COST289
Spectrum and Power Efficient Broadband Communications

PROGRESS REPORT

Period: 1 July 2003 to 30 June 2004

Web site: http://cost289.ee.hacettepe.edu.tr

TC-TIST & MC Chairpersons Meeting, 30 June - 2 July 2004, Bucharest, Romania

Outline

- Objectives and Benefits
- Status
- Working Groups
- Project Groups
  - Wide Area Coverage with High Mobility Access Systems for 4G
  - Pervasive Wireless Access for 4G
  - Software Defined Radio
- Seminar
- Dissemination Plan

Objectives

To increase the capacity of communication systems within a specified transmission bandwidth with minimum available transmitter power, bearing in mind the cost and the practical aspects of the system

Benefits

- Contribution to the realization of more spectrum- and power- efficient communication systems, i.e., higher capacity systems
  - The systems thus designed will contribute to the creation of an electromagnetically more clean environment
- High data rate services for customers with higher mobility to meet the new requirements

Management

- Chair:
  - Prof. Dr. Mehmet Şafak, Hacettepe University, Ankara, Turkey
- Vice-Chair:
  - Prof. Dr. Hermann Rohling, Technical University of Hamburg-Harburg, Germany
- Secretary:
  - Researcher Serap Haşimoğlu-Ertaş, Hacettepe University, Ankara, Turkey

Signatories

- Start date: 23 April 2003

  End date: 22 April 2007
- Signatories: 16

  Belgium, Bulgaria, Czech Republic, France, Germany, Greece, Hungary, Italy, Norway, Romania, Serbia and Montenegro, Slovakia, Spain, Sweden, Switzerland, Turkey
- Participating Organizations: 26

Management Committee Meetings

1. MCM: 24 March 2003, in Brussels
2. MCM: 3-4 July 2003, Hamburg
3. MCM: 30-31 October 2003, Kosice, Slovakia
4. MCM: 25-16 March 2004, Zurich, Switzerland
5. MCM and Seminar: 7-9 July 2004, Budapest, Hungary

Working Groups

- WG1: Information Theoretical Description of Radio Systems
  - Spectral and power efficiency
  - Channel capacity
  - User capacity
  - Coding
  - Modulation

Working Groups

- WG2: Communication Techniques and Systems
  - Adaptive transmission techniques (multicarrier systems, multiuser detection, adaptive modulation and coding)
  - Multiple access techniques
  - Multiple antenna systems
  - Adaptive/reconfigurable networks
  - Software defined radio

Project Groups

- The aim is to create synergy by coordinating the activities of different research groups, having expertise in similar areas, e.g.,
  - Channel coding
  - OFDM
  - CDMA
  - Multi-user detection
  - Multiple access techniques
  - MIMO systems

Project Groups

- Wide Area Coverage with High Mobility Access Systems for 4G
  - Centralized systems with high mobility, lower data rates and wider coverage areas
- Pervasive Wireless Access for 4G
  - Decentralized systems with low mobility, higher data rates and restricted coverage areas
- Software Defined Radio (SDR)
  - Bridges the two projects horizontally

How to Cooperate ?

- Minimum level of interaction
  - Use same requirements
  - Use same channel models for evaluation
  - Use same simulator?
  - Each partner works on his own solutions
- Higher level of interaction
  - Form a common solution based on partner proposals
  - Joint evaluations
  - Short term scientific missions (STSM)

How to Cooperate ?

- Each partner is informed about what others have done and starts to think about system solutions
- Sub-Working Group meetings, if necessary,
  - to define the system requirements, and
  - to cooperate and coordinate the research activities
- Separate sessions on future MCMs to discuss progress and give feedback
- STSMs for closer cooperation

How to Cooperate ?

- E-mail groups are already formed to establish close cooperation and coordination between researchers directly involved in the joint research projects:
  - cost289.wa@ee.hacettepe.edu.tr
  - cost289.pwa@ee.hacettepe.edu.tr
  - cost289.sdr@ee.hacettepe.edu.tr
- A separate web site for sharing documents.

