Radar in narrow band areas | MIC | 781 | Part of 16 418 |
| B | Good use of FPU frequency | MIC | 0 | Part of 16 418 |
| B | Joint use of frequency via satellite communication system | MIC | 0 | Part of 16 418 |
| B | Wavelength Division Multiplexing Satellite communication technology | MIC | 0 | Part of 16 418 |

[46] Source: http://www.nsftokyo.org/rm05-01.html and http://www.nsftokyo.org/rm04-09.html

| | PROJECT | Ministry | JFY2005 Budget Yen Million | JFY2006 Request Yen Million |
|---|---|---|---|---|
| A | Infrastructure of e-life | MIC | 1 500 | 1 950 |
| S | Prevention of cyber attacks, including spam mail and phishing | MIC | 0 | 1 250 |
| A | Detection/recovery/prevention of route hijacking | MIC | 0 | 300 |
| B | Autonomous control of electronic data | MIC | 0 | 180 |
| B | Detection of super high-speed/high-precision cyber attack | MIC | 0 | 120 |
| A | Early-stage caution of computer security | METI | 882 | 1 880 |
| B | Industrial and individual security countermeasures | METI | 920 | 1 903 |
| | **Software** | | | |
| B | e-society software | MEXT | 1 034 | 1 034 |
| | **Robot** | | | |
| C | Elucidation of high-level dialogue mechanism | MEXT | 0 | 158 |
| S | Commercialization of service robots | METI | 0 | 420 |
| | **Large-scale/High-speed calculation** | | | |
| A | R&D for future supercomputing | MEXT | 1 454 | 1 391 |
| S | Innovative simulation software | MEXT | 1 160 | 1 160 |
| | **Electric Device** | | | |
| B | Materialization of world advanced IT nation | MEXT | 1 596 | 1 420 |
| B | Next-generation high-speed communication equipment | METI | 2 619 | 2 619 |
| | **Others** | | | |
| A | Strategic information communication | MIC | 3 181 | 3 400 |
| A | Fostering of leading IT specialists | MEXT | 0 | 1 000 |
| B | Personnel fostering for advanced simulation by industry/university/government | MEXT | 0 | 200 |
| C | IT basic technology | METI | 0 | 200 |
| B | Comprehensive research information infrastructure to promote industry/university/government cooperation | MAFF | 0 | 462 |

Table 2 Large IT-projects supported by the Japanese government in 2005-06[47]

*The first column contains the priority mark of the projects:*

S: Very important projects and to be proactively implemented

A: Important projects and to be implemented

B: Some problems to be solved but efficient and effective implementation is expected

C: To be reviewed

*The full names of the ministries supporting the projects:*

[47] Source: http://www.nsftokyo.org/rm05-05.html

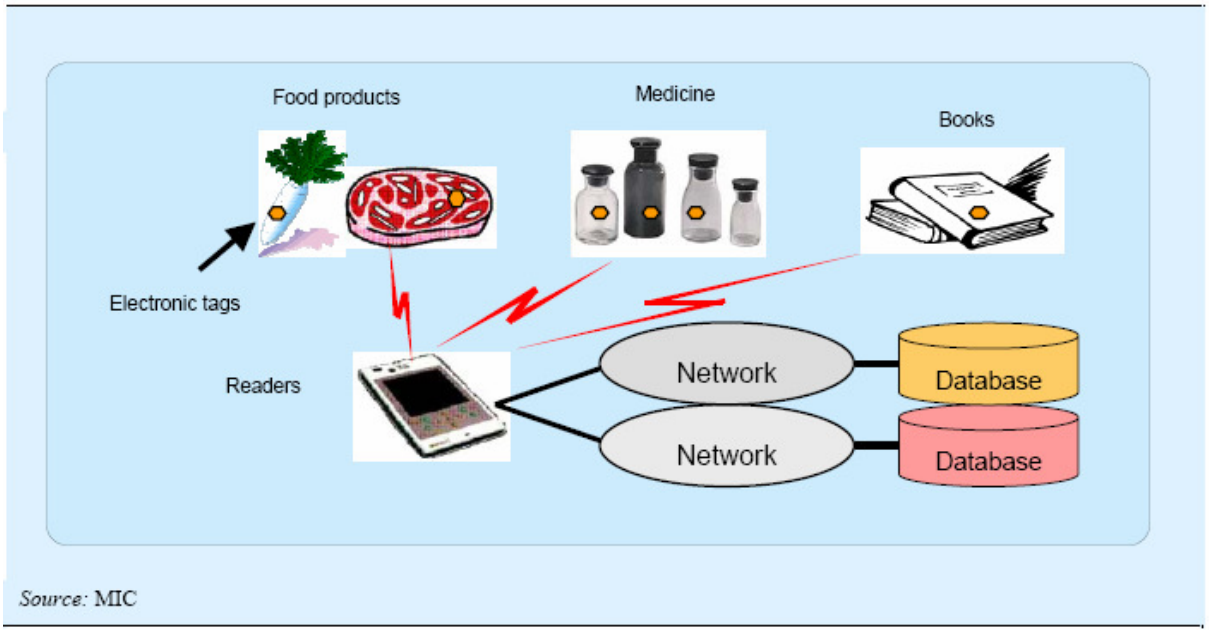
MAFF: Ministry of Agriculture, Forest and Fisheries[48]
METI: Ministry of Economy, Trade and Industry[49]
MEXT: Ministry of Education, Culture, Sports, Science and Technology[50]
MIC: Ministry of Internal Affairs and Communications[51]
MLIT: Ministry of Land, Infrastructure, and Transport[52]

The u-Japan programme is very wide and ambitious therefore it cannot be described here in its entirety. In the following paragraphs the emerging field of Radio Frequency Identification (RFID) technology as one of the top-priorities in Japan will be described shortly.

**The four-year plan of "Research and Development for Utilization of RFID"** [53]

*Radio Frequency Identification (RFID)*

The MIC has embarked on a research and development programme as part of the 4-year "Research and Development for Utilization of RFID" plan, to realize sophisticated utilization of RFID in a variety of fields, such as food products, distribution, medical treatment and environment (Figure 2).




*Source:* MIC

[48] Ministry of Agriculture, Forest and Fisheries, http://www.maff.go.jp/eindex.html
[49] Ministry of Economy, Trade and Industry, http://www.meti.go.jp/english
[50] Ministry of Education, Culture, Sports, Science and Technology, http://www.mext.go.jp/english/index.htm
[51] Ministry of Internal Affairs and Communications, http://www.soumu.go.jp/english/index.html
[52] Ministry of Land, Infrastructure, and Transport, http://www.mlit.go.jp/english/index.html
[53] Ubiquitous Network Societies: The Case of Japan, Page 23, http://www.itu.int/osg/spu/ni/ubiquitous/Papers/UNSJapanCaseStudy.pdf#search='UNSJapanCaseStudy'

**Figure 2 RFID technology**

The main technologies that are being explored under this R&D programme are the following:

- **Mutual exchange gateway technology**
  Research and development on technology to link RFID, network addresses and attribute information of objects on the network; search and reverse probe information on IDs and attribute data.

- **Security adaptability control information**
  For the exchange of information between RFID and the network, research and development on the prevention of forgery and illegal access of data stored on an RFID or in a database, and the flexible control of the disclosure of privacy information.

- **Seamless tag information management technology**
  Research and development on technologies for the exchange of information contained in RFID systems between different platforms, as well as the seamless management of this information in line with any environmental changes.

In addition, as part of its research and development initiatives in the field of RFID, the MIC is undertaking a range of trials focused on users. A good example is the use of RFID tags in stock farm products to ensure that these products can be traced during the whole distribution process, from farms to the supermarket shelves.

The aim is, through the linkage of RFID over the network, to promote utilization of RFID that transcends corporations and industries and to move from limited use in corporations and industry to further diffusion.

*Ubiquitous sensor network technology*

Ubiquitous sensor networks enable sensors to detect the status of people and objects and their surrounding environment, dealing with them in real-time through autonomous circulation of information between sensors. Through the development of this technology, it is expected that ICT support be strengthened in a wide range of social and economic activities, such as medical care, welfare, crime prevention, security, disaster management and environmental risks. The MIC plans to undertake research and development in this area as of 2005, thereby contributing to the creation of diverse applications and new services (Figure 3).

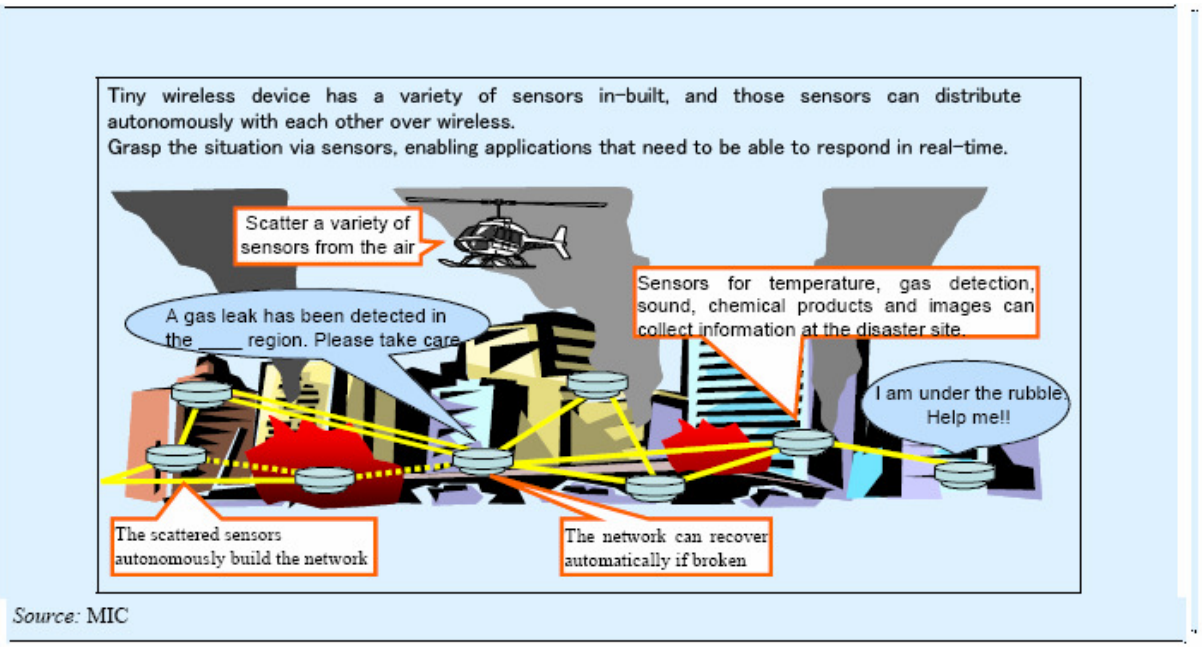



**Figure 3 Ubiquitous sensor networks**

*Next generation backbone – Advanced Testbed Network*

The research and development testbed network, with a leading approach to a variety of technologies through research and development and verification testing, is bringing about wide-ranging wave effects, such as in improving Japan's technological competitiveness, strengthening links between industry, academia and government, stimulating regional activities and nurturing human resources.

It has been verified that with the gigabit network (JGN: Japan Gigabit Network) operated from 1999 to 2004 as well, through its use by 650 institutions and 2000 researchers, large-scale benefits were brought about in the fields of broadband, stimulation of regional areas and nurturing of human resources.

