Communications Research Centre Canada
An Agency of Industry Canada

Centre de recherches sur les communications Canada
Un organisme d'Industrie Canada

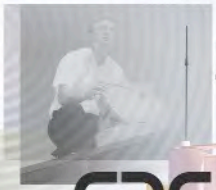
Wireless Communications R&D in Canada

ISART

01 March 2005

Veena Rawat

Communications Research Centre



Canada

CENTRE DE RECHERCHES SUR LES COMMUNICATIONS RESEARCH CENTRE

Content

- Canadian Government Innovation Strategy
- Communications Research Centre (CRC)
- Example of CRC's Wireless R&D
  - Sensor Network
  - Convergence
  - MILTON
  - Spectrum Explorer
- Commercialization
- Summary

Government of Canada | Gouvernement du Canada

"We must strive for Canada to become one of the top five countries for R&D by 2010"
(Speech from the Throne, Jan 2001)

"The Government will develop policies to foster Canadian capability in key enabling technologies which will be drivers of innovation and productivity in the 21st century economy"
(Speech from the Throne, October 2004)

Canada's R&D Target

- Canada's goal is to be recognized as one of the most innovative countries in the world.
- In responding to the Speech from the Throne, the Prime Minister committed to "***at least double the current federal investment in research and development by the year 2010***."

CANADA'S R&D Goals -- Implications

- "top five countries" interpreted to mean within the OECD
- Canada is in 15th place with GERD/GDP of 1.85%
- Trends in GERD/GDP indicate that to reach 5th place, Canada's GERD/GDP would have to exceed 3.00% by 2010
- If federal spending on R&D were to double by 2010, business and university R&D spending would have to almost triple to reach the 3.00% GERD/GDP target
- Present Federal Government S&T investment: C$9.7B

Prime Minister Strengthens Commitment to Innovation

- Prime Minister Paul Martin emphasised the importance of innovation in building a 21st century economy when he announced a continuing focus on science and technology:

  - Commercialization of R&D is an important federal government agenda

R&D Players in the Canadian ICT Sector

- Private Sector
- Federal Government Labs (CRC & NRC)
- Universities & Colleges
- 4th Pillar Organizations (Canarie, Precarn, CMC)
- Regional Labs & Centres (TR Labs, IIT, CCMC, TARA, OCE-CITO and others)

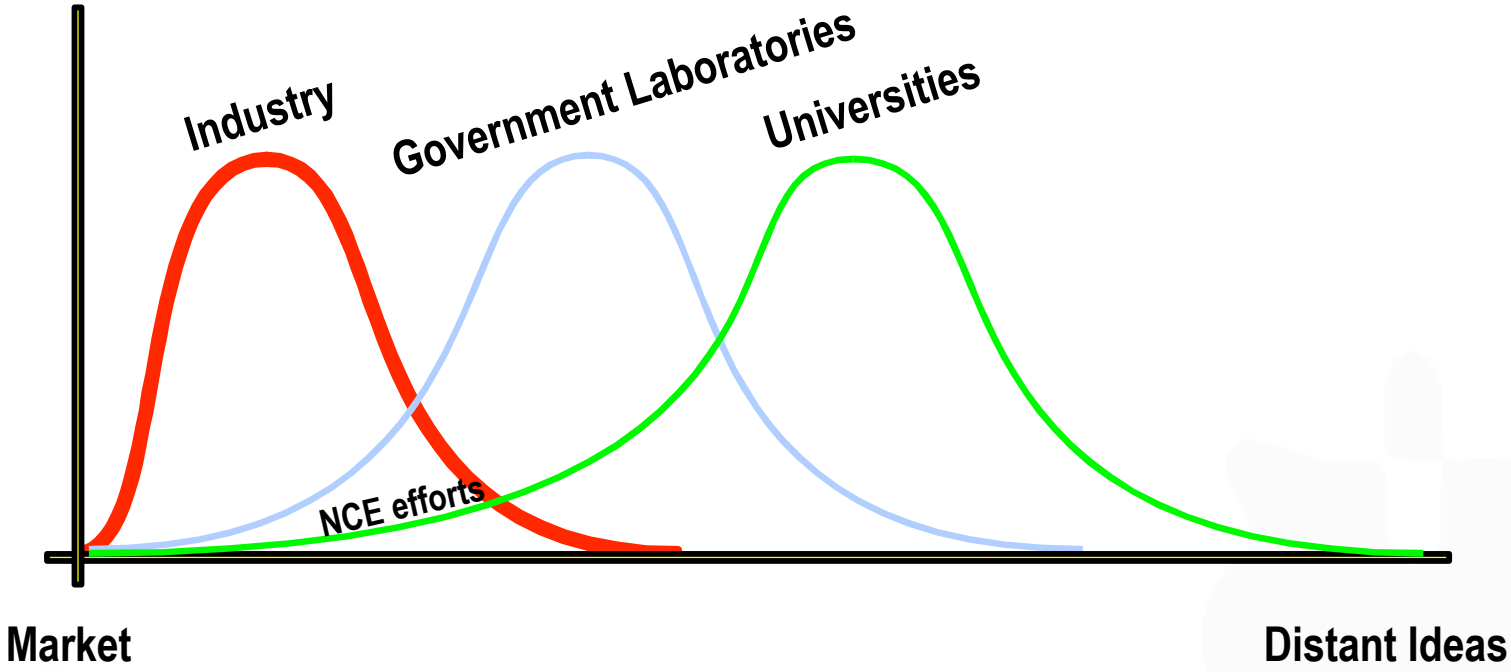
Communications Research Centre

CRC Mission

- To be the federal government's Centre of Excellence for communications R&D, ensuring an independent source of advice for public policy purposes

- To help identify and close the innovation gaps in Canada's communications sector by:
  - *engaging in industry partnerships*
  - *building technical intelligence*
  - *supporting small and medium-sized high-technology enterprises*

Concept to Commercialization



The Roles of Federal Government Laboratories

- Providing support for decision making, policy development and regulations
- Developing and managing standards
- Enabling economic and social development
- Providing support for public health, safety, environmental and/or defence needs

Alignment with Industry Canada Priorities

- **Marketplace**
  - National and International standards and regulation
  - R&D and technical expertise for spectrum management
- **Economic Development**
  - Commercialization and technology transfer
  - Innovation Centre for SMEs
  - Rural and remote broadband technology development
  - CWCnet
  - Applications development
- **Science & Technology**
  - Commercialization framework
  - Advise for policy development
  - S&T Integration Board
  - Public security technology program (PSEPC/DND/others)
  - CA*Net 4