Wide Area Coverage with High Mobility Access Systems for 4G

- Coordinator: Prof. Arne Svensson (Chalmers University of Technology)
- Participating organizations (10): Chalmers University of Technology, University of Florence, Ramonn Llull University, CEI-CETI, University Carlos III of Madrid, Hacettepe University, TU Kosice, Czech Academy of Science, Norwegian University of Science and Technology, DLR

Background

- Intense research efforts are currently ongoing towards the definition of physical layers for 4G systems.
- For the downlink, there are several proposals based on
  - OFDM transmission techniques, and
  - the combination of OFDM and CDMA

Background

- The recent parameters for the downlink include (used by DoCoMo)
  - Available downlink bandwidth is 100 MHz
  - Carrier frequency around 5 GHz
  - Maximum speed is 250 km/h
- The downlink design is simpler than the uplink design, since it is all about multiplexing within each cell.
  - Nevertheless, there are still some open areas to study in the downlink design

Background

- In the uplink, the situation is more complicated,
  - since a combination of multiplexing and multiple access takes place in each terminal when more than one service is transmitted at the same time.
- The uplink is also normally asynchronous and oscillators in different terminals are not synchronized.

Background

- This may suggest that OFDM can not be used due to its sensitivity to frequency synchronization errors.
- It may be more difficult to use channel state information in a transmitter in the uplink at least in FDD systems, due to increased overhead.
- The motivation: The partners are expected to develop jointly the uplink solutions for 4G.

Background

- Some work towards specifying 4G:
  - DoCoMo has proposed a system
    - Variable spreading factor-orthogonal frequency and code division multiplexing (VSF-OFCDM) in downlink
    - Variable spreading and chip repetition factors (VSCRF)-CDMA in uplink
  - A Swedish project has proposed a downlink
    - Channel prediction, OFDM, adaptive modulation, scheduling
  - EU project Winner started on January 1, 2004

Proposed project

- The uplink parameters (also used by DoCoMo)
  - Wide area coverage (cell of similar size as 3G)
  - High mobility < 250 km/h
  - Carrier frequency around 5 GHz
  - Available uplink bandwidth 40 MHz
  - ITU requires 100 Mbps (is this possible in 40 MHz bandwidth?)
  - Multiple cell system
  - UMTS channel models