As the successor of the JGN, JGNII which began operation from April 2004 has leading optical equipment to enable high speed traffic of up to 10Gbps ×2, and by cutting-edge functionality for research and development, such as the establishment of an optical testbed environment that enables an IP network environment on a national scale and wavelength level optical testing, have established access points in all prefectures of the country, enabling linkups between industry, academia and government and regional linkups on a national scale, such as universities, research institutes, private entities and local governments.

The MIC is actively promoting a focused approach to the testbed network

## Important R&D laboratories in the ubiquitous domain

| Institute | Research areas | Web address |
|---|---|---|
| **Aoyama Morikawa Laboratory** | next generation network architectures, protocols | http://www.mlit.go.jp/english/index.html |
| **Hitachi Ltd., Systems Development Laboratory.** | RFID applications, Ubiquitous network technology | http://www.8mg.jp/en/outline_goals01.htm |
| **Hokkaido University, Knowledge Media Laboratory** | quantum electronics, integrated circuits, wireless communication | http://km.meme.hokudai.ac.jp/cgi-bin/wiki.cgi/English?page=Projects |
| **Keihanna Human Info-Communications Research Center Distributed and Cooperative Media Group** | Knowledgeable Architecture for Real-Life Appliances | http://www2.nict.go.jp/jt/a135/eng/index.html |
| **Kyushu Institute of Technology** | Ubiquitous networking | http://ubila.cse.kyutech.ac.jp/index.html |
| **NEC Laboratories** | next-generation network architecture | http://www.labs.nec.co.jp/Eng/innovative/index.html |
| **Osaka University, Graduate School of Information Science and Technology** | Integrated System Design, Integrated Systems Diagnosis, Dependability Engineering | http://www.ist.osaka-u.ac.jp/english/ise/index.html |
| **Sony Computer Science Laboratories** | virtual 3D, VRML, cognitive robotics | http://www.csl.sony.co.jp/index.shtml |
| **Tokushima University, Center for Advanced Information Technology** | high-speed networking, multimedia systems | http://www.ait.tokushima-u.ac.jp/mainE/ |
| **Tokyo Denki University, Graduate School of Information Systems and Multimedia Design, Ubiquitous Networking Laboratory** | sensor networks, protocols for UC, security for UC, home-area networks | http://www.unl.im.dendai.ac.jp/ |
| **Tokyo University, Graduate School** | computer architectures for ubiquitous systems | http://www.u-tokyo.ac.jp/ |
| **Ubiquitous ID Center** | RFID technology | http://www.uidcenter.org/ |
| **YRP Ubiquitous Networking Laboratory** | ubiquitous computing environment | http://www.ubin.jp/english/aboutus.html#pamphlet |
| **Waseda University, Department of Computer Science, Distributed and Ubiquitous Computing Laboratory** | middleware for next-generation systems | http://www.dcl.info.waseda.ac.jp/home/index.html |
| **Ubiquitous Computing Laboratory** | sensor networks, intelligent appliances | http://www.ubi-lab.org/ |

## Further readings and references


- e-Japan Priority Policy Programme – 2004, http://www.kantei.go.jp/foreign/policy/it/040615summary/040615gaiyo_e.pdf

- u-Japan, video presentation, http://www.soumu.go.jp/menu_02/ict/u-japan_en/index.html,
- ICT R&D Programmes for the Ubiquitous Network Society, July 2005, http://www.soumu.go.jp/joho_tsusin/eng/features/r_d_progrums.pdf
- IT Policy Package – 2005, http://www.kantei.go.jp/foreign/policy/it/itpackage2005.pdf

# KOREA

In 1992, Korea established a national coordination office for IT R&D support, the Institute of Information Technology Assessment (IITA).[54] This organization is responsible for planning, supervising, and supporting the national IT R&D strategy. The IT R&D plan, developed by IITA, presents a mid-to-long term vision, and describes investment priorities and strategies. This IT R&D plan is the starting point for the Ministry of Information and Communications (MIC)[55] to elaborate the annual Basic Plans and Action Plans for IT R&D. The IT industry is one of the ten strategic industries in Korea that drive the economy. It is planned that the per capita income of Korea will be raised to USD 20,000 by 2012, and 25% of it, i.e. USD 5,000, will be produced by the IT industry alone. In order to achieve this ambitious goal, IITA elaborated the 'IT New Growth Engines' strategy in 2003, and then the 'IT839 Strategy R&D Master Plan'.[56] A comprehensive information portal has been set up to help understanding the strategy.[57]

I

Korea pays attention also to international cooperation possibilities. To coordinate IT collaboration between Korean and foreign companies and institutes, Korea established a dedicated office called International Cooperation Agency for Korea IT (ICA),[58] which operates under the supervision of MIC.

*The role[59] of ICA is defined by ten important points:*

1. To share the Korea brand of "Ubiquitous Korea" through aggressive international cooperation. Ubiquitous means that the goal is to develop ubiquitous computing infrastructure, applications, and services.
2. To help Korean IT SMEs easily make inroads into the global market through consulting services and settlement of such problems the industry might face as trade disputes.
3. To assist Korean IT companies to better understand the opportunities and needs of their partners.
4. To assist Korean IT companies to build strong commercial ties with IT industry players in overseas markets.
5. To create business opportunities in emerging markets.
6. To stimulate bilateral transaction.
7. To conduct optimized joint activities for technology development and particularly to share the accumulated experience of their own.
8. To provide comprehensive information of Global IT market for Korean IT companies.
9. To provide comprehensive information of Korean IT market for foreign companies.
10. To be at the forefront in terms of expanding the range and scope of international cooperation.

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[54] Institute of Information Technology Assessment, http://iita57.iita.re.kr/IITAPortalEn/index/Index.htm
[55] Ministry of Information and Communications, http://www.mic.go.kr/eng/index.jsp
[56] http://iita57.iita.re.kr/IITAPortalEn/function/Index.htm
[57] Dynamic IT Korea Portal, http://www.dynamicitkorea.org
[58] International Cooperation Agency for Korea IT, http://www.ica.or.kr/en
[59] http://www.ica.or.kr/en/intr_02.html

## The IT839 Strategy

The main strategic plans of the Korean IT sector are summarized in the IT839 Strategy.[60] The plan contains three main areas of development. The first is the *infrastructure* development to create a robust network platform for the applications. The second development goals are *products* that use the infrastructure and can be used for information processing. The third group is the group of *services* that use the infrastructure and products to offer high level functionality to the users. (Figure 1)

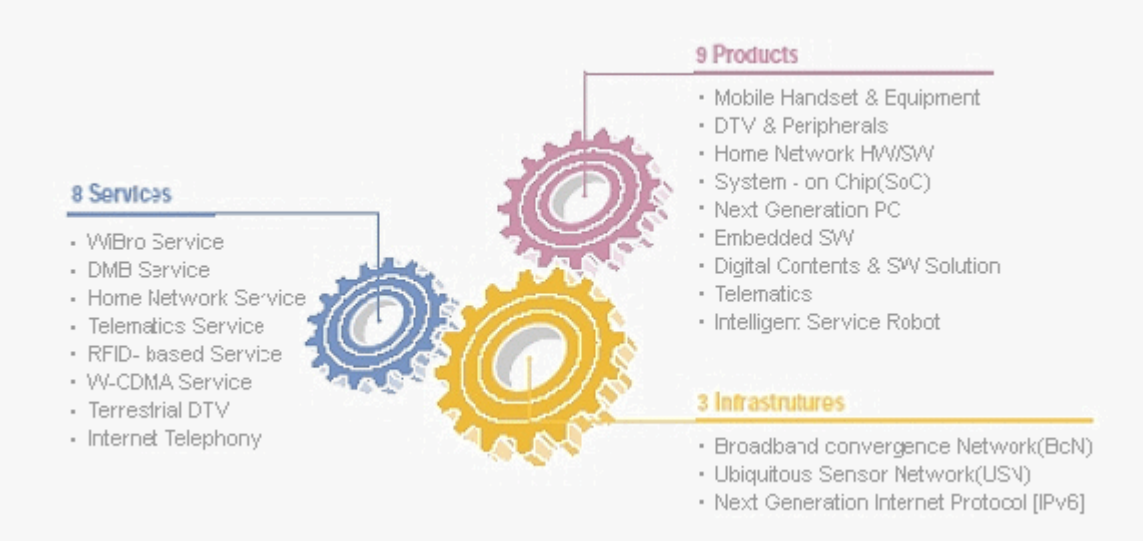


**Figure 1 IT839 strategy**

# Infrastructures

Broadband convergence Network (BcN)

### Background

The Broadband Convergence Network (BcN) is a next generation network through which multimedia services that integrate telecommunications, broadcasting and the Internet are delivered. Korea will be the first in the world to build BcN, creating a ubiquitous service environment and laying the foundation for new growth engines of IT industry.

### Goal and Strategy

BcN will be deployed by 2010, providing quality services at the speed of 50 to 100 Mbps to 20 million fixed and wireless subscribers. The BcN will support quality of service (QoS), security and IPv6, and extend various convergent services. A high-tech R&D network will be established to develop and verify core technologies for the BcN. Pilot projects will be carried out. A wide range of applications will be developed

[60] http://iita57.iita.re.kr/IITAPortalEn/New/Index.htm, http://www.ipc.go.kr/servlet/download?pt=/ipceng/policy&fn=it839_eng.pdf

and distributed and revision will be made to relevant laws and regulations to create a favorable environment for the deployment of BcN.

Ubiquitous Sensor Network (USN)

**Background**

The Ubiquitous Sensor Network (USN) recognizes and manages information by connecting RFID tags and u-sensors to the Broadband Convergence Network. Expanding the scope of informatization from human into all objects, the USN will be the basic infrastructure of a ubiquitous society.

**Goal and Strategy**

A USN test center will be established and pilot projects will be expanded in 2005 with the goal of making the vision of u-life into reality by 2010. A USN test center that has similar conditions to our living environments will be established to help SMEs test and verify the technology specifications, compliance with standards and tag identification of the products under development.

Pilot projects will be carried out on the applications such as transportation and environment that have huge ripple effects across the industry and our daily lives to create an early demand in the market. Pilot projects with good outcomes and areas with high potential demand will be encouraged to participate in the USN project. Laws and regulations will also be revised to protect personal data.

Next-Generation Internet Protocol

**Background**

The expected depletion of the Internet Protocol version 4 (IPv4) address from 2006 requires a fundamental solution. IPv6 is expected to play a key role in the introduction of Broadband Convergence Network (BcN), home network and telematics service and to contribute to making Korea an Internet powerhouse.

**Goal and Strategy**

IPv6 pilot projects will be expanded and IPv6 will be introduced to public/commercial networks in 2005. All-IPv6 based services will be available starting from 2010. Through IPv6 pilot projects, equipment and services will be verified in advance. In addition, the IPv6 Strategic Council will establish collaboration among industries, academia, research institutes and the government.

The IPv6 technology including IPv6-based routers and security equipment will be developed to suit the world's best Internet environments and create an early market demand .IPv6 will be applied to new projects such as BcN, WiBro and home network services. It will also be developed in connection with RFID and 3G mobile communication services.

# Products

## Next-generation Mobile Communications Devices

Next-generation mobile communications is a technology that enables users to have a fast and clear access to multimedia information, while on the move or at a standstill, via mobile and satellite communication networks.