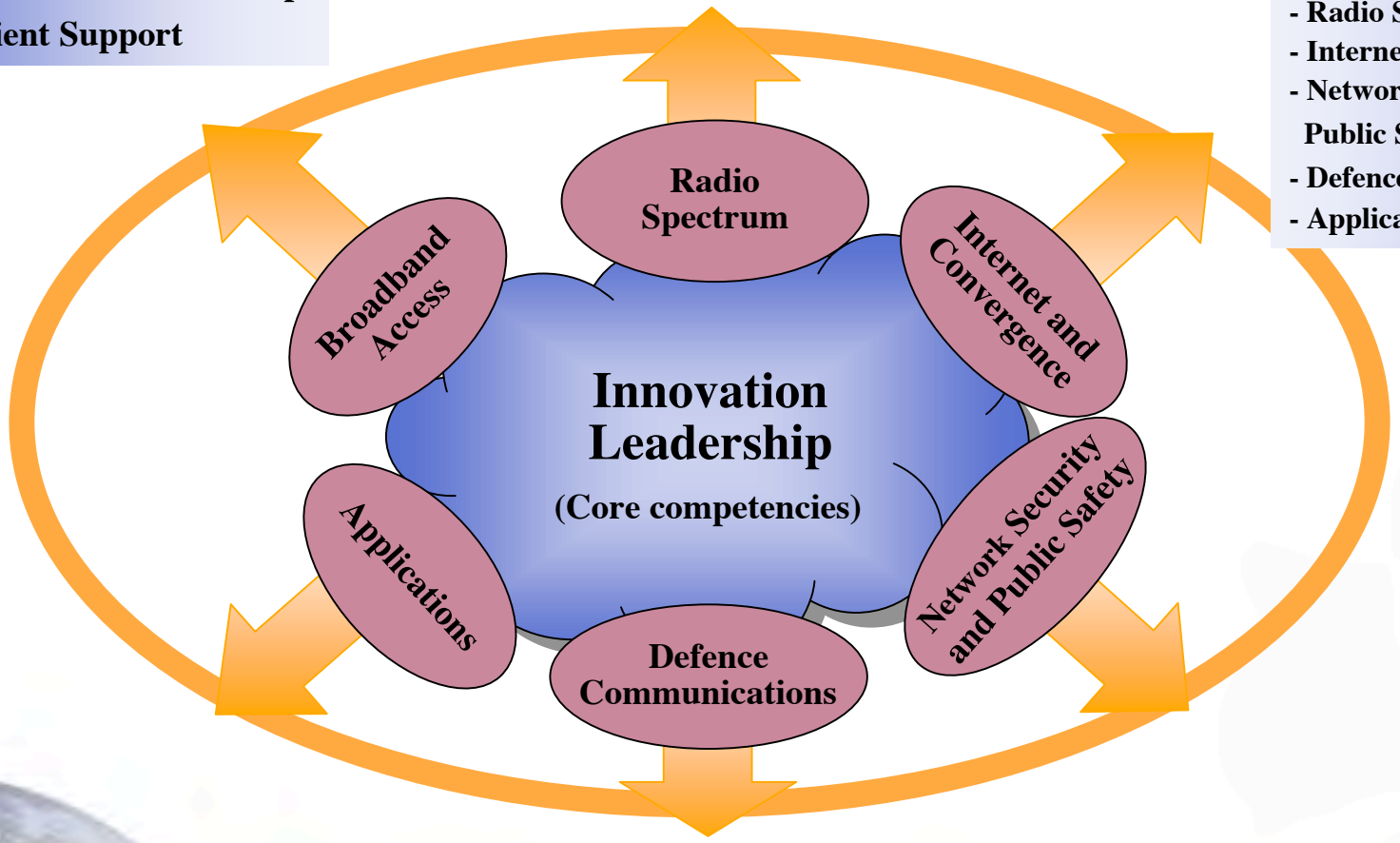
Core Competencies

- Wireless Systems
- Communications Networks
- Radio Fundamentals
- Interactive Multimedia
- Photonics

Strategic Research Priorities (2004-2007)

Strategic Goals:
- Innovation Leadership
- Client Support

Strategic Priorities:
- Broadband Access
- Radio Spectrum
- Internet and Convergence
- Network Security and Public Safety
- Defence Communications
- Applications



CRC Wireless Research Direction

- Adaptive and Cognitive Radio
- Software Defined Radio
- Wireless Security
- 700 MHz, Wi-Max Adaptation
- 60-94 GHz Public Safety Applications
- Dynamically Reconfigurable Antennas & RF Front-end
- B3G Wireless Systems
- 3-Dimension Component Integration
- MINO
- Next-generation Satellite Systems Architecture
- Covergence-Broadcasting and telecom systems
- Emerging Network Protocols

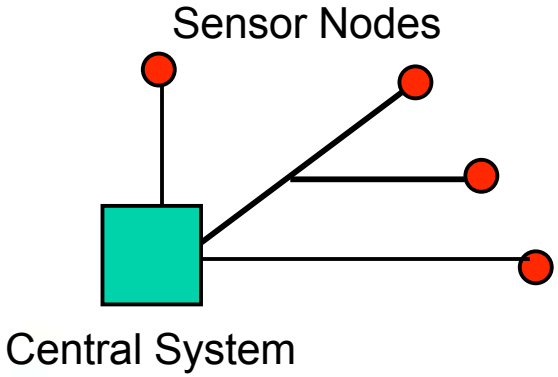
Examples of CRC's R&D in Wireless Networks & Systems

- Security - Sensor Networks, Mobile ad-Hoc Networks
- Convergence - Hybrid networks
- Wireless Broadband Access - MILTON
- Spectrum Management - Spectrum Explorer