Pervasive Wireless Access for 4G

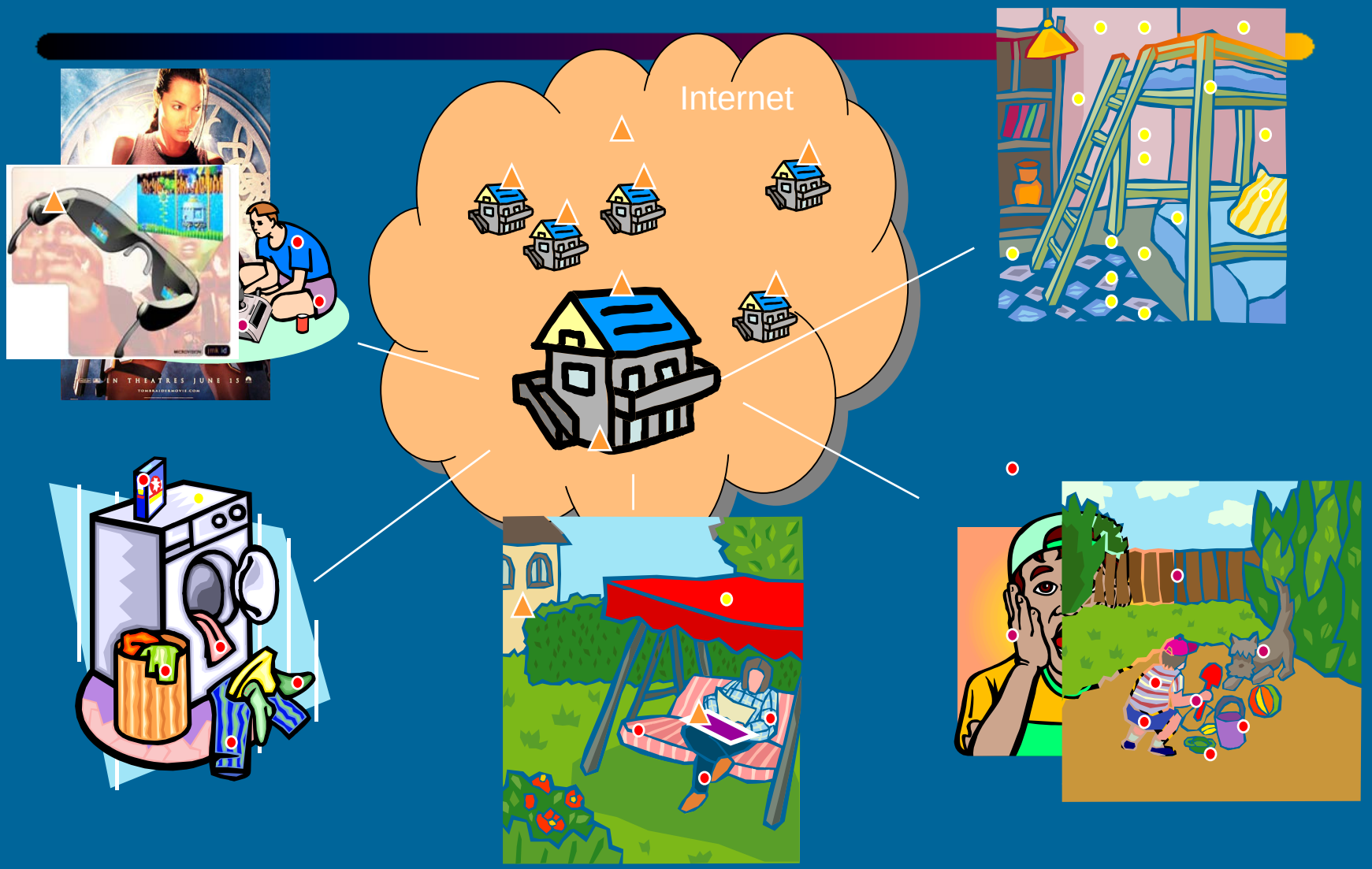
- Coordinator: Prof. Armin Wittneben, ETH Zurich
- Participating Organizations (6): ETH Zurich, Hacettepe University, Norwegian University of Science and Technology, University of Ulm, Budapest University of Technology and Economics, University Carlos III of Madrid

