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Symbiotic networks

Benoît Latré, Eli De Poorter, Ingrid Moerman, Piet Demeester

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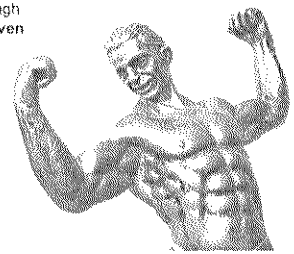
Interdisciplinary Institute for Broadband Technology

IBBT is an independent research institute, that performs multidisciplinary research on ICT

IBBT has as mission to form highly competent human capital through **interdisciplinary demand driven research** focused on **ICT and broadband services** in cooperation with industry and government.



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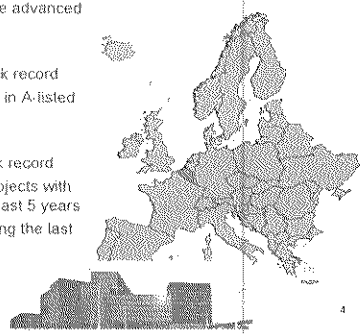
IBBT bundles the ICT knowledge in the Flemish region

Critical mass to enable advanced research
- 600+ researchers

Proven academic track record
- 400+ publications in A-listed magazines
- Several patents

Proven business track record
- 150+ research projects with industry over the last 5 years
- 20+ spin-offs during the last 5 years



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IBBT research groups and competence clusters

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Research groups	regulation	user	content	network	terminal
UA PATS - C. Blondia					
VUB ETRO - J. Cornelis					
UG MICT - E. De Bens					
KUL CUO - D. De Grooff					
UG IBCN - P. Demeester					
KUL ICRI - J. Dumortier					
UH EDM - E. Flerackers					
IMEC DESICS - R. Lauwereins					
UG WiCa - L. Martens					
VUB SMIT - C. Pauwels					
KUL COSIC - B. Preneel					
VRT R&D - H. Sorgeloos					
UG MMLab - R. Van de Walle					
KUL DISTRINET - P. Verbaeten					

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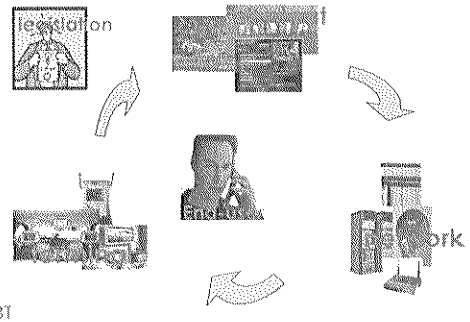
Interdisciplinary research



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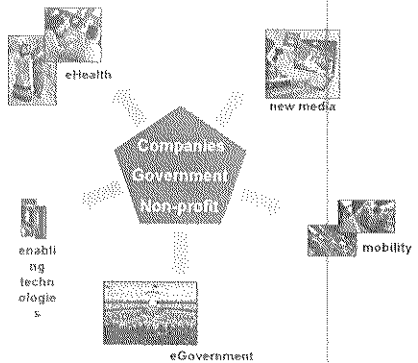
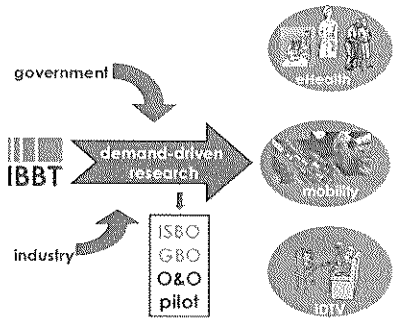
Demand-driven basic research in selected application domains



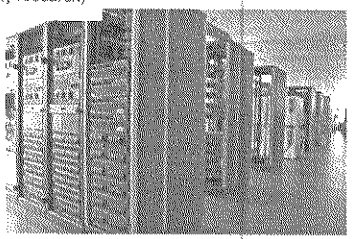
Demand-driven research



IBBT Partners

iLab: infrastructure for demand driven ICT research

- iLab Gent
  - technological lab infrastructure for ICT services of the futures (e.g. sensor networks, grid computing ...)
- iLab Leuven
  - Usability research (Center for Usability research)
- iLab Brussels
  - Policy support on open innovation



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Symbiotic networks

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State of the art

- Collaboration of different wireless networks
  - Cognitive networking
  - Opportunistic networking
  - Cooperative networking
- Main goal
  - mprove the energy efficiency and reliability
- Focus on the physical (& MAC) layer
- All within the same network

State of the art

- Cognitive networks
  - cognitive radio
  - avoid interference by spectrum sensing

- Opportunistic networks
  - limited cooperation
  - use node that is available at time of transmission
  - no end-to-end connectivity
  - examples
    - delay tolerant networks
    - replication of packets

State of the art

- Cooperative networking
  - Cooperative diversity
    - PHY layer: antenna diversity
  - Cooperative MAC
    - Cooperative transmission to lower total transmissions time
  - Cooperative routing
    - Relaying for increased network resilience