It is necessary to advance the world-class mobile communication technology and maintain the competitive edge in next-generation mobile communication areas including WiBro, 3G Evolution and 4G.

## Digital TV/Broadcasting Devices

The digital broadcasting service will not only provide high-definition but also intelligent, personalized, realistic and paid services in addition to those converged with telecommunications. The digital broadcasting terminals are projected to become a user friendly tool that delivers various broadcasting services anytime anywhere.

The DMB industry will focus on core technologies essential for next generation broadcasting such as intelligent broadcasting, telecom & broadcasting convergent services and interactive DMB services, and seek standardization of related technologies both in domestic and global markets. The public and private sectors will cooperate in commercializing DTV technologies and digital CATV technologies to maximize the effects of technology transfer.

## Home Network Devices

Home network devices and software, which consist of home gateways, information home appliances and networking, are basic technologies for consumer service. The home network industry will develop core technologies and set standards to lead the global home network market, which is expected to grow to USD 97.8 billion in 2010.

An open home network framework, a wireless home network and a next-generation server, which are core technologies for a telecom broadcasting-game convergent home server, will be developed. A home network working group will be established among China, Japan and Korea to lead standard development for the home network service.

## IT SoC (System on Chip)

IT SoC refers to a non-memory integrated circuit which is not only a growth engine itself for the next-generation but also a key that determines the success of IT products. A much-needed development in IT SoC will further drive the growth of Korea's chip industry which is memory IC oriented.

Low-power core chips for mobile communications will be developed in 2005, and Korea will emerge as one of the three major IT SoC countries in the world by 2007.

Core SoC and Intellectual Property (IP) will be developed in connection with other growth engines including mobile communications, Digital Multimedia Broadcasting (DMB) and home networks. An IP DB will be also established.

In order to nurture SoC experts who satisfy the demand from the industry, the SoC Architect Training Programme will be run jointly with universities, and SoC will be co-developed by industry, academia and research institutes. An IP-based design environment will be created and support will be rendered in design, verification and test of chips to enable easy, low-cost designing and manufacturing of SoC. SoC design companies, SI and foundries will seek to collaborate and design companies will join hands to develop technologies.

Next-Generation PC

A next-generation PC refers to a key information device that takes the form of cloth, accessories and others and has information processing and networking power. The next-generation PC that integrates sensors and human interface technologies will provide human-centered services with convenience and excellent portability.

Prototypes for a wearable PC will be developed in 2005, technology standards established in 2006 and a wearable computer commercialized in 2007. From 2004, the development of core technologies will be encouraged such as micro platform and human interface required for the implementation of a wearable PC.

Embedded SW

Embedded SW is software built in information appliances, vehicles, robots, industrial equipment, medical equipment, SoC and so on. Embedded SW provides smart functions such as the HW control, communications, multimedia, Internet and artificial intelligence services.

*The software industry in Korea will develop SW platforms and solutions to be embedded in various devices and grow into the second largest embedded SW producer in the world by 2010.* Standard-, micro- and nano- platforms of embedded SW as well as solutions including DTV, smart phones and robots will be encouraged to be developed and distributed.

World-class technologies will be secured through open source codes and applied to mobile terminals and digital homes. Human resources development programme will be run in cooperation with industries, academia and research institutes to foster top-notch engineers who can handle both HW and SW. The embedded SW industry will develop standards, conduct compliance tests, build an efficient test-bed and carry out a pilot project to quickly advance into the market.

Digital Contents & SW Solutions

The advent of a digital era increased the importance of digitalized content on culture, education, medicare and other areas of our daily lives. The digital content & software solution industry is a key strategic industry in the future that creates new demand and strengthens the competitive edge of other industries.

The digital content and SW solution industry will develop real image digital actors for supporting roles in 2005, and put five Korean SW companies on the list of top 100 global SW companies in 2010. Core technologies such as 3D computer graphics, multi-platform geared online game engines and multi-platform e-learning solutions will be developed.

Open source SW and SW engineering will be strategically nurtured to enhance technology competitiveness. The MIC will improve market conditions to promote fair competition and achieve co-prosperity of large and small companies. The MIC will support operation of global test-beds and joint research with advanced countries such as the US and Germany.

Telematics Devices

The telematics industry will develop core technologies that support various in-vehicle multimedia services such as information for traffic and emergency rescue operations, remote auto inspection and the Internet via location-based, mobile communications networks. The telematics industry will develop services that satisfy the demand of those who want to lead an enriching in-vehicle life.

A telematics test-bed will be established in 2005 and telematics services will be sophisticated in 2007 to realize an in-vehicle mobile office. Standardized technologies for a terminal platform and an open-type server will be developed, accommodating demands from service users, mobile carriers and car manufacturers. Close cooperation between IBM and the Electronics and Telecommunications Research Institute will strengthen standard development activities and promote entry into overseas markets such as Malaysia.

Intelligent Service Robots

An IT-based intelligent service robot refers to a Ubiquitous Robotic Companion (URC) that provides necessary services anytime anywhere. The URC will be commercialized by the end of 2007. Consumers will be able to enjoy various services of the robot at lower costs since the URC will operate by simply adding network functions to the existing robots.

URC platforms and application services will be developed in 2005, and *Korea will become one of the top three URC manufacturers in the world by 2007.* In 2005, a URC will be installed in 100 apartment houses to examine its economic feasibility.

The URC will be developed with a priority placed on human-focused functions and a strategy to develop lego-like composite technologies will initiate further advancement of the URC. The MIC will support the promotion of the URC and standardization of intelligent service robots.

# Services

## WiBro (Wireless Broadband) Service

The Wireless Broadband Service is a portable Internet service that provides a high-speed wireless Internet connection anytime anywhere, whether you are on the move or at a standstill. The market saturation in the fixed-line, mobile and broadband Internet areas raised the need to develop new driving forces and create a new market.

WiBro service operators will be selected by January 2005 and commercial services will be launched in 2006. The selection of WiBro operators will be completed by January 2005 through the review of the Information and Communication Policy Deliberation Committee and concrete service and investment plans of each operator will be set forth. The WiBro Promotion Working Group composed of experts in related fields will be launched to detect potential technical and operational difficulties and make a joint response. Commercial WiBro systems and handsets will be developed by 2005 and operators will carry out trial services to promote the WiBro service.

## DMB (Digital Multimedia Broadcasting) Service

The DMB service is a mobile multimedia broadcasting service that provides quality audio and video services over handheld devices or in a vehicle. It enables CD-level audio and data services as well as high-definition mobile TV broadcasting on a maximum seven-inch screen.

The terrestrial DMB service will be launched in the first half of 2005 in the Seoul metropolitan area and extended across the country by 2006 when reassignment of channels is completed. Core components and interactive multimedia technologies will be developed to introduce an interactive service over telecommunications networks in 2006.

The DMB industry will make efforts to adopt the terrestrial DMB as the standard of international organization such as ETSI and ITU and promote the terrestrial DMB service in overseas markets.

## Home Network Service

The home network service refers to a series of future services including consumer electronics control, interactive D-TV, Video on Demand (VOD), health care and e-learning that will be provided at home. The home network service has ripple effects through the economy since it is related to telecommunications, broadcasting, construction, home appliances and solutions.

The home network service will be provided to 2 million homes by 2005 and the number will increase to 10 million (60% of total households) by 2007. Service providers, manufacturers and construction companies will jointly participate in a pilot project to develop services of the future and provide the trial services to 13 million homes.

To encourage the private sector to deploy home network infrastructure, the government will offer low-interest loans. The Ubiquitous Dream Exhibition Hall will be upgraded to display major achievements of the IT839 Strategy and allow the general public to experience future u-Life.

Telematics Service

Telematics is an in-vehicle multimedia service that offers infotainment as well as information for traffic and emergency rescue operations via location-based, mobile communications networks. On the basis of world-class fixed and wireless communications networks and competitive auto manufacturing, telematics is a new kind of value-added service, connecting the vehicle to the Internet based on wired/wireless and broadcasting networks.

*The telematics industry will secure 750,000 subscribers by 2005 and 4 million subscribers by 2007 to become one of the top five telematics industries in the world.* The collection and provision of key telematics information such as traffic, road-map and tourism will be systemized and the tariff system will be improved.

The key telematics projects such as a pilot project and establishment of an information center that aim at laying a solid supply and demand foundation will be carried out in cooperation with local governments, research institutes and companies.

The telematics pilot project in Jeju Island is expected to increase public awareness and market demand for the telematics service by providing tourists with an opportunity to experience the service.

RFID based Service

Radio Frequency Identification (RFID) is a sensor technology that identifies information on the product with an RFID tag and gathers information on its surrounding environments.

The technology is expected to be used extensively in our daily lives from management of food, livestock, wastes and environment to logistics, distribution and security services.

The 433MHz technology standard and mobile RFID will be developed and promoted in 2005, and core technologies such as RFID chip technology will be developed by 2007.

The 433MHz technology standard will be determined at an early date to promote RFID services in various fields including ports, telematics and home networks.

The development of mobile RFID that integrates mobile communications and RFID will introduce ubiquitous information devices and facilitate application services such as the provision of detailed information on products.

The private sector will focus on the development and commercialization of tags, readers and middleware while research institutes will develop next-generation technologies such as ubiquitous network-related sensor nodes.

W-CDMA Service

The W-CDMA service is an IMT-2000 service that provides voice, video and high-speed data service in the 2GHz band. A full-scale W-CDMA service will be launched to maintain Korea's high status in mobile communications.

The W-CDMA service will be provided to 23 large cities in 2005 and to 84 cities across the country in 2006. The foundation for the W-CDMA market will be laid through temporary introduction of a fixed rate for unlimited use of data and differentiated services such as video telephony and multimedia services.

Quality standards that guarantee QoS will be established to ease concerns over quality that usually arise at the initial stage of services. The W-CDMA Working Group composed of experts from industries, academies and research institutes is in operation to explore ways to boost service competitiveness and cope with related technical and business issues.

Terrestrial Digital TV Service

The terrestrial digital TV service is a high-quality, multi-functional broadcasting service that provides CD-level audio and a definition five to six times higher than analog broadcasting. Global competitiveness in the digital TV area is expected to enhance the life quality of citizens and greatly contribute to economic growth.

The nationwide terrestrial digital TV service will begin in 2005 and the data broadcasting service will be provided in 2006. The coverage of terrestrial digital TV broadcasting will expand to provinces, cities and towns by 2005 and across the country in 2006. The digital broadcasting will be promoted through the development of different kinds of low-priced TV sets, increase in the minimum mandatory HDTV broadcasting hours and reception improvement.

Internet Telephony (VoIP)

The high broadband penetration and improvement in the quality of service on the Internet created VoIP that offers inexpensive phone services.

The VoIP service converts voice signals into packet data to provide a phone service over the Internet. This service is expected to become a killer application of the All-IP based Broadband Convergence Network.

Internet telephony will develop into a key BCN-based service through its classification as a facilities-based telecom service and quality enhancements in 2005. By the first half of 2005, a policy framework for Internet telephony including classification of the service into a facilities-based telecom service and revision of interconnection schemes will be set up.

Within the second half of 2005, the MIC will promote the service by assessing quality of VoIP and exploring ways to introduce service level agreements.

## Summary

The integrated IT strategy of Korea is focusing on the *ubiquitous computing* vision and defines clear goals for the industrial and academic sectors. The government also tries to create international partnerships in order to speed up technology development and international standardization.