Sensor Networks

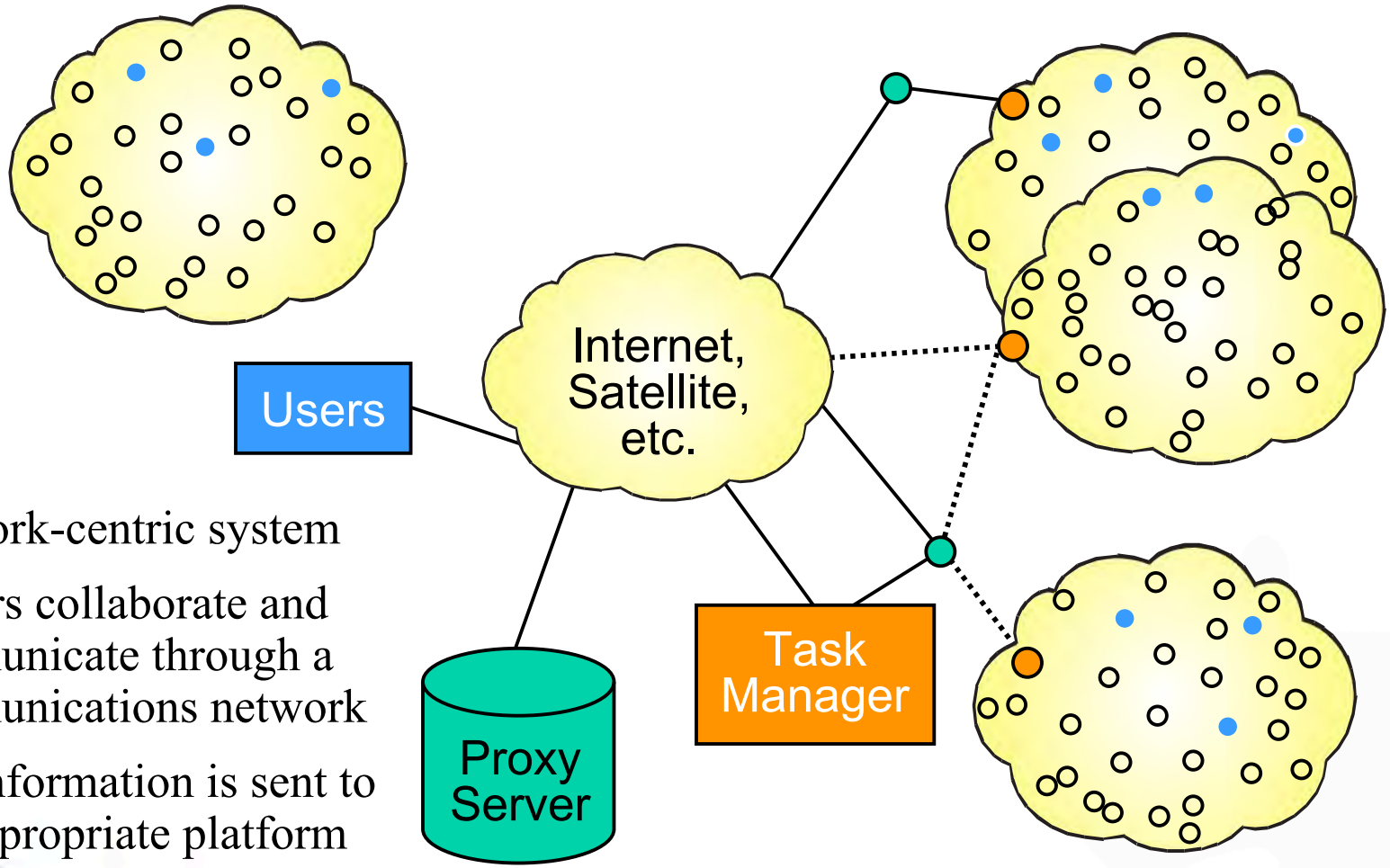
- Ad hoc network protocol
- Modeling and simulation
- Integrating and modifying wireless systems

Traditional Sensor Networks



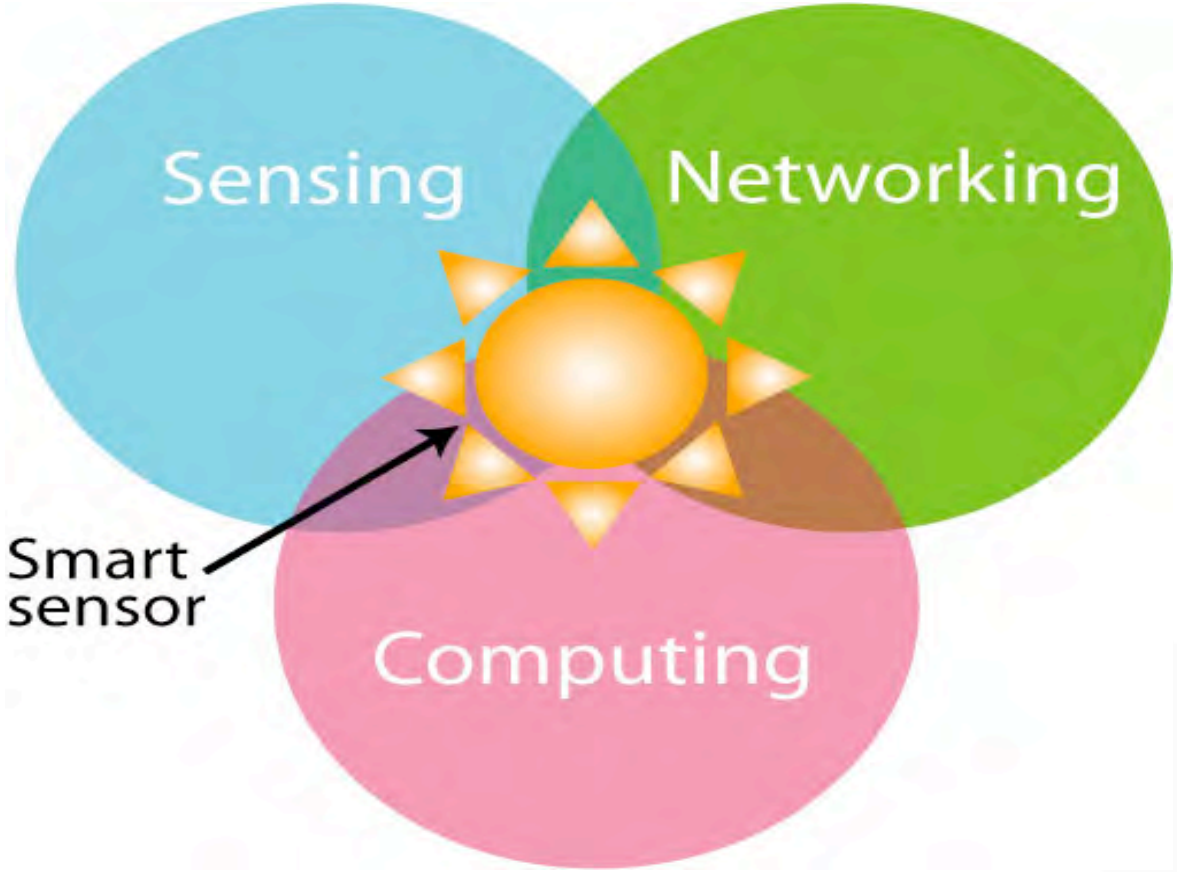
- Platform-centric system, sensors are owned and controlled by a specific platform
- Several sensors deployed near the phenomena and sending time series to a central system
- Very little networking

New Sensor Networks



- Network-centric system
- sensors collaborate and communicate through a communications network
- The information is sent to the appropriate platform