Pervasive Wireless Access for 4G

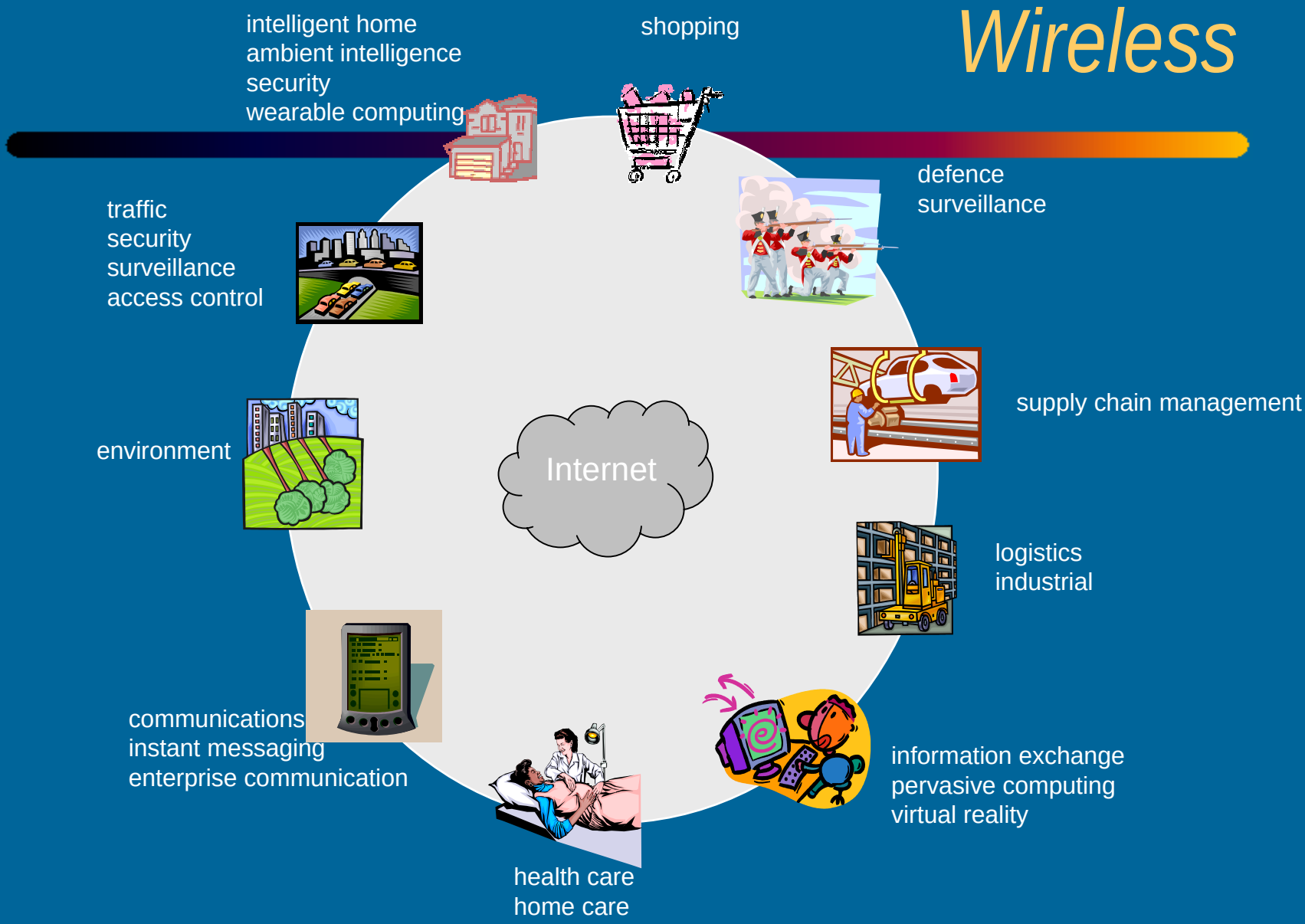
- Pervasive wireless access networks imply next generation WLANs that will provide ubiquitous connectivity
  - for a variety of heterogeneous nodes, e.g., RFID tags for object identification, sensors and computers,

  with data rate requirements ranging from 1 Mbps to 1 Gbps.
- We foresee high node density and low node mobility

