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Global Routing in Heterogeneous Wired/Wireless Ecosystems

IBBT — UNIVERSITEIT GENT

11th Strategic Workshop (SW'09)
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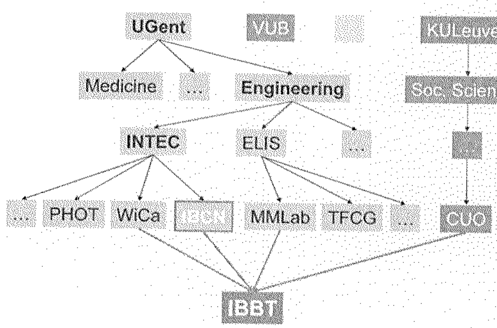
IBBT

- Interdisciplinary Institute for Broadband Technology
- Research institute
- Funded by Flemish government
- R&D support for companies and organizations
- multi-disciplinary demand-driven research
- Central staff
- 600+ researchers (mainly at universities)

IBBT and Ghent University



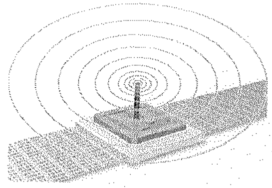
Overview

- Motivation
  - Wireless research @ IBCN
  - DEUS project
- Global Routing
  - general
  - short term
  - long term
- Conclusion

Motivation

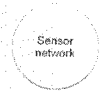
Wireless research @ IBCN

- Fast Mobile Users
- Fixed Mobile Convergence
- Wireless Mesh Networks (WMN)
- Wireless Sensor Networks (WSN)
- Intelligent Transport Systems
- Virtual Private Ad Hoc Networks

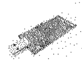


Motivation

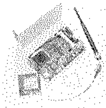
WSN vs. WMN

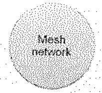


- Sensor nodes
  - cheap
  - limited capabilities
  - sensors and actuators



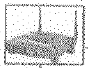
- Meshed nodes
  - relatively expensive
  - relatively powerful
  - wireless and wired





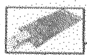
Motivation

WSN vs. WMN: research focus



Wireless Mesh

- multi hop infrastructure
- 'unlimited' energy
- high bandwidth
- low delay
- mainly IEEE 802.11 based
- provide connectivity



Wireless Sensor

- networked, multi-hop
- low energy
- small code size
- 'no legacy'
- mainly IEEE 802.15.4 based
- provide connectivity AND source of data

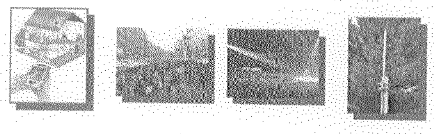
Motivation > DEUS

DEUS project

Deployment and Easy Use of wireless Services

GOAL: *to develop wireless network solutions & service architectures for easy deployment of wireless network infrastructures and easy set-up of location-aware services in dynamic environments*

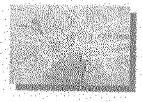
some Industrial partners: Alcatel Lucent, OneAccess, TeleAtlas



Motivation > DEUS

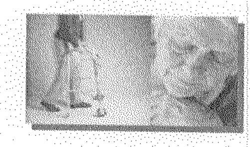
Application domains

- Cultural events
  - dynamic setting
  - location-aware and profile-based services
    - virtual museum
    - tracking/guiding of persons



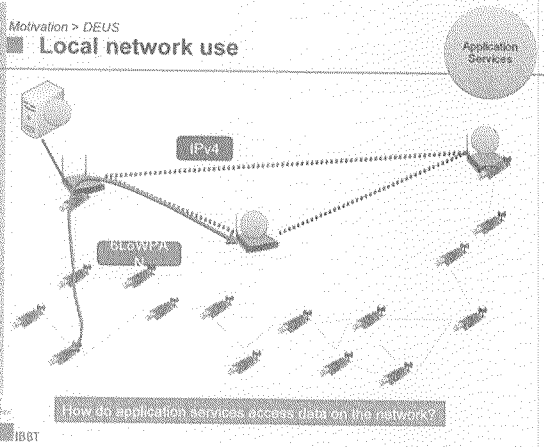
- Guiding of persons in and around public areas
  - using cheap wireless technologies