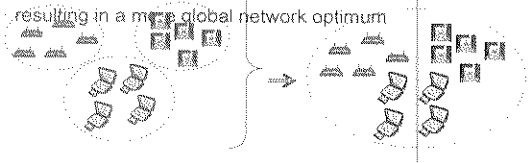
Extending the current research …

- Taking cooperation to a new level
  - exchanging information
  - sharing of resources
  - sharing of infrastructure
  - sharing of code
  - → **induces new functionality in the network**

- Support the merging of wireless networks
  - of the same technology
  - of different technology
    - need for nodes which support multiple technologies
  - over all layers (ranging from physical to application)

Symbiotic network: Definition

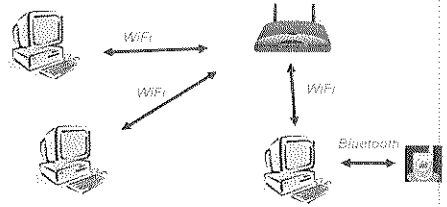
- two or more wireless networks that can fully function on their own
- share or merge their resources & services with each other
- and cooperate over all layers! (not only PHY-layer)
- hereby inducing new functionality in network
- resulting in a more global network optimum



Examples (1): Bluetooth + WiFi

- Currently, Bluetooth is a wire-replacement
- By connecting to a WiFi, longer ranges can be crossed

→ Relaying over heterogeneous technologies



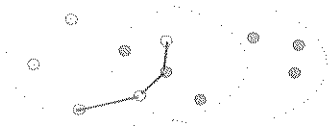
Examples (2) : WiFi & WSN

- Sensor network provides interference information for the WiFi nodes
- WiFi nodes provide relay services and localization information

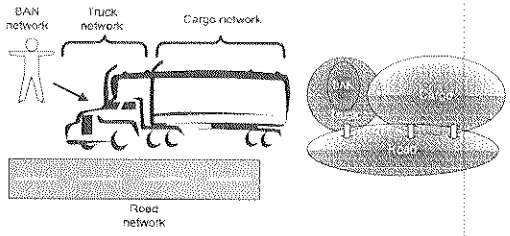
Examples (3) : WSN & WSN

In a home environment, several sensor networks will be installed (security, heating, …)

These networks can use each others nodes for routing purposes



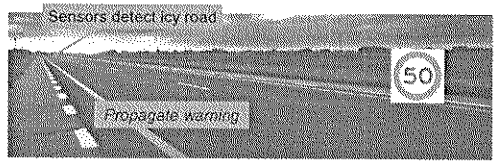
Examples (4) - BAN & truck



- Other example: BAN + Ambulance

Examples (5): Vehicle communication

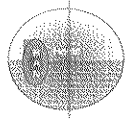
- Vehicle to road (intelligent roads)
  - electronic toll collection
  - real time information (traffic signals, work zone,…)
- Vehicle to vehicle communication
  - propagate warnings (lane changes, precrash,…)
- Can lead to "Fully Automated Vehicles"



Examples (6): Home/Public services

Home WSN/Fire department/Law enforcement

- Fire department / law enforcement
  - BAN
  - HUD (Heads Up Display)
- Home WSN
  - HVAC
  - Security
  - Lighting etc..
- When merged:
  - Home WSN:
    - Send log file to fire fighters
  - Fire fighters
    - Unlock doors
    - Find trapped persons
    - Use home network for communication, positioning, …



Other example: Home/eHealth services

General challenges

- Extreme fast network/service discovery
  - E.g.: bike detection next to a truck
- Security and authentication
- Design of middleware
- Localization
- Translation of QoS
- Address translation
- Uninterrupted service when symbiotic networks disconnect
- Exchange of code

DiNS

- Solution: DiNS
  - Phase 1: Distributed Network Discovery
  - Phase 2: Network Binding
  - Phase 3: Service Discovery

DiNS

Solution: DiNS
- Phase 1: Distributed Network Discovery

Task
- Detect other networks to cooperate with

Challenges
- Which networks to detect?
- Which nodes to use for the detection?
- How to detect hopping / UWB / OFDM / CDMA networks?
  - scanning network channels takes a long time!
  - e.g. Zigbee: max 16 channels x 256 seconds BI
- Role of software defined radios?
- Role of gateways?

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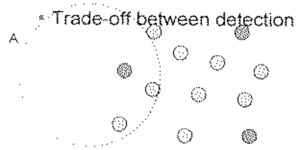
DiNS

Solution: DiNS
- Phase 1: Distributed Network Discovery

Example: which node scans which frequency?
- Trade-off between detection reliability and energy cost

How to detect network A?



e.g.: only 3 nodes have to scan for network A to have full coverage

→ avoid redundant scanning

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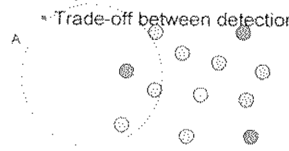
DiNS

Solution: DiNS
- Phase 1: Distributed Network Discovery

Example: which node scans which frequency?
- Trade-off between detection reliability and energy cost

How to detect network A?



e.g.: but to detect the network in time, more nodes can be used

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DiNS

Solution: DiNS
- Phase 2: Network Binding

Task
- Matching of communication characteristics

Challenges
- Exchange of network parameters
- Exchange of security and authentication codes
- Match network characteristics (frequency, hopping sequence, ...)
- Share infrastructure
- Updating the network protocols with new information (routing, QoS, ...)
- Exchange of code (different routing protocols,...)