Pervasive Wireless Access: Home Scenario



More Applications of Pervasive Wireless



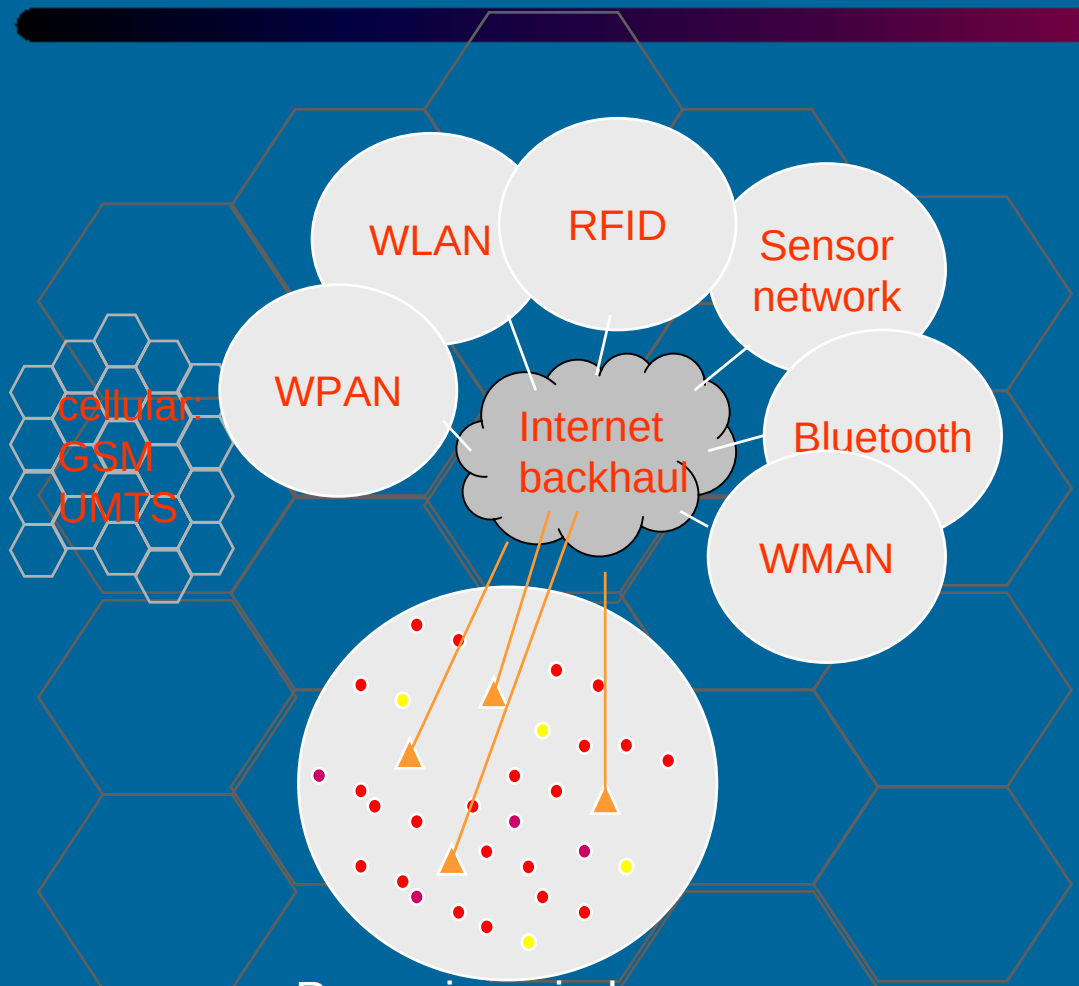
Pervasive Wireless Access for 4G

- For spectral reasons, the next generation WLANs will operate beyond 5 GHz, e.g., 17/24 GHz ISM bands.
- In the 17/24 GHz ISM bands, we face a poor scattering/rich array situation as opposed to the rich scattering/poor array situation at 5 GHz.

Pervasive Wireless Access for 4G

- Pervasive wireless access networks will exploit
  - Cooperative signalling, which has a potential to benefit from spatial multiplexing in poor scattering channels.
  - adaptive modulation and spatial multiplexing (MIMO) for scalability and spectral efficiency
  - adaptive scheduling to meet heterogeneous QoS requirements

Pervasive Wireless Access Networks



Heterogeneous nodes

- RFID tags, readers
- sensors, actors
- communication appliances
- information access
- information processing
- backhaul access points
- ...

Heterogeneous standards

- IEEE 802.11 WLAN
- IEEE 802.15 WPAN
- IEEE 802.16 WMAN
- (Hiperlan)
- Bluetooth
- DECT
- various RFID
- ..

Lots of spectrum (approx.)