- Senior mobility support
  - Tracking & identification of persons
  - Emergency button



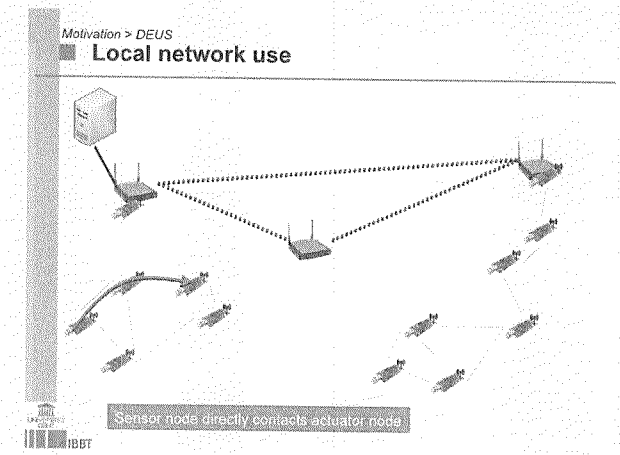
Motivation > DEUS

Local network use



Motivation > DEUS

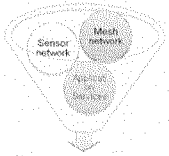
Local network use



Motivation > DEUS

WSN, WMN and...

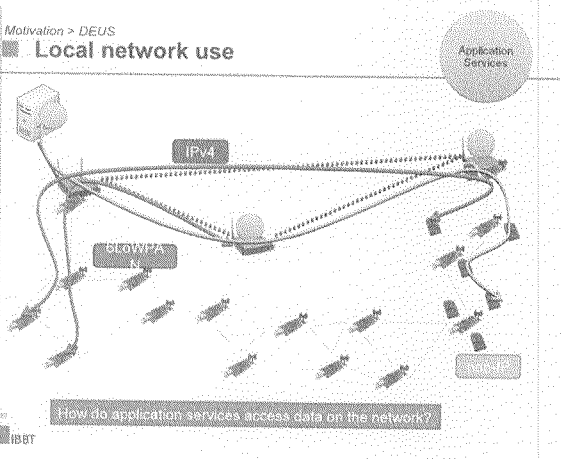
- Application Services
  - management and data
  - distributed
  - reasoning techniques
  - requires addressable nodes
    - accessible anywhere, not by anyone



Integrated solution

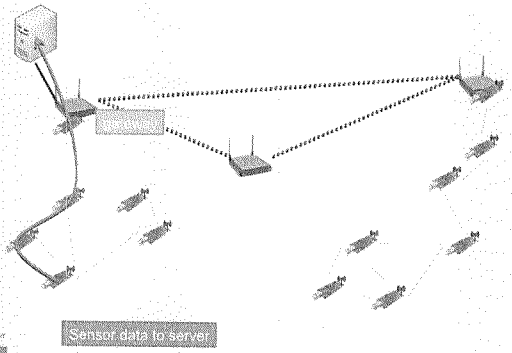
Motivation > DEUS

Local network use



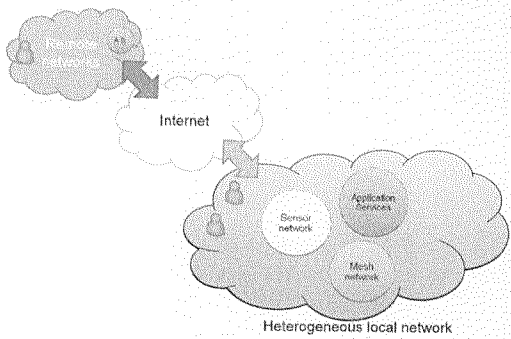
Motivation > DEUS

Local network use



Motivation > DEUS

DEUS project architecture



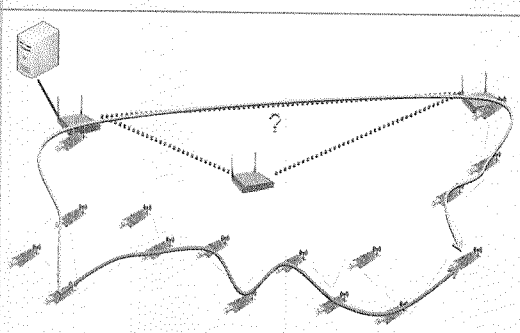
Heterogeneous local network

Overview

- Motivation
- Global Routing
  - general
  - short term
  - long term
- Conclusion