One of these collaborations was the *Conference on EU-Korea Collaboration in Embedded Systems*[61] *in April 2005.* The aim of the workshop was to identify important topics in the area of Embedded Systems where strong synergy between Korean and EU teams would have the greatest benefit. In order to achieve this, common understanding and background on which future collaborative actions and joint projects can be based were found during sessions presented by nine high-level speakers from Europe and Korea.

## Further reading

- Ubiquitous Network Societies: The Case of Korea, http://www.itu.int/osg/spu/ni/ubiquitous/Papers/UNSKoreacasestudy.pdf

[61] Conference on EU-Korea Collaboration in Embedded Systems, http://www.delkor.cec.eu.int/en/news&event/conference%20on%20eukorea.htm

# RUSSIA

Currently, the Russian Federation does not have an official strategy on embedded systems research and development. The most important ICT-related programme in Russia is the "Electronic Russia 2002-2010" programme[62] that includes the following important goals:

- Extend and adapt current regulations to help the spreading of ICT technologies and applications.
- Open towards e-Government solutions to improve the information exchange between the government and the citizens.
- Improve the collaboration of central and local authorities using ICT solutions.
- Train experts and users of ICT.
- Develop communications infrastructure, including television, radio, and data communications.
- Create suitable environment for e-Commerce.

The objective of this programme is to increase the share of ICT products in the GDP from 0.5% in 2002 to 2% in 2007.[63] The programme does not mention explicitly embedded systems.

The fast growing IT industry has recently caught the attention of the Russian state that helped to start a second important programme in the ICT field. Government support for IT has increased dramatically in the last two years. In 2004 an intensive dialogue between IT Associations and the Government agreed in the official adoption of the resolution entitled the "National Concept for IT Market Development in the Russian Federation" (November 18, 2004) which is characterized by the following key elements:

- Deregulation of IT exports
- Support for the international marketing efforts of Russian IT companies
- Support for the QA (quality assurance) certification efforts of Russian IT companies
- Domestic market stimulation
- Support for an IT-parks development initiative
- Tax holidays and favorable tax laws for the IT industry
- State investment in industry infrastructure
- Creation of a state owned investment fund for IT businesses
- Enhancements in the IPR Protection system for IT

While this strategy is important because it is the result of a dialogue between industry and government it is only the foundation of the IT-related R&D work in Russia. The results of these programmes will present themselves only after some years of intensive business development.

[62] http://www.e-rus.ru
[63] Compare it with the ambitions of Korea where in 2012 ICT should produce 25% of the GDP, i.e. USD 5000 per capita (see page 35).

While Russia had important R&D results in the field of embedded systems before the political changes (mostly in the military, aeronautic and space industries) the changes produced a radical decrease in the central R&D budget. Most of the programmes were cancelled, and researchers lose their job. Recently, the private sector and the foreign investors want to benefit from the availability of the traditionally well-educated Russian engineers and scientists. There are a number of global companies that have created Russian R&D centers and integrate these institutions within the framework of their global R&D strategy. Currently, while the Russian government does not have an official strategy on embedded systems there are several important companies that do have their own strategy also in Russia. As an example for companies doing R&D in Russia major activities of Siemens are described below.

> *Siemens* has established R&D centers in Saint-Petersburg and Moscow. R&D is focussed on material sciences (high-temperature materials, coatings for turbine blades), power and sensors (combustion technologies for gas turbines, fluid mechanics), and software engineering (embedded Linux, dependable systems, code quality management). Software engineering is an important research field in embedded systems and Siemens plans to make Embedded Linux the main software platform for most of their applications. To achieve this goal, Siemens will increase the size of the Russian Linux Competence Center that will support the other R&D facilities by supplying Linux distributions, development strategies, and education.

More and more companies are using Russia as a development outsourcing area because of its highly skilled professionals and relatively low costs. Several Russian companies are specialized in this type of development, like Mirantis Inc. a company specialized on high-tech R&D projects; EPAM Systems, a company active in the domain of Enterprise Information Systems; or SPIRIT, a company active in mobile application developments.

Several Russian companies have experience with embedded Linux development, and they are expecting a strongly increasing importance of this technology; therefore they put more and more effort on open-source Linux-related development to be ready for industrial projects.

## Further reading

Finally, here is a list of homepages containing information on ICT activities in Russia:

Automation integrator Antrel: http://www.antrel.ru

Russian Windows Embedded Developer Group: http://www.we-dg.gotdotnet.ru

Info Business: http://www.ibusiness.ru

MicroMax Computer Intelligence: http://www.micromax.ru

Quarta Technologies: http://www.msembedded.ru

Tools and systems for computerised automation: http://www.asutp.ru

Real-time security systems: http://www.kpda.ru

SWD and QNX systems: http://www.swd.ru

# SINGAPORE

Singapore was one of the four countries where experts of the International Telecommunication Union (ITU) studied the realisation of a ubiquitous networked society. [64] Although a number of factors went into this decision, the most significant one was the clear presence of elements critical for the healthy development of a ubiquitous network society. These include an omnipresent high-speed network (both fixed-line and wireless), applications and services that leverage on their pervasive nature, a nurturing policy and regulatory environment, and a population receptive to technology.

At the time of writing the report, 74% of all households in Singapore owned one or more personal computers. Internet access was enjoyed by 65% of all households with two out of three accessing the Internet through broadband. About 83% of all companies in Singapore used a computer with 76% of all companies having Internet access. Mobile phone penetration in Singapore reached a high of 92% in 2004.

Many parts of the current chapter were taken from this comprehensive study. [65]

## National strategies

The government of Singapore has traditionally taken an active role in the development of the nation's ICT sector. From the early 80s, the Singapore government has methodically designed and implemented a succession of national plans and strategies to guide the nation on its ICT development path. Since December 1, 1999, the then established Info-Communications Development Authority (IDA) is responsible for the development of national strategies in infocommunications.[66]

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**National strategies**
*1980 to the present*

Reflective of the changing technological, business and social climate, Singapore has progressed through five distinct national IT plans over 25 years.

**National Computerisation Plan** (1980-1985). One of the key objectives of the National Computerisation Plan was to computerize the major functions in every government ministry. Directed at improving public administration through the effective use of IT, the effort focused on automating traditional work functions, reducing paperwork and escalating the deployment of IT in the Public Service.

**National IT Plan** (1986-1991). The focus then shifted to the provision of one-stop services through cross-agency linkages. A significant number of public services were

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[64] Ubiquitous Network Societies, http://www.itu.int/osg/spu/ni/ubiquitous
[65] Ubiquitous Network Societies: The Case of the Republic of Singapore, http://www.itu.int/osg/spu/ni/ubiquitous/Papers/UNSSingaporeCaseStudy.pdf
[66] Info-Communications Development Authority (IDA), http://www.ida.sg

developed in the direction of the 'One-Stop, Non-Stop' strategy by using IT to automate and integrate traditional manual administrative processes.

**IT2000** (1992-1999). The IT2000 masterplan was launched to position Singapore *as a global IT hub.* Building on the National IT Plan, the expanded focus included construction of a nationwide broadband network, the development of common network services (e.g. directories, billing, security authentication), the forging of international alliances with industry leaders in Japan, Europe and the US and the establishment of a policy and legal framework on issues such as intellectual property rights and computer crime. In the public sector, the Internet was introduced as a new delivery channel providing both information and transaction-based services to the public.

**Infocomm 21** (2000-2003). Spurred by the convergence of telecoms and IT, the Infocomm 21 blueprint was launched in 2000 to develop Singapore *into a global infocomm capital* with a thriving and prosperous e-economy and a pervasive and infocomm-savvy e-society. The plan involved multiple strategic thrusts that included: developing the ICT industry, promoting e-business practices and applications, delivering more government services online, expanding access to ICT to the population, nurturing ICT talent and creating a pro-competitive ICT policy environment.

**Connected Singapore** (2003- present). The current blueprint continues to build on the Infocomm 21 plan but with a different focus. It sees *infocomm as a key enabler,* to create new business opportunities, consumer value and cultural experiences.

Source: Adapted from IDA

In 2003, IDA launched its current national strategy, *Connected Singapore.* Essentially a re-visioning exercise of the previous national strategy, the current strategy takes cognizance of the need for Singapore to develop new sources of growth, including new areas involving creative inputs, like design and the arts. Instead of developing infocomm for its own sake, the vision *sees infocomm as a key enabler, aimed at increasing the productivity and efficiency of individuals, organizations and businesses.* Under this vision, infocomm technology is also regarded as a catalyst for the creation of new business opportunities, consumer value and cultural experiences.

IDA currently implements a wide range of programmes *under four key strategies* to bring about the realization of the *Connected Singapore* vision:

***Infocomm for Connectivity, Creativity and Collaboration*** aims to place *infocomm products and services into the hands of everyone* by developing an infocomm infrastructure for pervasive and secure access; encouraging the development and use of infocomm applications and services; and promoting infocomm literacy.

***Digital Exchange*** aims to develop Singapore as a *leading global digital distribution and trading centre.* IDA currently focuses on developing end-to-end infrastructure that integrates the processes of digital production, management, localization, archival and secure distribution. This infrastructure in turn is aimed at supporting a wide range of businesses such as online gaming, digital publishing and software distribution.

***Engine of Growth*** aims to grow new economic activities and job creation in infocomm by focusing on the development of *five key industry clusters: value added mobile services, infrastructure for wireless and wireless networks,*

*multimedia processing and management, web services and portals and security and trust infrastructure.*

***Agent for Change*** aims to help businesses and government agencies use infocomm to *achieve higher levels of efficiency* in delivering their products. This involves reengineering key business clusters and government services through deploying common infrastructure and standards, redesigning business processes and encouraging the use of technologies and applications that improve linkages between the government, companies and consumers.

With the 3-year *Connected Singapore* lifecycle ending in 2006, IDA is currently embarking on a new strategic visioning and planning exercise to develop the next national strategy termed *iN2015.*[67]

It is useful to note that despite the ostensible differences seen in the couching of each successive national strategy, the Singapore government's efforts to promote infocomm development have been *characterized by progressive evolution as opposed to disruptive revolution.* To a large extent, *national strategies preserve continuity in infocomm development* while serving as a catalyst for further renewal. *A large number of established programmes continue from one national strategy to the next, as do established institutional structures.* Institutional reorganization and the lapsing of established programmes are not generally timed to match the unveiling of a new national strategy.

At the same time, it is also important to realize that the introduction of each national strategy is not designed to be static nor does it exist as an exclusive self-contained policy guide. On a periodic basis, complementary strategies and policies are introduced during the lifespan of a national strategy to reinforce, refresh, and occasionally refocus its basic tenets.

**Infocomm Technology Roadmap (ITR)**

Alongside the development of national ICT strategies, IDA also embarks on periodic technology visioning exercises in order to identify key technology enablers and technology market trends. Referred to as Infocomm Technology Roadmaps (ITR), IDA is currently in its 5th cycle, having released its 10-year Infocomm Technology Roadmap 5 (ITR5) in March 2005.[68]

**Highlights from Infocomm Technology Roadmap 5 (ITR5)**
ITR5 forecasts the following broad trends:

***1. The computing wave***
By 2015, the PC as we know it today will 'disappear' and computer mainframes will be accessible via revolutionized devices infused with nanotechnology. *Computers will be so small that they will be embedded in everyday devices,* and computing will be further

[67] The Intelligent Nation 2015 (In2015) Master Plan, http://www.in2015.sg
[68] Infocomm Technology Roadmap, http://www.ida.gov.sg/idaweb/techdev/infopage.jsp?infopagecategory=&infopageid=I3344&versionid=3

revolutionized by innovations including Grid Computing, Peer-to Peer technology, Service-Orientated Architecture such as Web Services, and software agent technologies.