Smart Sensors Capabilities



Sensor Networks - Issues & Challenges

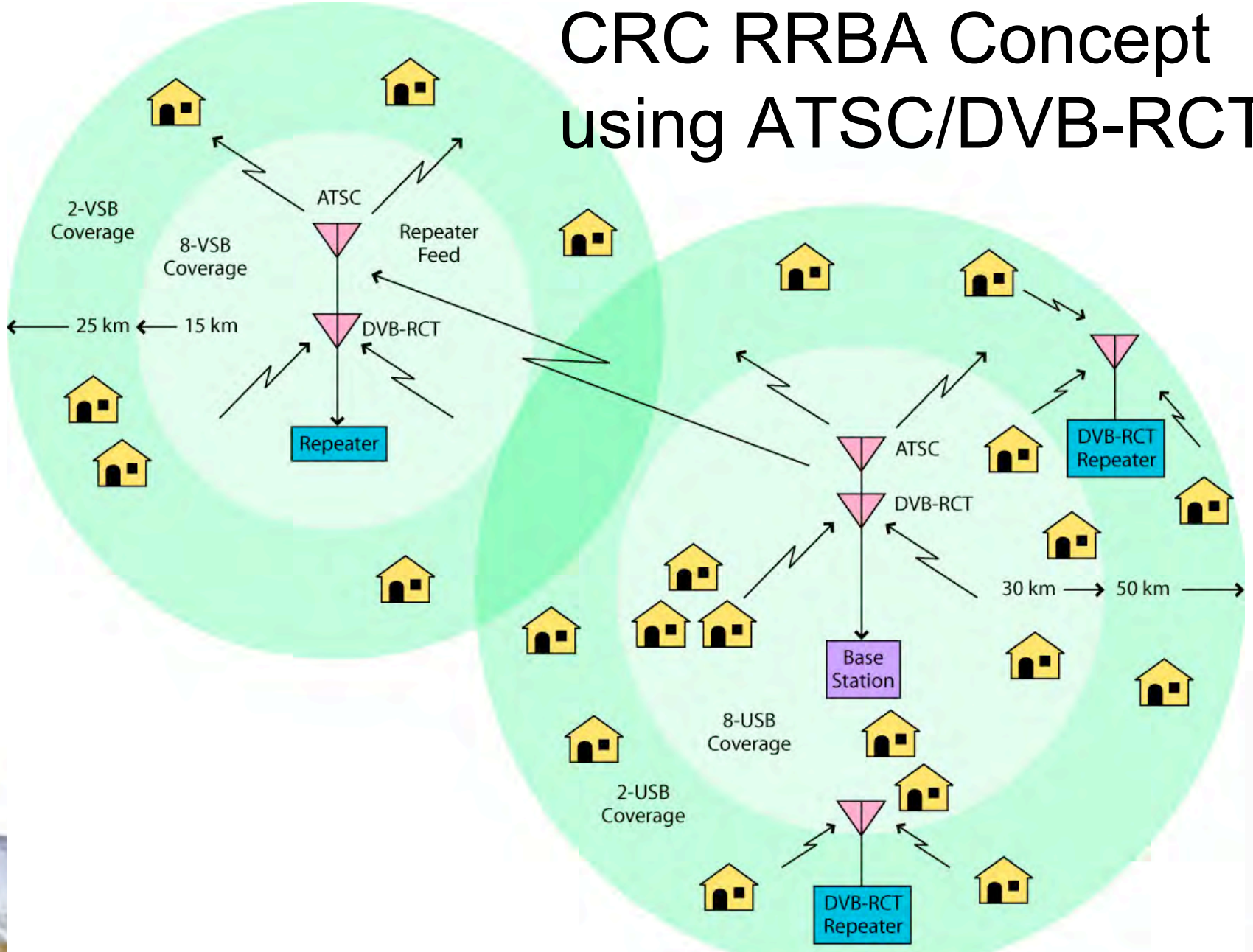
- Actual Sensors - size, weight,
- Power Supply Lifetime - sensor and communications
- Deployment - embedded, “sprinkled” left behind, etc
- Network Discovery - Self-deployment schemes
- Density-Scalability - new clustering schemes
- Routing Strategies - data-centric rather than node ID
- Transmission Media - multi-hop/wireless

CRC is developing new ad hoc network protocols, and modeling and simulations tools

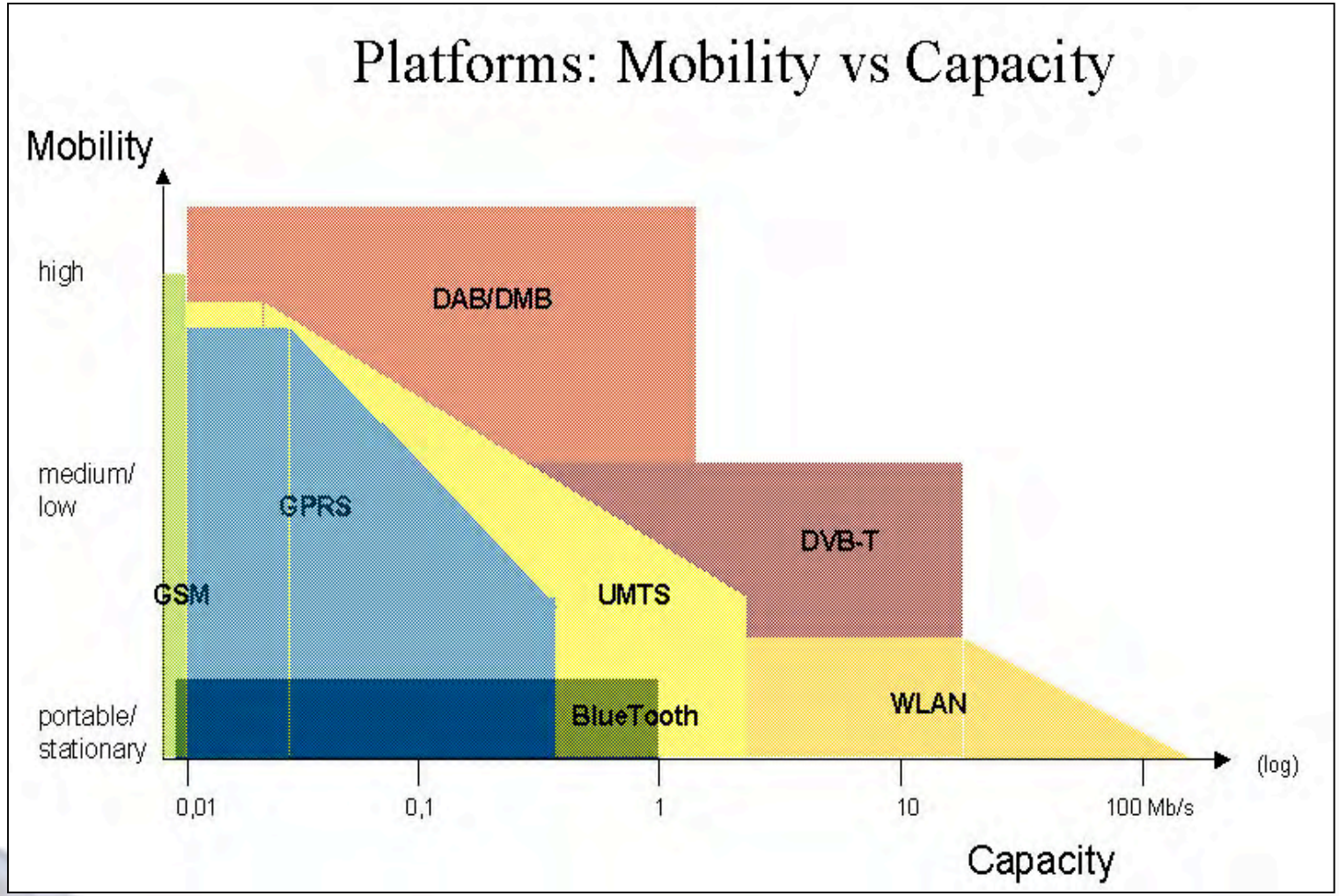
Convergence

- The coming together and overlap of computing technologies, telecommunications, broadcasting and other media, technologically, market and policy wise (DTV, DAB, Internet).
- Information is being converted to a standardized digital format for storage, processing and communication.
- Information may therefore travel freely over different types of networks and the same networks may be connected to many devices.