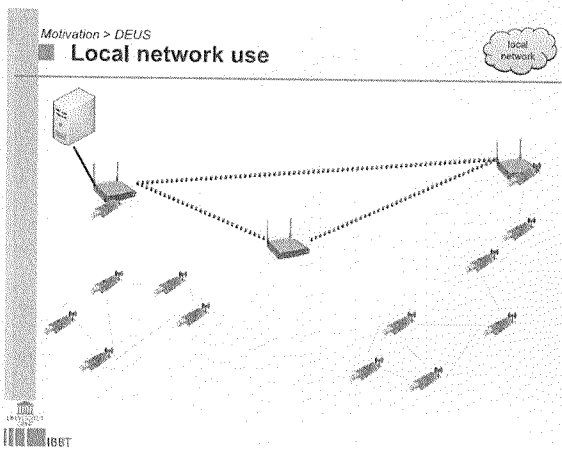
Motivation > DEUS

Local network use



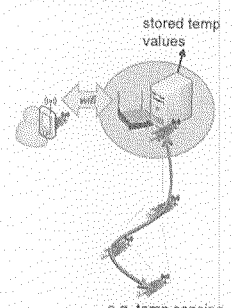
Motivation > DEUS

Local network use



Why not use a standard gateway solution?

- multi interface node
- algorithms
  - conversion
  - access control
- drawbacks:
  - single entry point
  - managed by administrator
  - static configuration
  - planned



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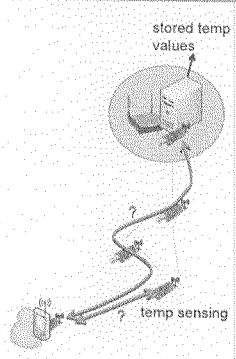

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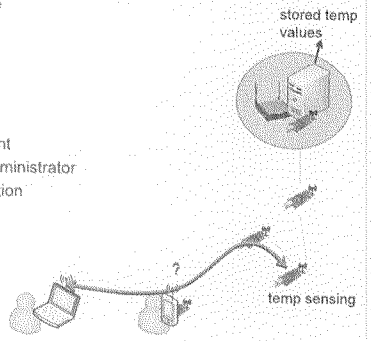


Global Routing (2)...

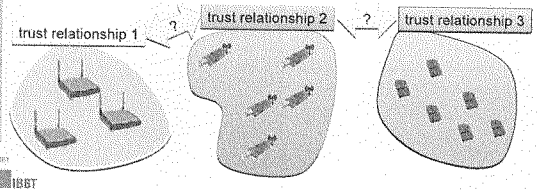
- ... in wired/wireless ecosystems:

Global routing in wired/wireless ecosystems ensures optimal internetworking of heterogeneous devices, situated in both local and remote networks.

FOCUS:
(1) easy-to use, auto configuring
(2) enable end-to-end services across heterogeneous devices
(3) secure internetworking

Challenges (1)

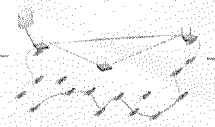
- differences in (radio) technology
  - interference
- differences in addressing schemes
  - IPv4 – IPv6 / 6LoWPAN
  - non IP
- differences in routing strategies
- security and trust



Challenges (2)

- Backward compatibility
  - re-use of existing protocols
  - re-use of existing infrastructure
- 'Clean slate' design?
- need for end to end connectivity
  - enable advanced services
- metric translation
- Scalability

Global Routing (1)...