***2. The communications wave***
Experts anticipate that the world will be covered by optical fiber providing an *almost unlimited capacity to transport data anywhere* around the world. Its low-cost deployment will result in unlimited bandwidth subscription, and this fabric of network connectivity will mean broadband will be available everywhere where the service is needed. It is also predicted that Internet Protocol (IP) will become the unifying platform, providing high levels of end-to-end quality of service and security.

***3. The sentient wave***
The confluence of the first two waves will result in *intelligent devices that can sense and interact with one another.* Countries will exploit these to build nationwide sensor networks, like chemical and biosensors, to operate around the clock, detecting a wide range of potential homeland threats. Smart systems will also be deployed for various purposes. For example, smart systems will be set up to advance *eldercare, sensing and reminding elderly patients at home* to take their medication.

*Source: IDA*

**"Wired with Wireless" programme**

Initiated in October 2000 under the *Infocomm 21* plan and reprised by the *Connected Singapore* blueprint, IDA's *Wired with Wireless* programme is main launch pad for major initiatives to develop the country's wireless value chain – from infrastructure to content.

Under the programme, IDA collaborates with industry to identify, develop and launch key projects with industry-wide impact. This collaboration largely takes the form of pilot and trial projects that are designed to foster thought leadership; market access development; manpower and technology development; infrastructure & product development; and industry and consumer adoption in *five key areas: machine to machine communications (M2M), wireless multimedia and messaging, location based services, mobile commerce and wireless enterprise.* Key ongoing initiatives under the programme include the following:

In October 2000, the *Pilot and Trial Hotspots (PATH) Initiative* was launched as a SGD 78 million government grant programme aimed at accelerating the development of innovative infocomm infrastructure, applications and products. The programme supports projects proposed by companies and organizations that are registered and operational within Singapore. Originally targeted at developing the five key wireless areas listed above, this initiative was subsequently expanded to include other innovative infocomm technology areas prioritized by IDA.

Under the PATH initiative, IDA uses a *Call for Collaboration (CFC)* mechanism to promote industry partnerships in the development of infocomm solutions and applications. Under this process, CFCs are issued to interested industry players for proposals to collaborate with one another in the development of pilot and trial projects that can benefit the entire industry as a whole. IDA support in the form of

grants and other incentives are used as an enticement. The list of *Wired with Wireless CFCs* that have been issued include:

- Mobile Payment Systems CFC
- Mobile Workforce Solutions CFC
- Wireless Java Solutions CFC
- Pervasive Wireless Access CFC
- Location-Based Services CFC
- Smart Airport & Passenger Travel CFC

Besides facilitating infocomm companies to develop and implement their solutions through pilots and trials, IDA also has a *Market Development (MADE)* initiative that was set up to help accelerate a company's foray into potential markets. The initiative supports market research activities such as test marketing, as well as showcases and promotes innovative products through joint promotional activities.

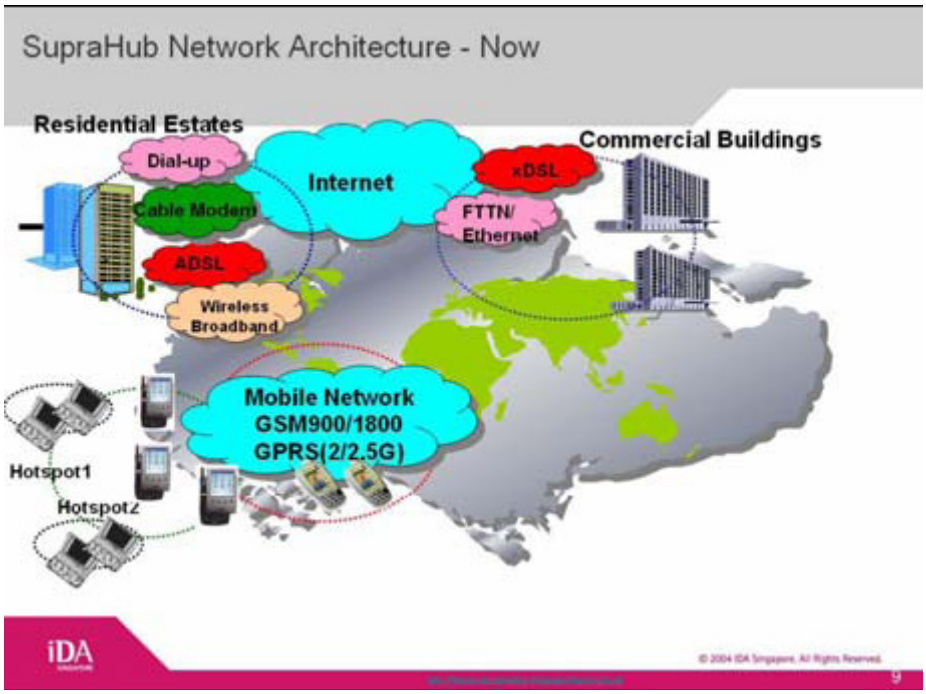
In keeping with the leadership role played by the government in industry development, IDA has also set up a *Wireless Technology Alliance (WTA)* to encourage the transfer of wireless technology skills and expertise among local wireless industry players. Designed as an industry forum, its goal is to match make industry players that occupy different tiers on the wireless value chain. For example, the partnerships that the initiative has brokered include the establishment of the Java Wireless Competency Centre, which brings together IDA, Sun Microsystems and the Institute for Infocomm Research for the purpose of Java research and training.

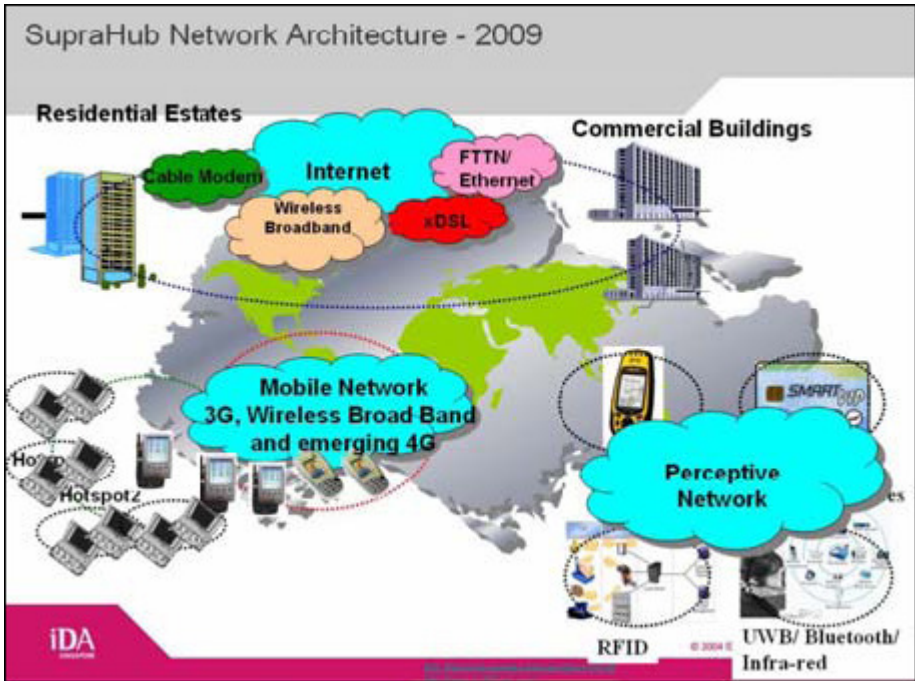
Reflecting the holistic approach to wireless development, the *Wired with Wireless* programme also incorporates elements of skills development and awareness building. With the aim of seeding talent and increasing exposure to the wireless industry among the youth in Singapore, IDA has facilitated the setting up of *Mobile Clubs* in secondary schools and junior colleges. *Mobile Clubs* are the product of partnerships between interested schools and a wireless industry sponsor(s) who works with the school to provide wireless training and industry exposure. Mobile club activities may include the development of basic logos and ring tones for mobile phones. More advanced students may be given an introduction to Wireless Access Protocol (WAP) and Java tools to program their own games and applications. Currently mobile clubs have been established in five schools on the island.

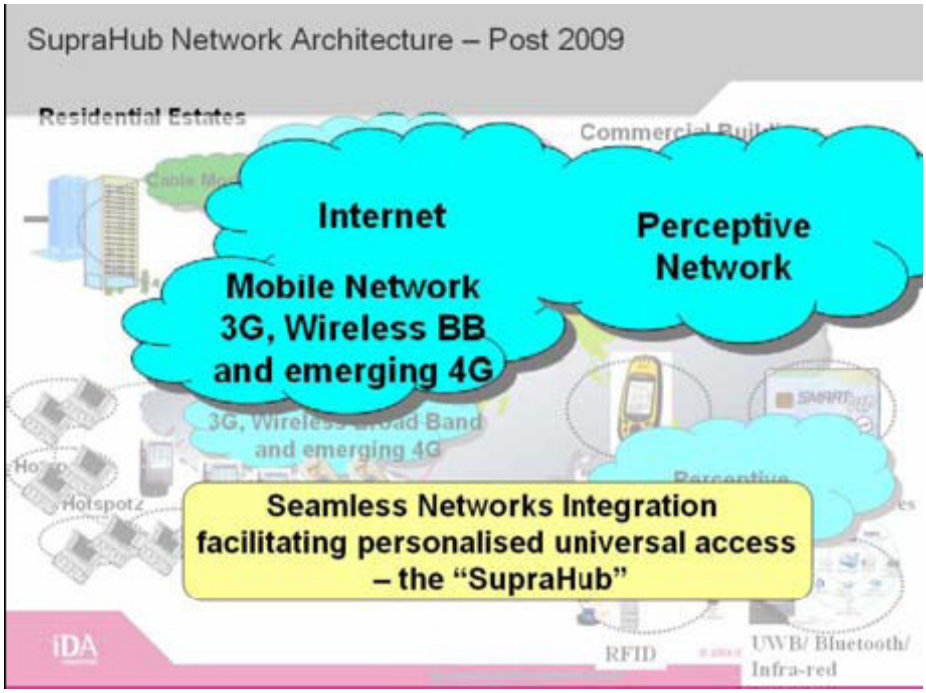
**The Next Generation I-Hub**

In February 2005, IDA unveiled its latest initiative and invited industry feedback on its vision of the *Next Generation I-Hub,* a *secured, high-speed and ubiquitous network* to drive next generation connectivity. By leveraging on the country's strengths in terms of its pervasive communications infrastructure, pro-business policy environment, and plentiful infocomm skilled manpower, the SupraHub envisages the creation of an island-wide ubiquitous network in the period running up to 2009.

**Building a SupraHub Network Architecture**
*To 2009 and beyond*






*Source:* IDA

It is important to note that the SupraHub vision is currently at an early stage of conceptualization. In 2005, the vision was still in the process of being refined and refocused through public consultations and informal meetings with countries that share similar ambitions. Nevertheless, it has been pointed out that the existing strategies, policies and initiatives, such as the *Wired with Wireless* programme, continue to lead the country on the path toward a ubiquitous network environment.