CRC RRBA Concept using ATSC/DVB-RCT



DIFFERENT PLATFORMS HAVE DIFFERENT CAPABILITIES



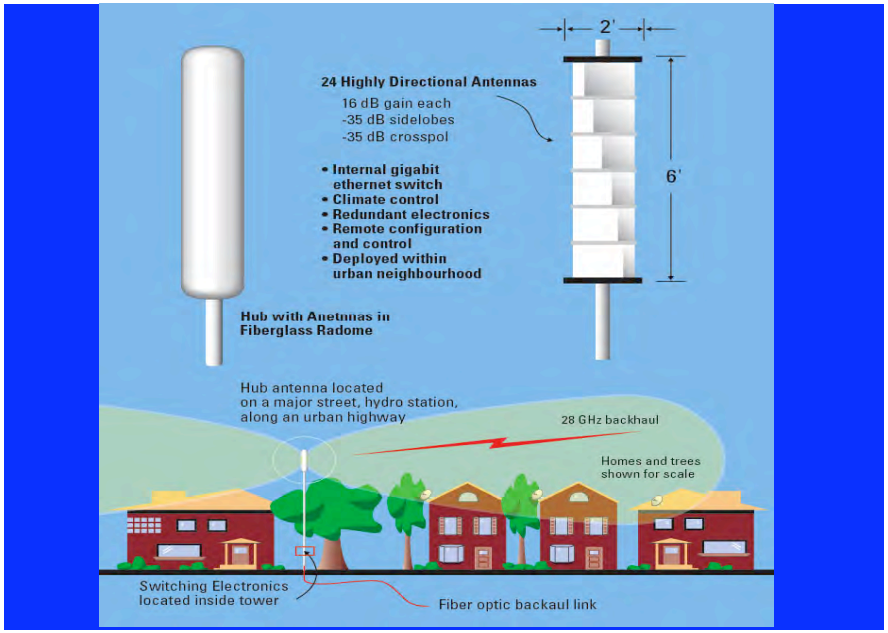
Source: World DAB Forum, IBC 2003

MILTON

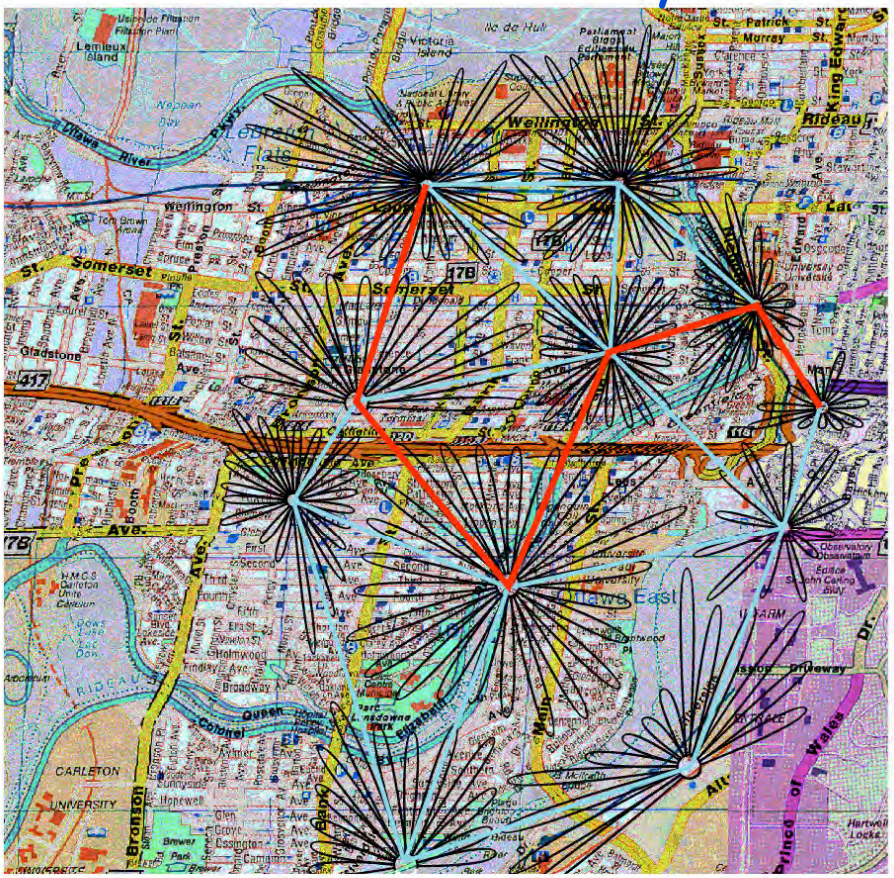
- MIcrowave LighT Orgainzed Network (MILTON)
- Broadband Wireless Access System
- One Gigabit throughput per base station
- High Frequency Re-use
- Cognitive Radio
- 20Mb/s per subscriber

Milton Cognitive Radio Rosette Antenna Array

Rosette Hubs



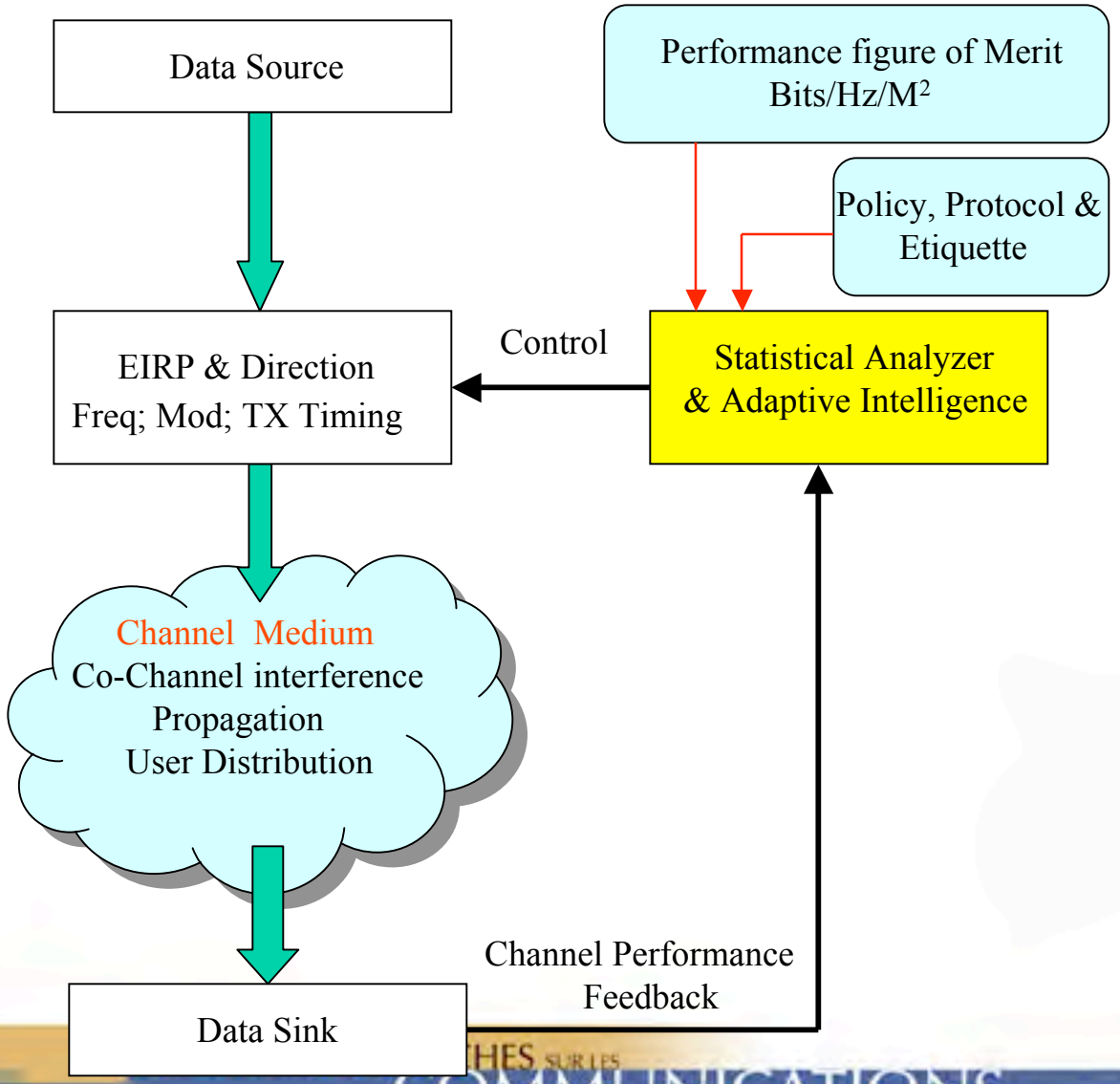
Constellation of Hubs in an urban overlay