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DiNS

Solution: DiNS
- Phase 3: Service Discovery

Task
- Automatic discovery of ***services***
  - Information (position, time, temperature, ...)
  - Resources (computing nodes, memory capacity, ...)
  - Software (updates, new functionality, ...)

Challenges
- Authentication
- How to identify services
- Restriction of networks which can use a service
- Support for relaying services

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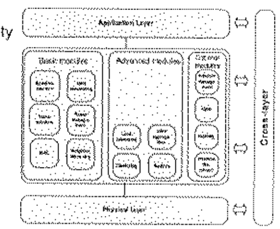
DiNS

Use modular framework to exchange code
- Easy to exchange and addition of modules
  - E.g. routing
- Easy to add new functionality to a node



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Conclusion

Symbiotic networks is the logical next step in the collaboration of wireless networks

- Current:
  - Many projects already make use of cooperation
  - No standardized method exists for the exchange of information or the discovery of services.
- Future:
  - Many networks can profit from the sharing of infrastructure, resources and code.
  - Increased energy efficiency and reliability
  - More efficient use of scarce spectral resources

15.30-16.00	Coffee Break
16.00-18.00	**Panel Discussion: Disruptiveness : IMT–A System and Network Aspect**
	Moderator: Juha Saarnio, Nokia, Finland
	Panellists: Laurent Herault, CEA-LETI, France
	Ignas Niemegeers, Delft University of Technology, The Netherlands
	Gregory Yovanof, Intracom Telecom/Athens Information Technology – AIT, , Greece
18.15	**Surprise Sight Seeing**
21.00	**Gala Dinner**

Friday June 1, 2007

09.30-11.00	**Session III: IMT-A: Network**
	Chairperson: Ole Brun Madsen, CTIF, Denmark
09.30-10.15	**Heterogeneous Networks - New Approaches Towards A Future Mobile Internet World**: Norbert Niebert, Ericsson, Germany
10.15-11.00	**Symbiotic Networks:** Ingrid Moerman, IBBT - Ghent University, Belgium
11.00-11.30	Coffee Break
11.30-12.30	**Special Session**
	IMT-A: Is There A Role For Communication And Navigation Satellites?: Enrico Saggese, Finmeccanica, Italy
12.30-13.00	**Concluding Remarks**
	Ramjee Prasad, CTIF, Aalborg University, Denmark / Marina Ruggieri, CTIF Italy, University of Rome "Tor Vergata", Italy
13.00	Lunch
	Departure

Final Programme

Center for Teleinfrastructure, CTIF
Aalborg University, Denmark

University of Rome "Tor Vergata"
Rome, Italy

Ninth Strategic Workshop (SW'07) May 30-June 1, 2007

INTERNATIONAL MOBILE TELECOMMUNICATIONS-ADVANCED (IMT-A): DISRUPTIVENESS??

Hotel Meliá Costa del Sol

Paseo Maritimo, 11 - Playa del Bajondillo, 29620 Torremolinos – Málaga, Spain
Tel: + 34 95 238 66 77; Fax: +34 95 238 64 17; E-mail: melia.costasol@solmelia.com

Wednesday May 30, 2007

20.00	**Informal dinner discussions**

Thursday May 31 , 2007

08.00	**Registration**
08.45-09.00	Welcome and Introduction: Ramjee Prasad, CTIF, Aalborg University, Denmark
09.00-10.30	**Session I:IMT-A: Technology and Management**
	Session Chair: Walter Weigel, ETSI, France
09.00-09.45	**Enabling Technology for IMT-A** : Shuzo Kato, NICT, Japan
09.45-10.30	**Identity Management for IMT-A:** Amardeo Sarma, NEC, Germany
10.30-11.00	Coffee Break
11.00-13.00	**Panel Discussion:Disruptiveness:IMT-A in General**
	Moderator: Jorma Lilleberg, Nokia, Finland
	Panellists: Erik Fledderus, TNO, The Netherlands
	Sunil Sherlekar, Tata Consultancy Services, India
	Mari Carmen Aguayo-Torres, University of Malaga, Spain
13.00-14.00	Lunch
14.00-15.30	**Session II : IMT-A Systems and Scenarios**
	Session Chair: Marina Ruggieri, CTIF Italy,University of Rome "Tor Vergata", Italy
14.00-14.45	**Scenarios On Context Capturing And New Services Through Wireless Sensor Networks**: Rui Aguiar, University of Aveiro, Portugal
14.45-15.30	**Cooperative and Opportunistic Communication:** Behnaam Aazhang, CWC, Oulu, Finland / CMC Rice, USA

Proceedings

9TH STRATEGIC WORKSHOP 2007

International Mobile Telecommunications—Advanced: Disruptiveness??

MAY 30—JUNE 1, 2007

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