To realize this vision, IDA intends to direct its efforts along six strategic thrusts:

*1. Infrastructure deployment for a convergent network*

IDA intends to support the provision of a multi-channel platform that achieves convergence between Wired and Wireless; Data and Voice; and Broadcasting and Telecommunications services. It is considering plans that include developing a favorable IP licensing regime, encouraging IPv6 adoption and investing in fiber to the home (FTTH).

*2. Provision of locations sensing network services*

IDA plans to promote the deployment of location sensing networks by leveraging on wireless technologies such as WLAN, Cellular, GPS, UWB, and RFID. Potential applications for such networks include telematics, mobile games, supply chain visibility in logistics, and patient tracking in healthcare.

*3. Exploring new input/output devices*

IDA proposes to promote the search for new Input/Output technologies that can be applied to seamlessly integrate the physical with the electronic. IDA may consider

facilitating R&D into new input/output technologies such as voice activated Telematics.

*4. Exploring new computing devices*

IDA will seek to promote the search for convergent devices that are ecologically integrated for ubiquitous living. IDA may consider supporting potential R&D projects with operators to develop partially or fully integrated portable multimedia devices with new form factors and shapes, and with longer battery lives.

*5. Promoting new media software/content/applications with security features*

IDA will work closely with other cluster developments in promoting the deployment of suitably secured new media software, content and applications. Potential users include various verticals such as schools, healthcare, logistics, construction, government agencies such as the Police and Civil Defense, insurance and real estate agencies, and the entertainment industry.

*6. Promoting industry alliances/collaboration for ubiquitous computing*

IDA will take an active role in promoting the formation of industry-led alliances, exchanges, and marketplaces while collaborating with industry to deploy infrastructure for ubiquitous offerings. Potential industry alliances can be forged in the areas of inter-roaming, interoperability and inter-working in a multi-operator, multi-platform environment.

The realization of these trusts will support the strategy imperatives of

- Deploying leading-edge ubiquitous network infrastructure for business and individuals for next generation communications, and
- Capturing the R&D IP creation and ubiquitous commerce segments of the international value chain in next-generation communications.

**Developing the RFID value chain**

As a regional logistics hub with a strong manufacturing base, Singapore stands to realize significant benefits by adopting RFID technologies. At the same time, the government and local infocomm companies also see the increasing global interest in RFID technology as a market growth opportunity.

Recognizing the challenges associated with an emerging technology like RFID, such as the lack of international standards, and the limitations Singapore faces, such as the absence of large retailers like Wal-Mart to drive large-scale adoption, *IDA decided to adopt a proactive approach to developing the RFID sector.* In May 2004, IDA announced that it would invest S$10 million (US$ 5.9 m) in a three-year plan to promote the adoption and development of radio frequency identification (RFID) technology along three lines:

*Alignment of Frequency spectrum and standards for global interoperability;*

*Building capabilities to develop new intellectual property* by building a robust RFID infrastructure in terms of research and development, skilled manpower, and supporting institutions;

*Collaboration to catalyze adoption of RFID in key sectors* by using a clustering approach to bring together groups of industry partners, infrastructure service providers and solutions providers to ensure concerted rollout and interoperability.

IDA has taken an aggressive role in accelerating the process of RFID adoption by creating an internal team of RFID evangelists dedicated to the promotion and adoption of RFID technologies. Currently, the team is focused on encouraging and supporting RFID adoption through awareness building and direct assistance in five key sectors: high-tech manufacturing, pharmaceutical manufacturing, consumer packaged goods manufacturing, retail and logistics.

In November 2004, IDA issued a Call-For-Collaboration (CFC) for "RFID for Business Efficiency".

**RFID spectrum policy**

Currently, different countries have allocated different radio spectrum frequency bands for RFID applications (e.g. North America - 902 - 928MHz, Europe/Singapore - 866 - 869MHz, Japan/Korea - 950 - 956MHz).

In order to ensure RFID interoperability with Singapore's major export markets - the United States and Europe - IDA realigned its spectrum bands allocated for the deployment of RFID applications. In October 2004, the spectrum for RFID applications in Singapore was set at 866-869 MHz and 923-925 MHz in the UHF bands. The licence-exempt power limit for both bands was also increased from 0.01W to 0.5W, while the power limit for the 923-925 MHz band was increased to 2W for RFID devices only. The 915MHz frequency, which is widely used in the US for RFID applications, is currently used for GSM services in Singapore.

**RFID research and development (R&D)**

As a relatively new technology, R&D on RFID technologies is still on-going in some key areas such global inter-operability of RFID systems, and the reliability of RFID when used in environments with high liquid and metal content. Given the increasing interest in RFID research, IDA hopes to position Singapore as a laboratory for pilot RFID research projects and as a development centre for innovative RFID products and solutions. To date, IDA has implemented plans to assist local and multinational companies in making Singapore a base for RFID research.

A key element of IDA's strategy will be the establishment of joint research facilities with institutions at the forefront of RFID development, such as MIT's Auto-ID Labs, which played a key role in developing the Electronic Product Code (EPC).

By mid 2005, a number of local companies have already taken up the opportunity to do R&D in RFID. For example, Tunity Technologies, a local company specializing in RFID and radio frequency (RF) related systems and solutions, is currently in the process of developing EPC-compliant multifrequency RFID tags that operate in three different RF bands in order to ensure frequency interoperability.

Another local company, GT&T Engineering, is developing an intelligent RFID tag that can communicate with other tags so that information can be relayed accurately to the final data collection point. When used in a warehouse management scenario, a tag on one pallet can communicate with the tag on another pallet in order to obtain a meshed network effect. Pallets that are located further away, which previously could not be located, can now be traced for real time monitoring and retrieval.

In addition to establishing research facilities and promoting local R&D, IDA has also strongly encouraged the setting up of an RFID testing centre in Singapore. NOL, APL Logistics and SUN Microsystems have declared that they will be jointly setting up an RFID Testing and Solutions Centre in Singapore, a first in Southeast Asia. It will provide companies with the necessary compliance testing and checks before RFID tagging of the goods. In particular, the Centre will locate the optimal position to place an RFID tag for the most accurate reading for different products. At the same time, the centre will also free up manufacturers from having to do their own tagging.

In September 2004, a Singapore RFID Alliance was formed with the support of IDA. With the aim of transforming itself eventually into an Asia RFID Alliance, it will develop reference architectures, share best practices and align standards. Its current membership includes Hewlett-Packard, Hitachi, Accenture, Port Singapore Authority (PSA) and EPCglobal Inc. among others.

IDA is also currently in the process of encouraging industry to establish RFID registries in Singapore. It is now trying to attract EPCglobal Inc., the leading organization dedicated to the development of industry-driven standards for the EPC, to set up its Asia Pacific headquarters in the country.

**RFID skills and training**

In order to support the growth of an RFID industry in Singapore, IDA has also undertaken the task of increasing the supply of relevant skill sets. IDA is currently working with a number of relevant organizations and training bodies to accomplish this aim. It is currently working with Institutes of Higher Learning and training providers to develop new courses RFID skills training. The two major state-run universities - National University of Singapore and Nanyang Technological University - are developing courses to provide electrical engineering graduates with specialized RFID knowledge while a local college, Republic Polytechnic, is developing new RFID curricula for students and executive RFID courses for businesses. The college is also conducting a survey to determine industry readiness for EPC, their concerns and

gaps. The survey was designed to be used as a tool for the development of government programmes to cater to the industry needs.

In addition to educational institutions, the local logistics industry has also introduced executive training in RFID technology. In November 2004, two RFID courses were launched: the first by The Logistics Institute - Asia Pacific in collaboration with Cambridge AutoID Labs; and the second by the Singapore Manufacturers' Federation in collaboration with RFID Focus.

**Embedded systems**

Singapore's electronics and infocommunications industry received a strong boost with the launch of the Embedded Systems Community (EsCOM) in August, 2005.[69]

An initiative spearheaded by Singapore Economic Development Board (EDB)[70] and hosted by Nanyang Polytechnic,[71] EsCOM[72] comprises a network of partners committed to providing support to technopreneurs and startups across the product research and development value chain for embedded system solutions. Initially, EsCOM has had 12 industry partners, including Intel, Wind River and Microsoft, and received registrations from eight Singapore-based startups, one of which was MRD Technologies.

One of EsCOM's primary roles is to nurture startups through the provision of incubator support and business linkages across all aspects of the value chain. The community also aims to create a conducive and supportive environment that will foster the innovation of embedded system solutions with services for product conceptualization, design and development, test and measuring, manufacturing, commercialization, consultancy, intellectual property management and funding.

As one of the fastest growing industries, the embedded systems industry is estimated to be US$67 billion worldwide in 2004. Singapore is a strategic partner for companies that are looking to develop innovative embedded systems and software applications for the Asia-Pacific and global marketplace. With a strong embedded technology base found in local research institutes, companies, universities and polytechnics, Singapore is an ideal location for multi-national companies and local companies to cost-effectively design, test and deploy products across multiple industries. In addition, the sophisticated manufacturing, supply chain and logistics infrastructure here also lends itself to manufacture and distribute these products globally.

Singapore possesses a vibrant embedded systems community and R&D expertise which global companies can leverage on to develop their next generation products. In Singapore, companies like Hewlett-Packard, Motorola, Siemens and Delphi are

[69] Embedded Systems Community (EsCOM), http://www.edb.gov.sg/edb/sg/en_uk/index/news_room/news/2005/launch_of_embedded.html
[70] Singapore Economic Development Board, http://www.edb.gov.sg
[71] Nanyang Polytechnic, http://www.nyp.edu.sg
[72] EsCOM, http://www.nyp.edu.sg/aboutNYP/PublicationsFiles/releases2005/escom.htm

developing advanced mobile phones, 3G base stations, inkjet printers, avionics, telematics, mobile MP3 players and semiconductor equipment. The Singapore Economic Development Board (EDB) believes in the importance of a vibrant embedded systems community in Singapore to drive future product innovation. It is committed to the advancement of Singapore's research, technology, education and product development foundations.

***Leading companies in the area of Embedded Systems in Singapore***

**Motorola Singapore** is the corporate headquarters for the company's operations in the Asia- Pacific region. Established since 1973, it has a team of 2400 employees, with over 300 R&D engineers.

**Renesas** System Solutions Asia, headquartered in Singapore, is the first middleware development centre outside of Japan designing multimedia devices for the consumer market. With a team of 50 engineers, it focuses its development and innovation in hardware and software systems with applications in data, voice and image processing.

**Philips**, a world class Netherlands electronics Multi-National Corporation (MNC), leads the world in wide ranging products in consumer electronics, domestic appliances and semiconductors. In Singapore since 1951, Philips Electronics Singapore has been a key player in electronics manufacturing in the country.

**Delphi** is a world leader in automotive electronics and systems technology. Since 1978, Delphi Singapore has been at the forefront of advanced technology-based design and manufacturing.

**Creative Technology** is a world leader in digital entertainment products. It launched Singapore onto the world stage with the SoundBlaster – their brainchild that introduced high quality audio on the PC and revolutionized the entire PC audio industry.

**Innvo Systems** is a provider of turnkey software solutions for embedded systems. Established in 2000, the Singapore-based company has a customer base stretching across the United States, Asia-Pacific and Japan. It focuses on the mobile phone and automotive electronics markets.