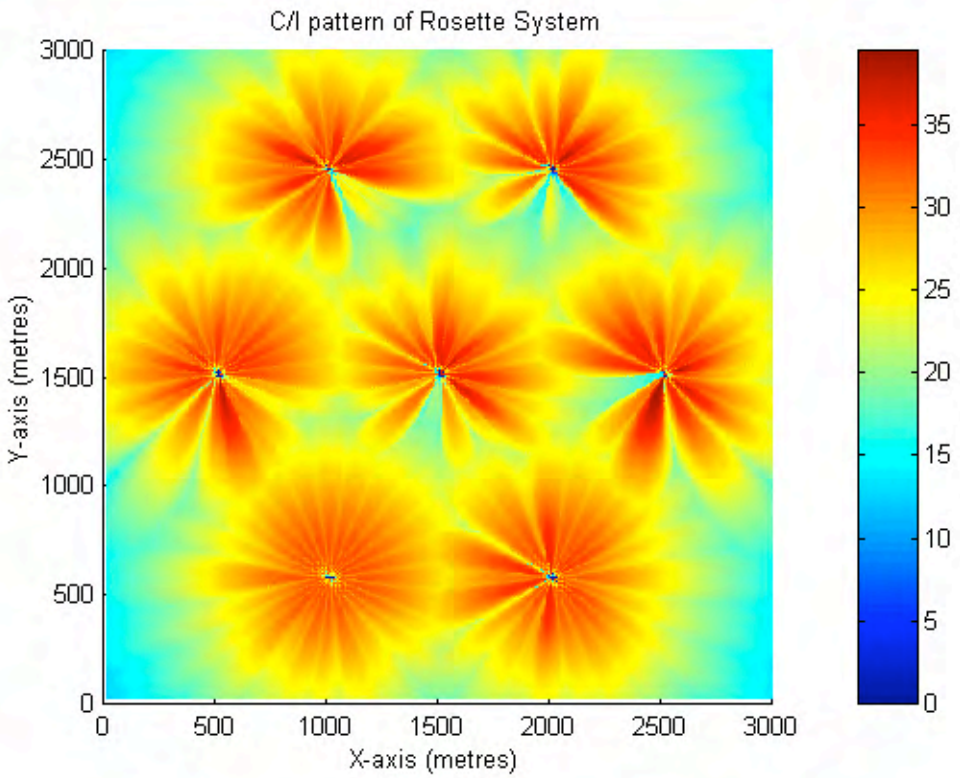


5 GHz (Milton) to 2.4 GHz WiFi STs installed at CRC


24 Petal Milton Hub
West Ottawa

Cognitive Radio

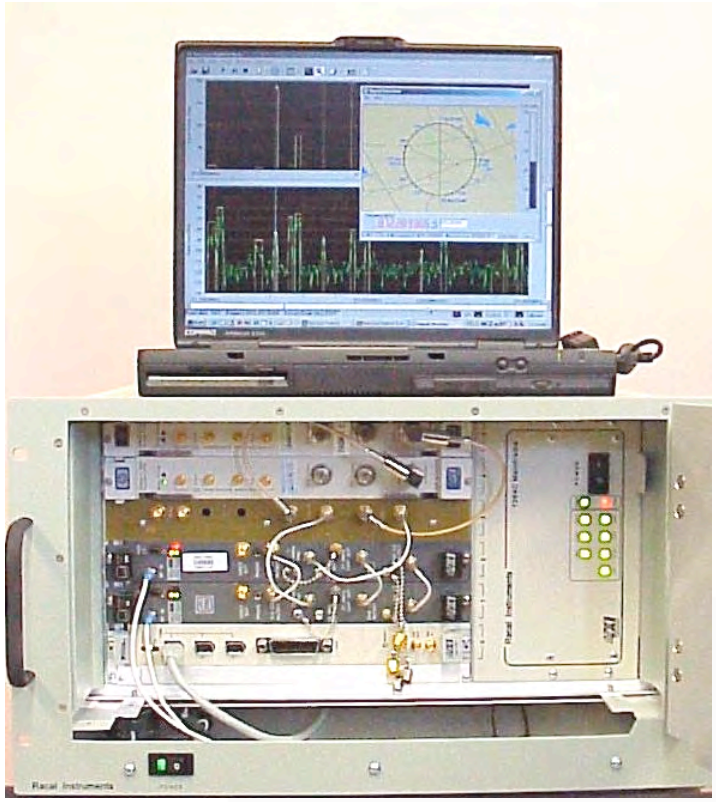




A constellation of rosettes that adapt to each other's presence. Cognitive Processing is used to orient cells in a manner that minimizes systemic co-channel interference.