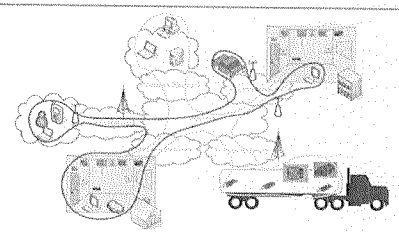


- ... in the context of DEUS project:

How to enable the use of the wireless (IEEE 802.11b/g/n) mesh backbone by the wireless (IEEE 802.15.4) sensor network, in a transparant way, ensuring optimal routes throughout the entire (local) network?

GOALS:
(1) use the available bandwidth in the wireless mesh
(2) reduce power usage in sensor network
(3) decrease delay (caused by sleeping schemes)

Evolution...



- larger networks: environment of *'networked objects'*
  - any wired / wireless device
  - local or remote (virtual environment)
- long term and temporary trust relationships
  - dynamic network
  - shielded and secured (independent)

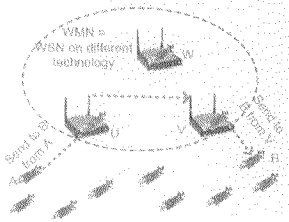
Evolution...

- managed environment
  - flexible creation
  - transfer and sharing of devices
- objects exist in harmony
  - self-organizing, self-management
  - cooperate toward common goal (interdependent)

An ecosystem is a completely independent, managed, virtual environment of interdependent, networked objects that cooperate in harmony.

option 5: Dual stack

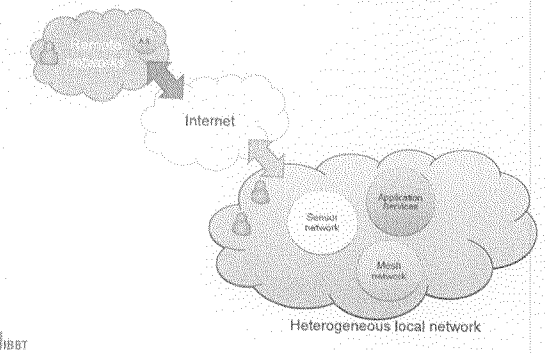
- Special designed mesh nodes run virtual sensor stack
- Sensor protocols, using a mesh link
- Not compatible with existing mesh network technologies



Overview

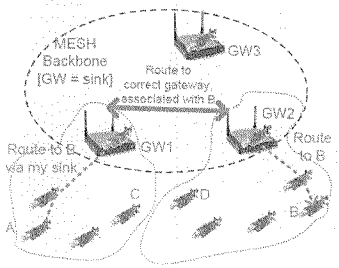
- Motivation
- Global Routing
  - general
  - short term
  - long term: global routing in ecosystems
    - what, and how to get there?
- Conclusion

Long term



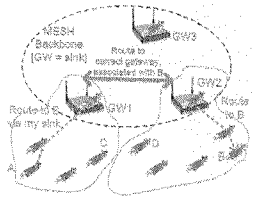
option 3: Termination Gateway (1)

- Two tier architecture
- Sensor paths are terminated at gateway



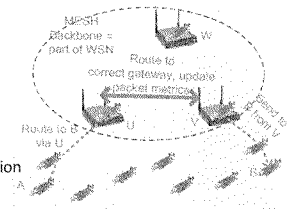
option 3: Termination Gateway (2)

- Pro
  - optimal routing possible
    - query gateway
  - more scalable
- Consequences
  - forwarding protocol in mesh
  - metric translation
- Con
  - sensor protocol redesign
  - mobility



option 4: Translation gateway

- 'translate' all packets at gateway
  - PHY translation
  - metric translation
  - address translation
  - packet translation
- no explicit hierarchy
- Pro
  - WSN <-> WMN communication
  - compatibility
  - native optimal routing
- Con
  - often impossible (only for similar protocols)
  - scalability

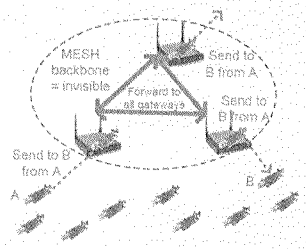


Overview

- Motivation
- Global Routing
  - general
  - short term: "How can the WSN use the WMN?"
    - Repeater backbone
    - Supernode
    - Termination Gateway
    - Translation Gateway
    - Dual Stack
  - long term
- Conclusion