**Softfoundry** International is an R&D company centered on next-generation embedded software development. Its spirit in relentless innovation and research has reaped its rewards in marketwinning products.

**Wind River** is the global leader in Device Software Optimization (DSO). Founded in 1981, it is headquartered in Alameda, California, with operations worldwide. Singapore oversees its ASEAN, Australia and New Zealand businesses.

**Zentek Technology** is a leading developer and software solutions provider for the consumer electronics industry. Leveraging on its technical expertise in digital television and wireless applications, Zentek has formed many strategic partnerships.

**Encore Technologies Singapore** is a joint venture between Indian software giant Encore Software and Time2Talk, a Singapore mobile computing start up. This collaboration was formed to start the development and globalization of the Simputer – a product hailed by The New York Times as the Invention of the Year in 2001.

**Bedd Pte Ltd.** is a developer of social networking software for wireless community applications and services. Founded in 2001, the company focuses on the development and commercialization of the BEDD application for mobile phones.

**Datamark Technologies Pte. Ltd.** is a pioneer in digital watermarking solutions in the Asia Pacific region. Founded in 1998, DMT's patented digital watermarking technologies allow unique information to be imperceptibly embedded into digital images or documents, ensuring the copyright protection and authenticity of digital content. The slightest modifications to an original document can be easily detected and isolated in the watermarked digital image through DMT's software.

### *Embedded systems research in Singapore*

The **Agency for Science, Technology and Research** (A*STAR)[73] is the key government agency leading and funding public research in Singapore. A*STAR aims to build a knowledge based economy through the Creation, Ownership, and Exploitation of intellectual capital by promoting and nurturing talents in the fields of science, engineering and biomedical research.

The Institute for Infocomm Research (I2R),[74] established in 1992, was formed to develop solutions for the communications and information technology industry. I2R's key areas of research include Services and Applications, Communications and Devices, and Media.

The Centre for High Performance Embedded Systems (CHiPES)[75] was formed in 1998 by the Nanyang Technological University's (NTU) School of Computer Engineering. CHiPES receives funding from NTU, A*STAR and industry partners such as Infineon Technologies.

### *Embedded Systems Forum - a one-stop portal site for embedded developers*

Embedded Systems Forum is a one-stop portal site[76] for embedded developers to source for partners, technologies, research, vendors, customers as well as to train

[73] Agency for Science, Technology and Research, http://www.a-star.edu.sg/astar/index.do
[74] Institute for Infocomm Research, http://www.i2r.a-star.edu.sg
[75] Centre for High Performance Embedded Systems, http://www.chipes.ntu.edu.sg
[76] Kenoir Embedded Systems Forum, http://www.esforum.com

engineers. In order to capitalize on these market opportunities, Embedded Systems Forum will help to bring the local embedded software and systems community together and provide a window into Singapore for potential investors.

***Kenoir Embedded Systems Centre***

The Kenoir Embedded Systems Centre[77] is committed to sustaining a vigorous academic and practice-oriented environment that values quality and diversity in the educational experience. Programme strengths include:

- the design experience from the top down,
- use of contemporary modeling tools throughout the curriculum,
- issues in hardware/software integration,
- embedded systems curriculum at the edge.

# Conslusion

In its desire to forge a ubiquitous network society, Singapore has benefited greatly from the advanced state of development of its fixed line, wireless and mobile networks. *This accomplishment owes itself in no small measure to the extensive measures taken by the Singapore government to develop the country's infocomm economy. Its highly pro-active and involved approach to industry development must be considered as the key driver of Singapore's journey to become a ubiquitous network society.*

Singapore nevertheless faces significant challenges in its journey, particularly as new technologies and new standards emerge. As a small country, *Singapore is limited in terms of market size.* As a result, it is often unable to set standards for new technologies, applications and services as they emerge. Nevertheless, *despite this constraint, the country has managed to wield a level of influence far greater than its size would otherwise warrant, largely through the efforts it has made to attract pioneering research and development activities in infocomm areas it deems as strategic.* Other goals such as the desire to develop a strong local industrial base in the area of innovative ICT technologies will continue to present a challenge to the Singapore government and people. Given the relative success Singapore has realized with its paternalistic approach, it is likely that the country will proceed on a similar path in the development of a Ubiquitous Network Society.

[77] Kenoir Embedded Systems Centre, http://www.kenoir.com

# USA

In the USA the current challenge areas in the field of ES are the following[78]:

- Medical devices and systems
- Flight-critical aviation systems
- SCADA (Supervisory Control and Data Acquisition) systems

Current solutions are soft real-time, information-centric, not secured, and need human interaction. The objective of future researches is to develop secure, mobile, aggregated solutions which are soft and hard real-time systems with open and hierarchical supervisory control.

Programmes in the field of ES are coordinated mainly by two agencies: National Science Foundation (NSF)[79] and Defense Advanced Research Project Agency (DARPA)[80].

The **National Science Foundation (NSF)** is an independent federal agency created by Congress in 1950. NSF plays a critical role in supporting fundamental research, education and infrastructure at colleges, universities, and other institutions throughout the country. Although NSF represents less than 4% of the total federal funding for research and development (R&D), it accounts for approximately 13% of all federal support for basic research and 40% of non-life-science basic research at U.S. academic institutions.

Congress appropriates NSF budget resources annually.

NSF does not hire researchers or directly operate its own laboratories or similar facilities. Instead, they support scientists, engineers and educators (single investigators and small groups) directly through their own home institutions.

The agency publishes a notice about a funding opportunity (usually called a "solicitation"), which invites researchers to submit proposals[81] describing their ideas on how to meet a particular need. Proposals are evaluated by a panel of independent reviewers consisting of scientists, engineers and educators, who do not work at NSF or for the institution that employs the proposing researchers. The panel's job is to decide which projects are of the very highest priorities.

One of NSF's current priority areas[82] is ***Information Technology Research (ITR)*** exploiting the fundamental research on the challenges facing the expansion and utilization of IT across science and engineering. It spans from the investigation,

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[78] Presentation of Helen Gill, Workshop on a Transatlantic Research Agenda: Future Challenges in Embedded Systems Design, http://www.artist-embedded.org/FP6/ARTIST2Events/PastEvents/IST-NSF/Friday/IST-NSF_NSF_HelenGill.pdf

[79] http://www.nsf.gov/

[80] http://www.darpa.mil

[81] http://www.nsf.gov/pubs/gpg/nsf04_23

[82] National Science Foundation Strategic Plan FY 2003 – 2008, http://www.nsf.gov/about/what.jsp

development, and strengthening of largescale networks to the creation of new integrative software and advanced architectures for high-end computing.
An exemplar project funded in part by the ITR project is the *Center for Hybrid and Embedded Software Systems (Chess)*[83].

Some ES related active funding opportunities recently announced on the NSF webpage are:

- ***Control Systems Programme (CSP)*** supports advances and novel developments in control system strategies and technologies with broad applicability to both mechanical and civil systems; embedded / distributed real-time control and mechatronic systems; control of dynamical systems at all scales (nano to micro to macro), with or without humans in the loop.
- ***The Sensor Technologies for Civil and Mechanical Systems (STCMS)*** programme element supports research on acquiring and using information about civil and mechanical systems to improve their safety, reliability, cost, and performance. This includes research that extends the knowledge base for development of advanced sensors for solution of inverse problems related to system identification and characterization, and for implementation of real time adaptive system performance capabilities that use the sensed information. Examples of research areas to be supported include innovative developments in sensor technologies, analytical strategies for CMS monitoring, and active noise and vibration control technologies.
- ***Dynamical Systems Programme (DSP)*** supports fundamental advances in the understanding, design and operation of dynamic systems, including acoustics, vibrational response, and kinematic relationships; active noise and vibration control technologies; modeling and simulation of nonlinear time-varying and distributed systems.
- In the frame of *the Networking Technology and Systems (NeTS)* programme ***Networking of Sensor Systems (NOSS)****:* Funded projects will seek to create architectures, tools, algorithms and systems that make it easy to assemble and configure networks of sensor systems.
- The *Computer Systems Research (CSR)* programme contains ES related topics like ***Embedded and Hybrid Systems (EHS).***
- The ***Integrative, Hybrid and Complex Systems (IHCS)*** programme focuses on areas (among others) like
  - Miniature implantable devices that combine sensors, actuators, computational algorithms and microcircuits for biomedical applications ranging from drug delivery to microsurgery;
  - Wireless networks of handheld or wearable computing devices that incorporate microsystem transmitters, receivers, antennas and sensors, and constitute a complex distributed network with high bandwidth and high information-transfer rates.

In addition to the priority areas, NSF participates in a wide range of cross-cutting activities. An important set of these activities is identified annually by the Office of Science and Technology Policy and the Office of Management and Budget as the Administration's interagency research and development priorities. Embedded

[83] http://chess.eecs.berkeley.edu/

Systems related FY2004 priority has been the ***Networking and Information Technology Research & Development (NITRD)*** programme[84].

The NITRD Programme is composed of 12 agencies; its members work in collaboration to increase the overall effectiveness and productivity of federal information technology (IT) R&D. A National Coordinating Office coordinates the activities of the NITRD Programme and reports to OSTP (White House Office of Science and Technology Policy) and the National Science and Technology Council. Of those 12 members, the majority of funding goes to the National Science Foundation, National Institutes of Health, National Aeronautics and Space Administration, Defense Advanced Research Projects Agency, and the Department of Energy, Office of Science.

The NITRD Subcommittee provides policy, programme, and budget planning for the NITRD Programme and is composed of representatives from each of the participating agencies. Six Coordinating Groups reporting to the NITRD Subcommittee focus their work in seven Programme Component Areas (PCAs). One of these PCAs is the area of ***High Confidence Software and Systems (HCSS)*** — to develop the scientific foundations and IT to achieve affordable and predictable high levels of safety, security, reliability, and survivability, especially in U.S. national security and safety-critical systems.

The FY2005 budget provides USD 2.256 billion for the NITRD Programme, while the FY2006 budget calls for USD 2.155 billion. (The NITRD Programme is funded out of each member agency's individual budget, rather than in a single appropriations bill.)[85]

In the frame of the HCSS programme the strategic priority for 2006 is to search for new science-based concepts, technologies, and tools that can revolutionize not only the engineering processes for construction, testing, and certification of software, but also the overall engineering of systems to incorporate high assurance levels at every stage of system design[86]. Further highlights are programmes in basic and technology research for high-confidence embedded systems, hybrid control, distributed systems.

Several statistical data can be founded on the NSF webpage[87], the following example is representing the federal R&D funding for FYs 2001-2006.