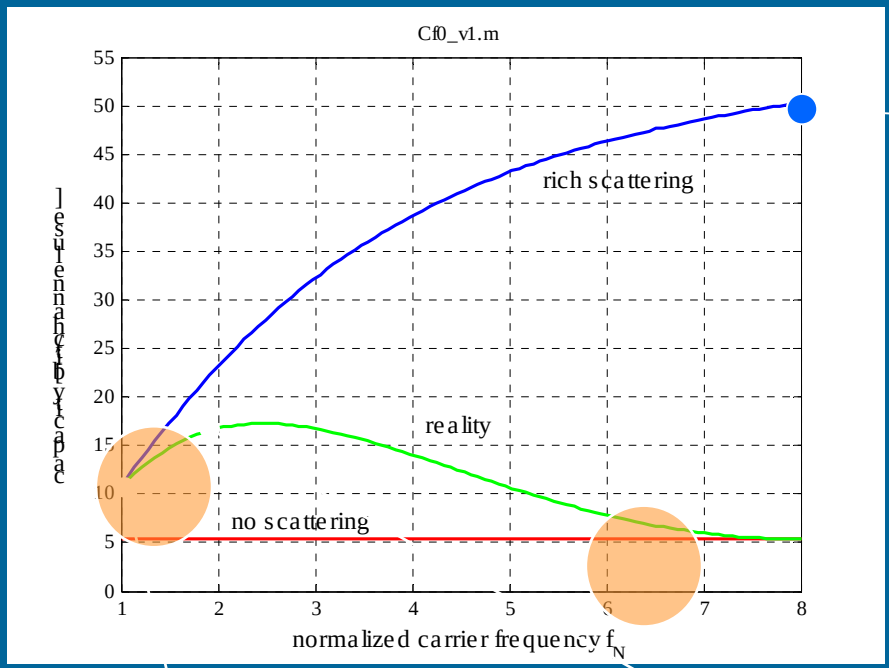
- 100MHz@2.45GHz (ISM)
- 150MHz@5.8GHz (ISM)
- 200MHz@17.2GHz (ISM)
- 250MHz@24.125GHz (ISM)
- >3GHz@5GHz (UWB)
- ..

Pervasive Wireless Access for 4G

- Motivation: To open up the benefits of
  - cooperative diversity,
  - channel adaptive scheduling, and
  - spatial multiplexing (MIMO)

  in a low mobility environment with
  - poor scattering, and
  - heterogeneous nodes.