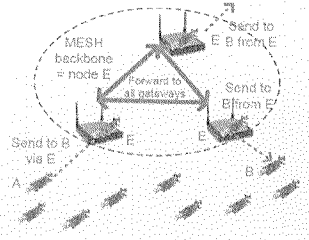
option 1: Repeater backbone

- mesh nodes blindly forward sensor data
- enables sensor-over-mesh traffic
- 'invisible repeater'
- Pro
  - simple
  - full transparency
- Con:
  - scalability
  - duplicates
  - sleeping schemes
  - multi channel sensor protocols

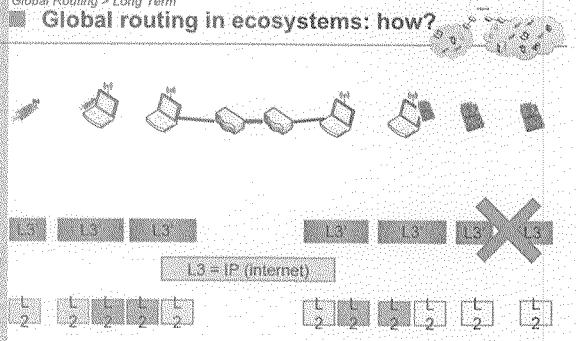


option 2: Supernode

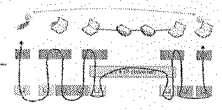
- 'intelligent' sensor interface at gateway
- 'common state'
- supernode *E*
- Pro:
  - enables synchronization
- Con:
  - scalability
  - duplicates



Global routing in ecosystems: how?

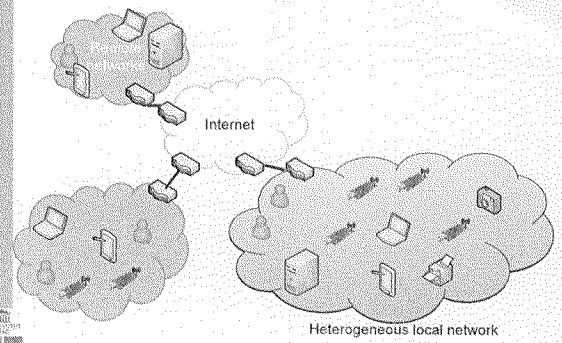


Stack view

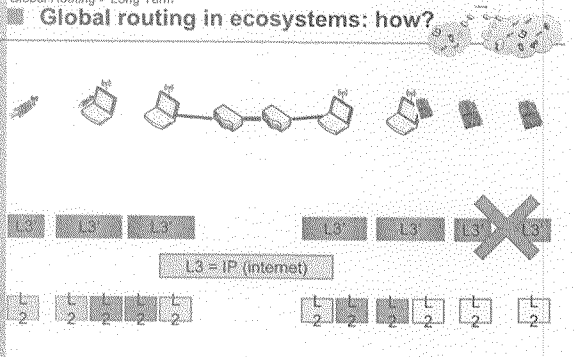


- Implement own neighbor discovery above existing connections
  - ⇨ routing in overlay network
- Technology to achieve this exists!
  - VPAN (Virtual Private Ad Hoc Networking)
- However…
  - designed for IP capable, personal devices
  - currently: low end devices cannot be added to VPAN

Long term



Global routing in ecosystems: how?



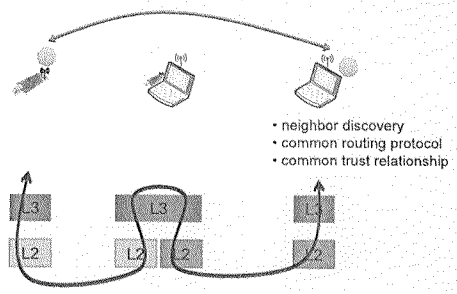
Global routing in ecosystems

- Goal
  - integrate low-end devices in virtual environment
    - avoiding use of 'powerful' gateways
    - e2e connections between any device
- Need:
  - protocols and algorithms for low end devices
    - neighbor discovery
    - routing
    - trust relationship
    - starting, joining and leaving ecosystems