[84] http://www.nitrd.gov
[85] www.ipmall.info/hosted_resources/crs/IB10130_050502.pdf
[86] http://www.nitrd.gov/pubs/2006supplement/hcss.pdf
[87] http://www.nsf.gov/statistics/

TABLE 1. Federal R&D budget authority, by budget function: FY 2001–06

| Funding category | FY 2001 actual | FY 2002 actual | FY 2003 actual | FY 2004 actual | FY 2005 preliminary | FY 2006 proposed | Percent change, FY 2005–06 |
|---|---|---|---|---|---|---|---|
| | Billions of current dollars | | | | | | |
| Total | 86.756 | 97.624 | 112.544 | 121.867 | 127.336 | 127.621 | 0.2 |
| National defense | 45.713 | 53.016 | 63.048 | 69.593 | 74.668 | 74.759 | 0.1 |
| Nondefense | 41.043 | 44.608 | 49.495 | 52.274 | 52.668 | 52.862 | 0.4 |
| Health | 20.758 | 23.560 | 26.517 | 28.251 | 28.746 | 28.984 | 0.8 |
| Space research and technology | 6.126 | 6.270 | 7.355 | 7.612 | 7.686 | 8.089 | 5.2 |
| General science | 5.468 | 5.753 | 6.129 | 6.466 | 6.482 | 6.423 | -0.9 |
| Natural resources and environment | 2.096 | 2.160 | 2.151 | 2.168 | 2.108 | 1.990 | -5.6 |
| Transportation | 1.640 | 1.838 | 1.869 | 1.863 | 1.828 | 1.640 | -10.3 |
| Agriculture | 1.657 | 1.606 | 1.708 | 1.750 | 1.803 | 1.575 | -12.7 |
| Other functions[a] | 3.298 | 3.421 | 3.767 | 4.164 | 4.015 | 4.161 | 3.6 |
| | Billions of constant FY 2000 dollars | | | | | | |
| Total | 84.756 | 93.635 | 106.034 | 112.579 | 115.288 | 113.330 | -1.7 |
| National defense | 44.659 | 50.850 | 59.401 | 64.289 | 67.603 | 66.388 | -1.8 |
| Nondefense | 40.097 | 42.785 | 46.632 | 48.290 | 47.685 | 46.943 | -1.6 |
| Health | 20.279 | 22.597 | 24.983 | 26.098 | 26.026 | 25.738 | -1.1 |
| Space research and technology | 5.985 | 6.014 | 6.930 | 7.032 | 6.959 | 7.183 | 3.2 |
| General science | 5.342 | 5.518 | 5.774 | 5.973 | 5.869 | 5.704 | -2.8 |
| Natural resources and environment | 2.048 | 2.072 | 2.027 | 2.003 | 1.909 | 1.767 | -7.4 |
| Transportation | 1.602 | 1.763 | 1.761 | 1.721 | 1.655 | 1.456 | -12.0 |
| Agriculture | 1.619 | 1.540 | 1.609 | 1.617 | 1.632 | 1.399 | -14.3 |
| Other functions[a] | 3.222 | 3.281 | 3.549 | 3.847 | 3.635 | 3.695 | 1.6 |

[a]Other functions include energy; veterans benefits and services; education, training, employment, and social services; income security; commerce and housing credit; international affairs; administration of justice; and community and regional development.

NOTES: Data reflect budget information collected through April 2005. Data for FY 2001–04 reflect final budget authorization. Preliminary budget authority for FY 2005 reflects all past congressional actions but may be revised, since at the time of table preparation, FY 2005 had not yet been completed. Proposed budget authority for FY 2006 from the Bush administration will be revised to reflect congressional appropriation and actual program-funding decisions. Details my not add to totals because of rounding. Percent change is derived from unrounded data.

SOURCES: Agencies' submissions to the Office of Management and Budget; agencies' budget documents; and supplemental data obtained from agencies' budget offices.

EU IST programmes and NSF has a long history of cooperation. Embedded Systems was the largest area of EU-US collaboration in FY2004.

The **Defense Advanced Research Projects Agency (DARPA)**[88] is the central research and development organization of the Department of Defense (DoD)[89]. It manages and directs selected basic and applied research and development projects for DoD, and pursues research and technology where risk and payoff are both very high and where success may provide dramatic advances for traditional military roles and missions.

DARPA's strategy is to hire programme managers for periods of only 4 to 6 years, this way to minimize the institutional interests. Another feature of DARPA's philosophy is that the agency has very limited overhead and no laboratories or facilities.

Figure 1 illustrates where science and technology (S&T) funding is invested along a national timeline from *Near* to *Far*. S&T is typically focused on known systems and known problems. The *Far* bubble represents fundamental discoveries where new science, new ideas and radical new concepts typically first surface.

[88] http://www.darpa.mil
[89] http://www.defenselink.mil

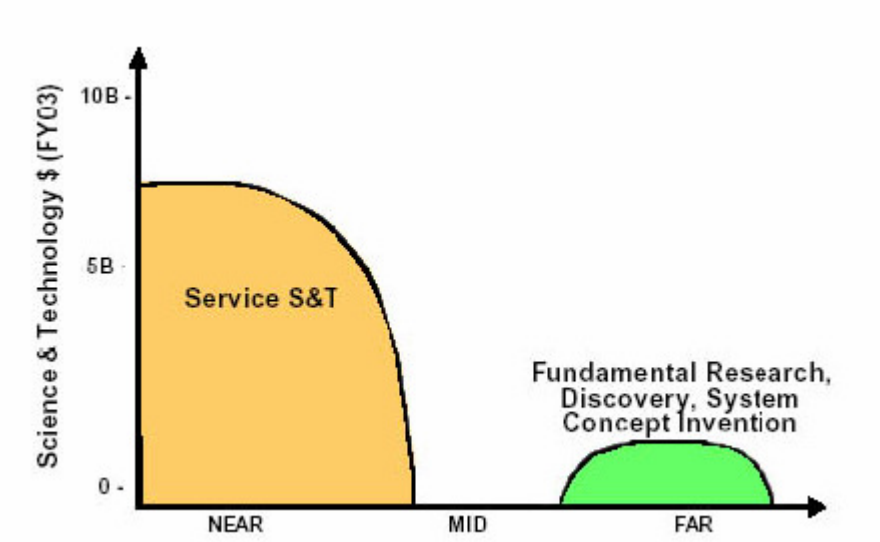


**Figure 1 Timelines and investments in science and technology.**

DARPA's mission, shown in Figure 2, is to bridge the gap between these two groups.

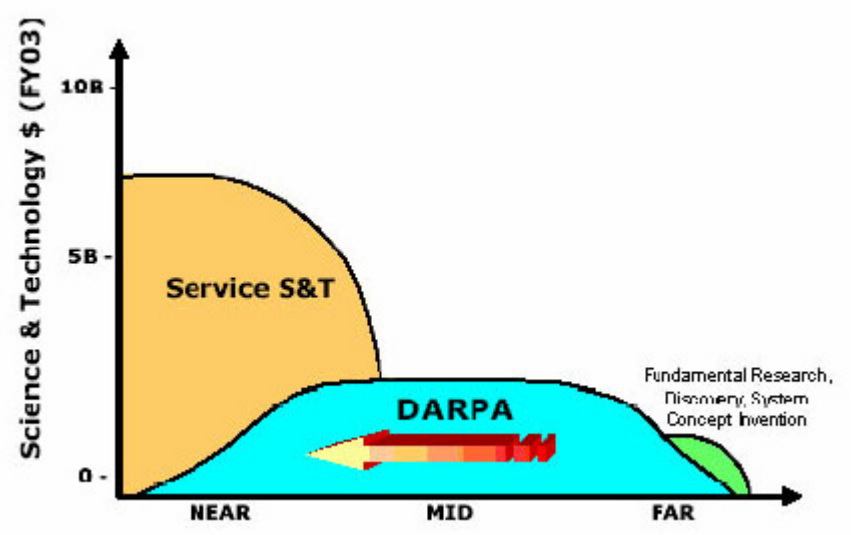


**Figure 2 DARPA's role in science and technology.**

DARPA uses a top-down process to define problems and a bottom-up process to find ideas, involving the staff at all levels. DARPA's upper management and programme managers identify "DARPA-hard" problems by talking to many different people and groups.

During DARPA's programme reviews, which occur throughout the year, DARPA's upper management looks for new ideas from programme managers (or new programme managers with ideas) for solving these problems. At the same time, management allocates funds for exploring highly speculative technology that has far-reaching military consequences.

There are *two basic technical offices* at DARPA: technology offices and systems offices. The *technology offices* focus on new knowledge and component technologies that might have significant national security applications. The *systems offices* focus on technology development programmes leading to products that more closely resemble a specific military end-product.

Among the technical offices programmes the *Information Exploitation Office (IXO)* Programmes[90] contain ES related themes. Some exemplar projects are:

- ***Networked Embedded Systems Technology (NEST):*** The quantitative target is to build dependable, real-time, distributed, embedded applications comprising 100-100,000 simple computing nodes. The nodes include physical and information system components coupled by sensors and actuators.
- ***Program Composition for Embedded Systems (PCES):*** The software research addressed by PCES concerns mechanisms by which DoD embedded systems may be constructed from separately developed parts, where the relationships of the parts to the whole may be far more sophisticated than the conventional subprogram-to-program relationship.
- ***Software Enabled Control (SEC):*** this programme is developing control technologies for advanced unmanned and manned aircraft. These control systems will enhance the autonomy and reliability of both fixed- and rotary-winged unmanned aerial vehicles (UAVs) and will improve the performance of manned vehicles. Advanced techniques are being implemented on a common, open computing platform using a flexible programmer's interface that facilitates re-use of real-time controllers across multiple vehicles. Advanced control system development is exploiting recent successes in hybrid systems research, which combines continuous-time systems with randomly occurring discrete events.
- ***Camouflaged Long Endurance Nano Sensors (CLENS):*** develop, demonstrate and transition an innovative real-time ultra-wideband (UWB) radar network that will detect, classify, localize, and track dismounted combatants under foliage and in urban environments.

Additional governmental bodies funding R&D projects in the field of ES are for instance: NASA[91], Air Force Research Laboratory (AFRL)[92], Air Force Office of Scientific Research (AFOSR)[93], and Office of Naval Research (ONR)[94], however these fundings are lower.

[90] http://dtsn.darpa.mil/ixo
[91] http://www.nasa.gov/externalflash/nasa_gen/index.html
[92] http://www.rl.af.mil
[93] http://www.afosr.af.mil

Decision-making process:

Request For Proposals (RFP) and Brad Agency Announcements (BAA) are published on the Foreign Business Opportunities website[95]. The submitted proposals are evaluated either by independent reviewers (NSF) or by internal specialists, managers (DARPA). The final decision is the authority of the programme leader, he or she has also the right to grant the financial support. The controlling or verification of a project flow can be very strict (DARPA) with regular, weekly phone conferences and meetings or more flexible (NSF) with annual reports and evaluations.

[94] http://www.onr.navy.mil
[95] http://www.cbd-net.com

# Conclusions

- Not surprisingly, the field of embedded systems is one of the most important research, development, innovation and application areas in the economically fast developing countries which is well reflected in their ICT strategies.
- In these days, embedded computing systems are no longer stand-alone devices isolated from their environment. More and more embedded systems are continuously communicating with their environment, which itself consists of other embedded systems through various, mostly wireless, communications channels.
- The importance of communicating embedded computer systems is well reflected also in the terminology that is recently used in Japan, Singapore, Korea and other East and South East Asian countries: they use the term “ubiquitous networking and computing” in their strategies and programmes.
- Ubiquitous networking and computing assumes advanced ultra fast data transfer networks, including “last miles” and “ad-hoc, dynamic local networks”, which are available everywhere, and by everyone for their use is easy and cheap.
- East and South East Asian governments whose activities in the ICT area are shortly described in this report support *proactively* research, development and innovation activities in ICT. In many cases they have special strategies and grant programmes in specific areas like RFID technologies, ubiquitous networking, software for embedded systems, etc. Often, there are also special programmes for innovative high-tech SMEs, and agencies to help them in the start-up phase.