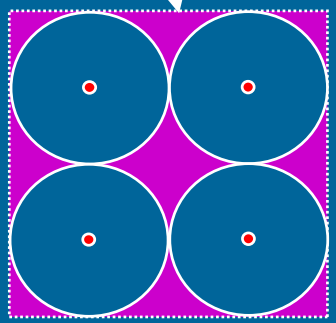
Rich Array/Poor Scattering Paradigm

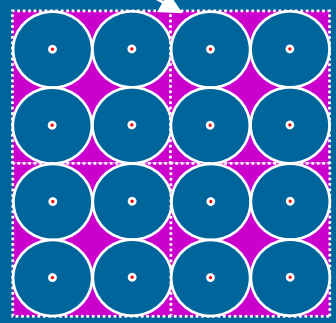


would require > 256 relevant scatterers

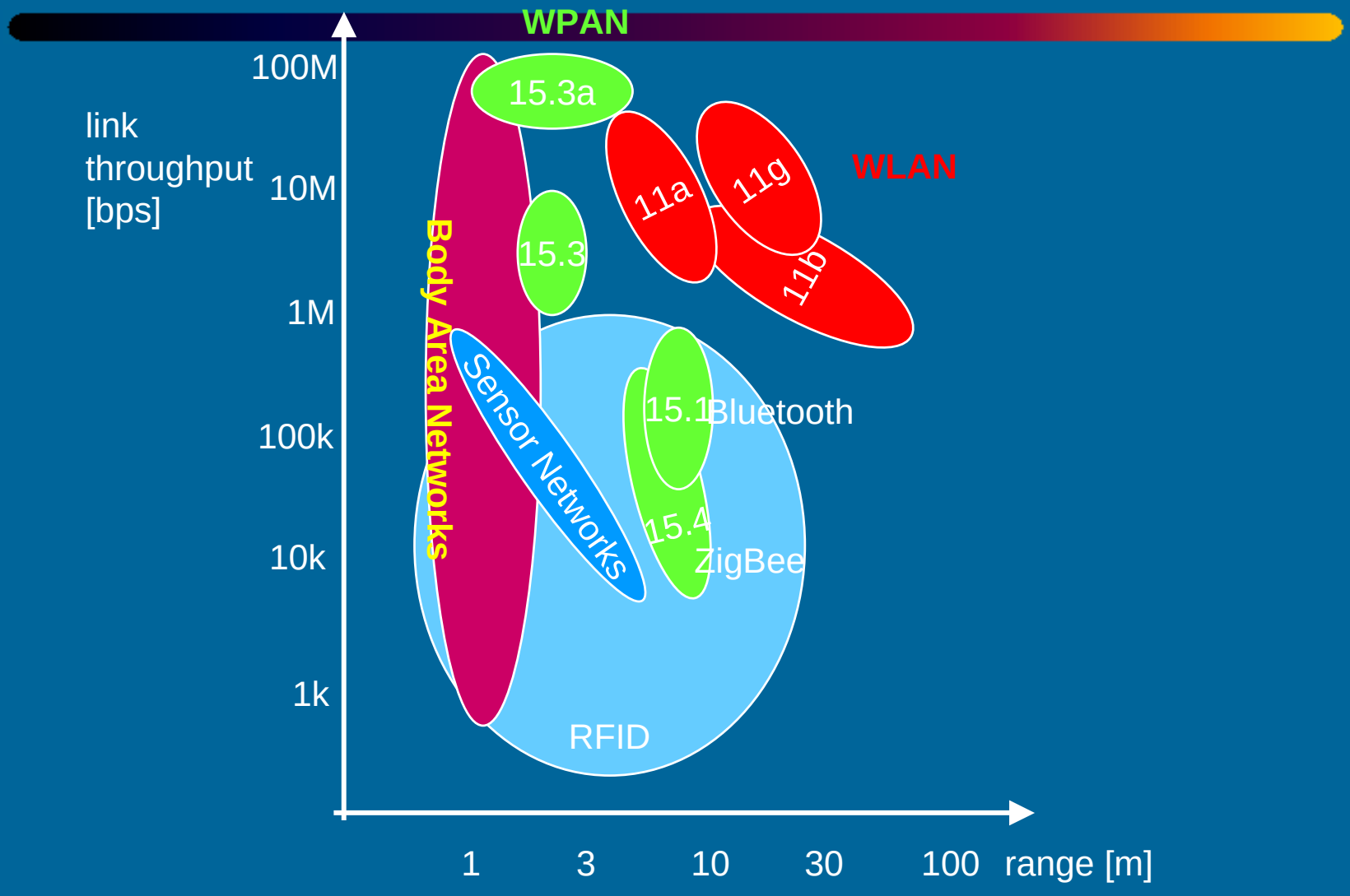
rich scattering ⟺ poor array

poor scattering ⟺ rich array

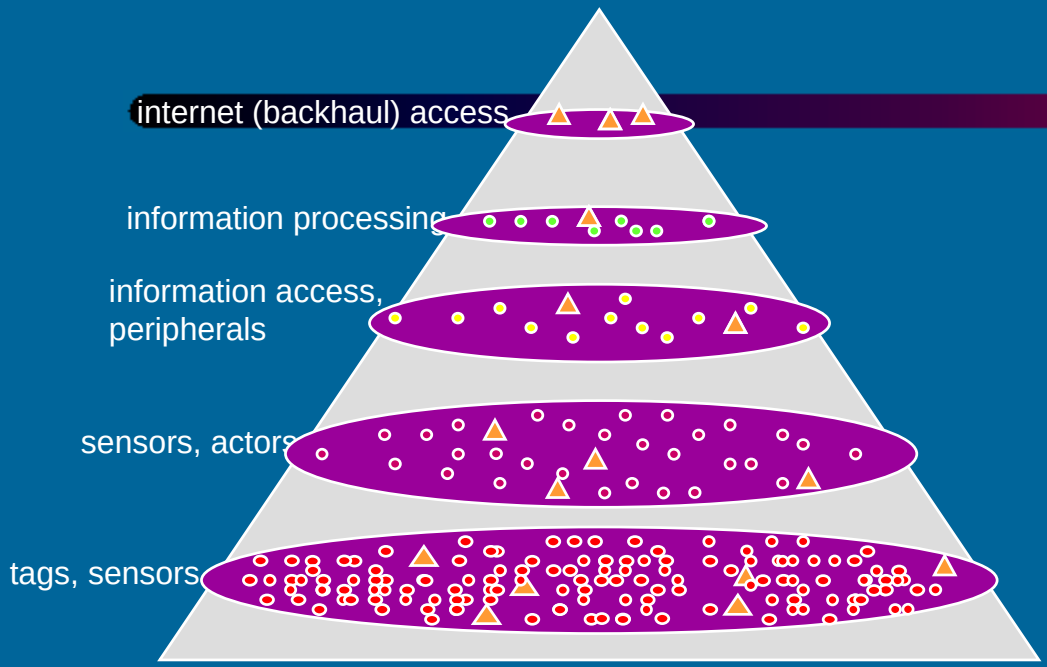




Some Existing/Upcoming Wireless Access Systems



Hierarchical Heterogeneous Nodes



Network characteristics
- hierarchical nodes
- node density
- „spot coverage“
- uncoordinated, unlicensed „ad hoc“ infrastructure

Design objectives
- data rate, QoS
- range
- position location
- low cost
- low EM exposure

Existing systems designs are insufficient
- designed for coexistance (at best)
- do not exploit potential of node cooperation in heterogeneous environment

No need for a unified air interface,
- rather a common set of parameters that facilitates cooperation

Important Work Items within COST 289

- Information theoretic and Layer 1-3 aspects of Pervasive Wireless Access:
  - principal performance bounds
  - signal processing and channel estimation for “huge” channel matrices
  - efficient utilization of partial channel state information at the source

Important Work Items within COST 289

- adaptive distributed space-time processing
- adaptive modulation in cooperative wireless networks
- adaptive scheduling in cooperative wireless networks
- cooperative multiple access
- Multihop / multinode forwarding

SDR

- Software Defined Radio (SDR) :
  - Coordinator: Prof. Sandor Imre, Budapest University of Technology and Economics
  - Participating Organizations (4): Budapest University of Technology and Economics, University Carlos III of Madrid, Ramon Llull University, Politechnical University of Catalunya