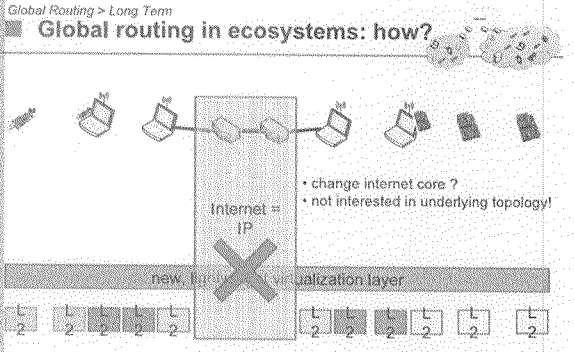
An ecosystem is a completely independent, managed, virtual environment of interdependent, networked objects that cooperate in harmony.

Stack view

- Global routing within ecosystem (local devices)



Global routing in ecosystems: how?

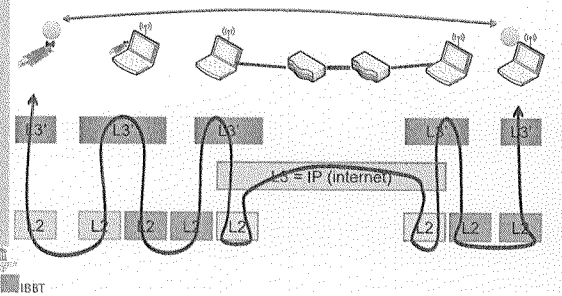


Unresolved challenges

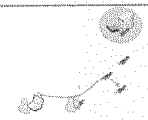
- creation of lightweight protocols
  - modular design?
- easy and secure set-up
  - starting ecosytems
  - adding and removing devices from an ecosystem
- more solid definition of these ecosystems
  - where do they start, where do they stop
    - 1 device, several ecosystems
  - how are they merged
  - level of detail when using other ecosystems
    - device basis
    - application basis
    - both?

Stack view

- Global routing within ecosystem (local and remote)



Conclusion



- possible benefits of 'global routing'
  - avoid smart gateways
  - optimized routes
  - new connection possibilities
- short-term strategies
  - mesh / sensor internetworking
- global routing in ecosystems
  - challenge: securely integrating low-end devices
  - unresolved challenges
  - possible approach on how to get there

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Thank you!

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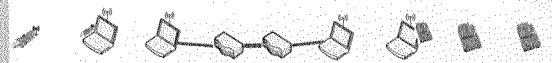
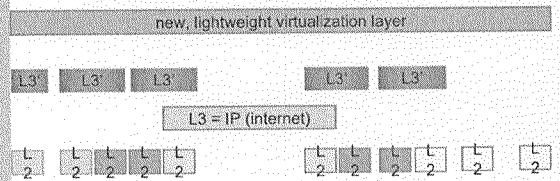
Global routing in ecosystems: how?





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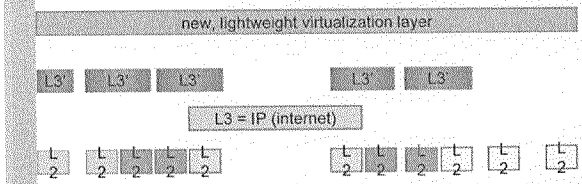
lightweight virtualization layer

- clean slate design
- ascertains backwards compatibility



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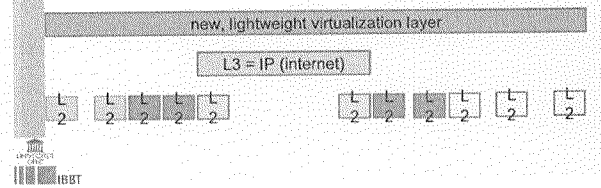
lightweight virtualization layer

- far future…



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Proceedings

11TH STRATEGIC WORKSHOP 2009

Wireless Innovation for InterDynamic TecHnology (WIDTH)"

MAY 15—17, 2009

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