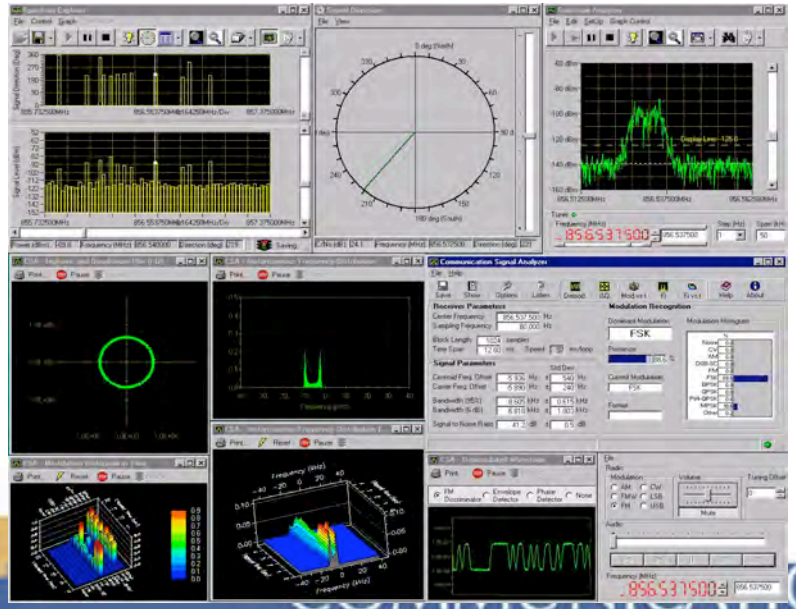
Spectrum Explorer (SE)

- The **Spectrum Explorer** (www.crc.ca/spectrum-explorer) is a radio-frequency monitoring and surveillance software-based system developed at the Communications Research Centre Canada.
- The military version is known as **MiDAS** (Military Digital Analysis System).
- It is built from a combination of commercial-off-the-shelf (COTS) RF receivers, digitizers and standard personal computer (PC) technology.
- It is based on an open software and open hardware architecture making it easy to maintain, up-grade, and re-configure.



What does the Spectrum Explorer do?

- Quickly detects all of the signals present in a wide portion of the radio spectrum (HF/VHF/UHF frequency bands)
- Spectral usage (e.g., channel occupancy) and noise level measurements
- Direction-finding and localization (i.e., places transmitters on a map)
- Identifies transmission types using modulation recognition and signal characterization (i.e., measurement of technical parameters)
- Cue a “listening” receiver or other special-purpose system (e.g., a jammer)
- Capture and store signals for post-processing
- Includes an advanced spectrum analyzer (a standard but expensive piece of equipment)



How It Started

- "Digital Implementation of Radio Project" in 1989
- Was initiated as a Spectrum Research Project in 1993
  - custom-developed hardware was used for DAS I
  - after promising regional field trials, DAS II development began based upon COTS hardware
- The on-going research and development of SE were guided by close interaction and cooperation between DGSE of Industry Canada (IC), CRC, and IC regional staff
- Beginning in 1997, close cooperation with DRDC-O led to a military version of the technology (MiDAS)

Managing Canada's Radio Spectrum

- Civilian *Spectrum Explorer* version adopted by Industry Canada for spectrum management in all of the regions
- On-going enhancements support increasing ability to montor the radio spectrum for current and future systems
- Software up-grades over the internet
- On-line training-at-a-distance

Current Industry Canada Activities

- 16 Spectrum Explorer units are in service (and growing)
- Integration of various Spectrum Explorer functions into the ISOC module (the software shell for the remote utilization of monitoring equipment)
  - measurement of spectrum usage
  - spectrum analyzer function in order to remove the need to purchase and maintain separate spectrum analyzer equipment
  - additional SE functions will be added in the future
- Development of an integrated direction-finding and transmitter localization system

Providing Security to Canadians

- Quebec Region radio inspectors used the SE in conjunction with the RCMP at the Summit of the Americas
- RCMP used the SE at the G20 meeting in Ottawa
- Used at the G8 meetings in Alberta
- The RCMP have purchased a Spectrum Explorer
- Meetings have been held with CSIS, CSE, and DFAIT

Support for National Defence

- The SE is a major component of the Integrated Communications EW Analysis and RF Sensor (ICEWARS) Technology Demonstration Program
- Development and demonstration of a 406 MHz traffic and interference Monitoring technology for SARSAT

International Interest

- U.S. Marines (TPCS Groundhog Systems)
- U.S. Army (Modulation recognition software)
- Aerosystems International has “leased” the SE for performing spectrum audits in developing countries (e.g., Caribbean communities, South Africa, India)
- High-level delegations have come for SE demos from a number of countries (e.g., Mexico, India, Jamaica)