SDR

- Inter-system roaming and handover (e.g. due to traveling or multiple coverage) would require implementation of many different standards in a single radio terminal/base station.
- Reconfigurable equipment with universal hardware and downloaded software can solve the problem efficiently.
- Easier and cost-efficient system upgrades.
- Efficient design of reconfigurable radios.

SDR

- The efforts can be focused in
  - the physical layer organization (DSP-type or INTEL-type philosophies)
  - downloading and reconfiguration algorithms and protocols
  - Specific hardware architectures that allows, e.g.,
    - reconfiguration with a minimum power consumption penalty
    - dynamic adaptation to the variations in user traffic

SDR

- Experiences that partially implement multiple standards as GSM, EDGE, WCDMA-FDD, Bluetooth using some strategies on any platform

Seminar

- The aim is to improve the background knowledge of young researchers directly involved in the joint research projects
- To be held in Budapest during 7-9 July 2004.
- Invited speakers:
  - Prof. L. Hanzo, Southampton University
  - Dr. H. Atarashi, DoCoMo, Japan
- Student papers:
  - Approximately 15-20 papers are expected on the three joint research projects

Dissemination Plan

- Two seminars will be organised
- An e-mail network is already established
- The web site of the Action is used
  - for communication within the Action
  - to convey aims and objectives to scientific community
  - to disseminate the results and developments
  - to advertise important activities
  - for accessing the publications of the Action members