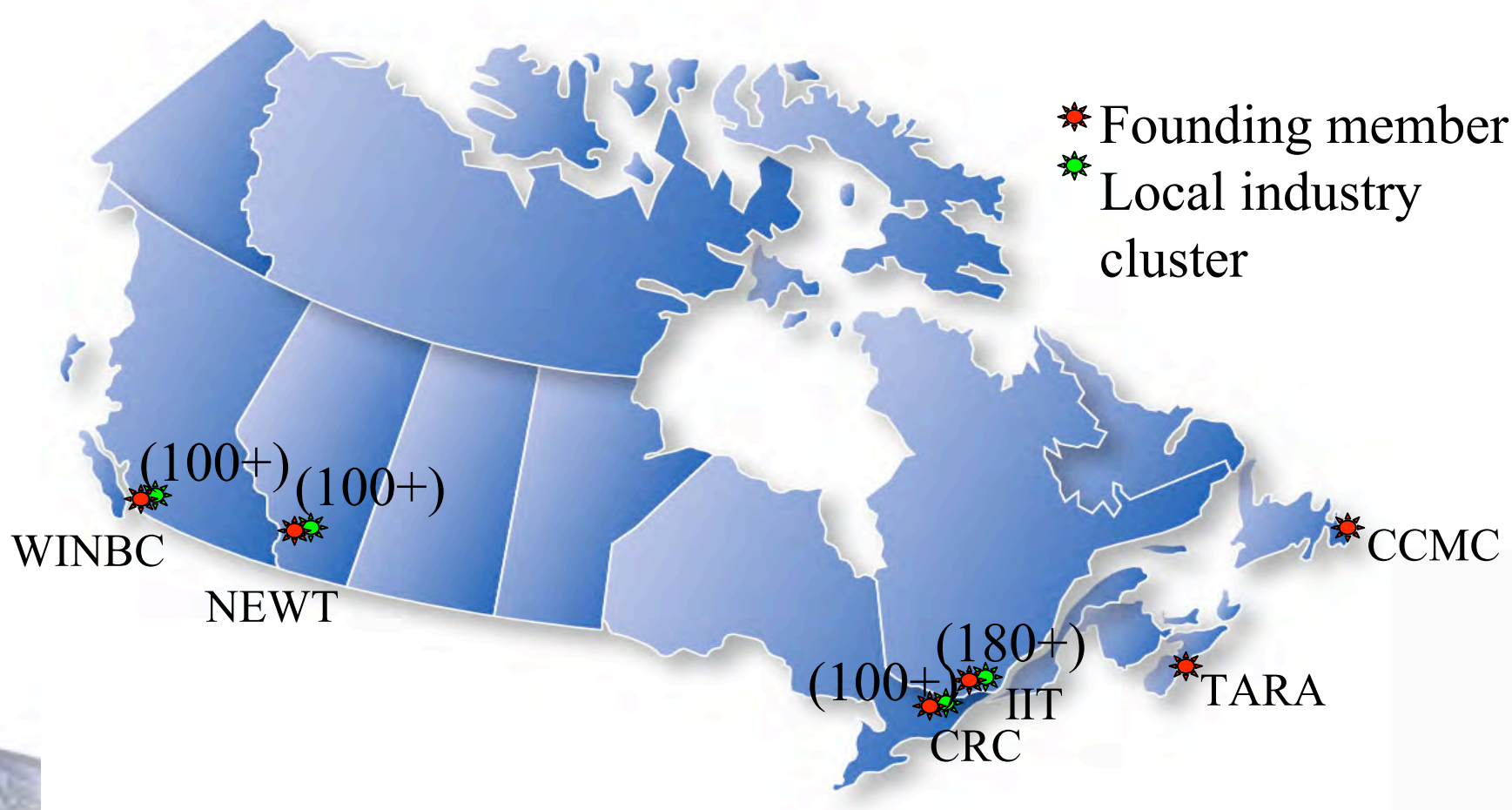
Commercialization

- CWCnet (Canadian Wireless Centre Network)
- Licencing
- Contracting-In
- Innovation Centre
- Over 100 companies were created due to either technologies or people from CRC

Other Examples of CRC Wireless Technologies Development for Commercialization

- Cognitive Radio/Software Defined Radio
- Turbo Codes
- Predict/CRC-COV
- Wireless Security
- Antenna Technologies

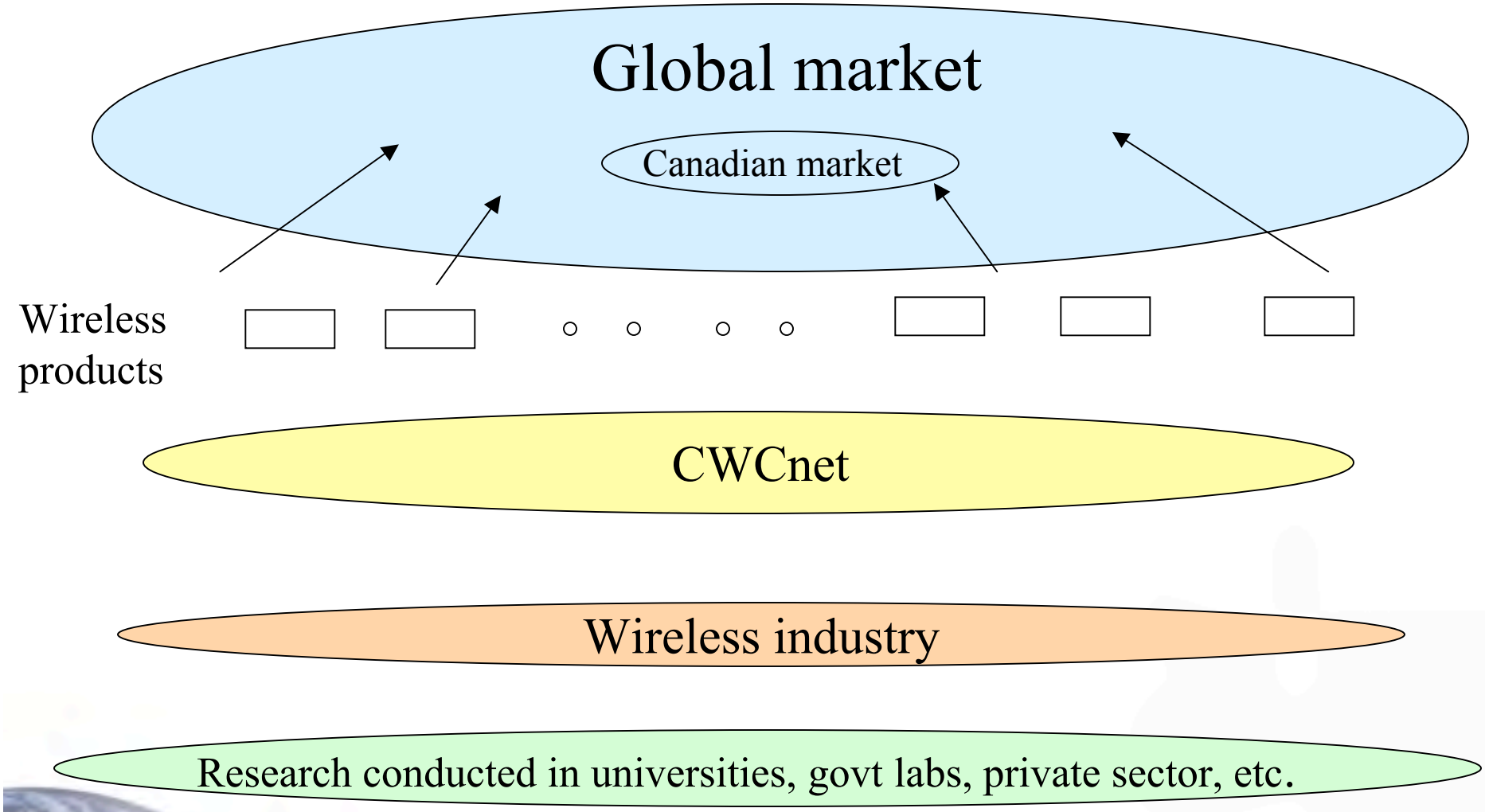
CWCnet Founding Members and industry clusters



CWCnet Objectives

- Strengthen support to SMEs on wireless testing infrastructure
- Fill the technology gaps in the Canadian wireless industry
- Foster commercialization of R&D
- Achieve National Coordination

Facilitating the Commercialization of Research into Products



Summary

- Outcome of CRC's R&D supports:
  - Policy, regulatory and standards development
  - Spectrum Management
  - Federal government programs
- CRC contributes to the commercialization by:
  - joint research collaboration
  - technology transfer
  - Access to our test-beds and facilities
  - Incubation Facilities
  - CWCnet

CRC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Myriad of Terrestrial Wireless Systems/Technologies

Bluetooth	Home RF	Wireless LAN	IEEE 802.xx	Military mobile systems

Sensor networks	Intelligent transportation systems	Ad hoc networks	Cellular radio

PDAs	PCS	2.5G systems	3G systems	4G systems	Free space optical systems

Trunked radio systems	Secured wireless systems	Location determination systems

Point to point systems	Point to multipoint systems	HF communications systems

Mesh networks	LMCS/LMDS	MCS	UWB	HAPS	BPL	Cognitive/SDR

New Technologies = New Challenges

- Next Generation Networks
- Voice Over IP
- Peer to Peer
- Integrated GPS
- WiFi / WiMAX
- Mesh Networks
- 3G and systems beyond
- Ultra Wide Band (UWB)
- Broadband Power Line (BPL)
- Software Defined Radio (SDR)
- Smart antennas
- RFID
- New Satellites
- Satellite Radio
- Digital Audio Broadcast
- DTV/HDTV
- Personal Video Recorder (PVR)
- Video On Demand (VOD)
- Grid Computing
- Quantum Computing
- Bio Computing
- Nanotechnology