Application Enablers for Challenged Networks

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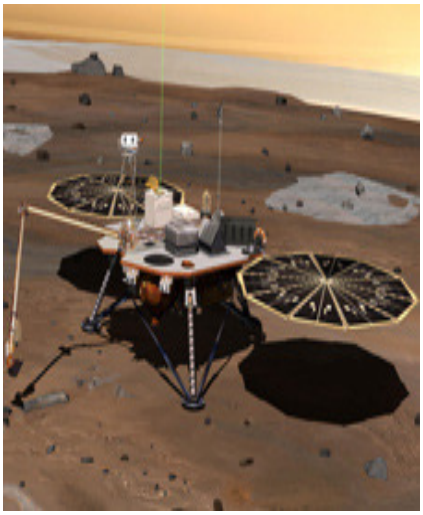
Challenged Networks

- "Challenged" according to dictionaries
  - Having disabilities or impairments
  - Deficient or lacking
- Challenged networks
  - Networks facing challenges because of "disabilities / impairments / deficiencies" (compared to "normal/conventional/usual" networks)
  - Examples of disabilities / impairments/deficiencies
    - High error rates
    - Asymmetrical bidirectional data rates
    - Intermittent bidirectional end to end path
- **In brief: Networks that do not meet Internet design assumptions**

Challenged Networks

Example: Deep space networks

Network for the exploration of the solar system and the universe
- Spacecrafts
- Stations with large antennas
- Databases



Challenged Networks

Example: Wireless Sensor Networks

Network for collecting ambient information (e.g. space, Environment, physiology)
- Sensors (small scale autonomous devices)
- Gateway node

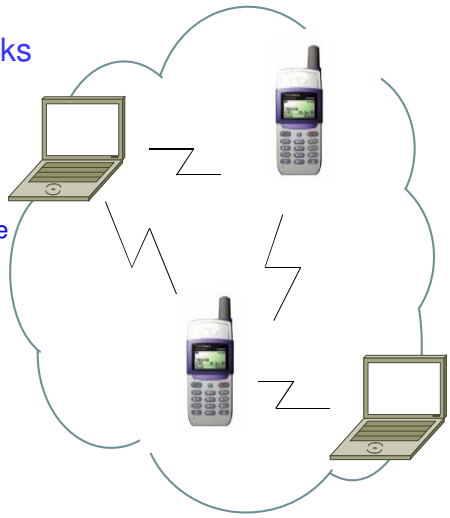
Challenged Networks

Example: Mobile ad hoc networks

Dynamically formed by wireless mobile nodes

Transient

No pre-configured infrastructure



Applications

Examples of conversational applications

- Two party phone calls
- Multimedia multiparty conferencing (e.g. multiparty multimedia games)

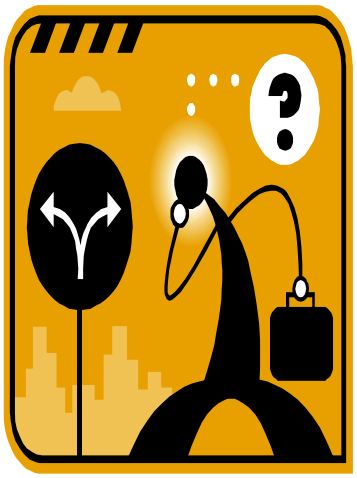
Examples of non conversational applications

- Internet access
- Email
- File transfer

Why Research End-User Applications and Services Enablers in Challenged Networks?

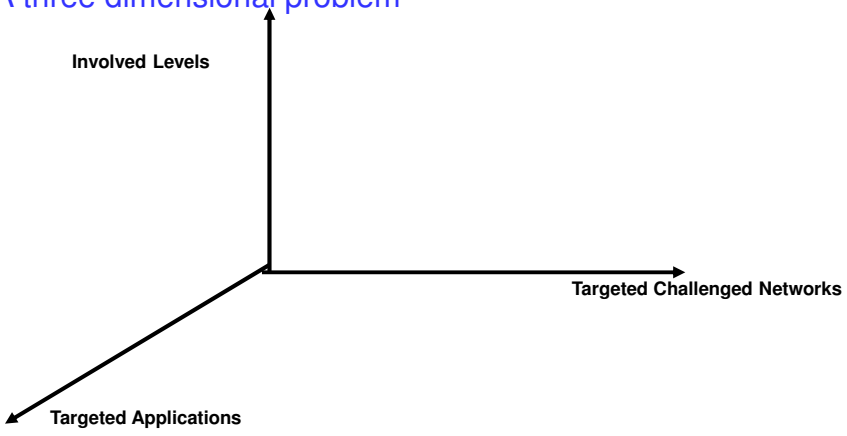
1. Conventional networks are not viable alternatives in some environments
   - Deep space
   - DAKNET project (India)
   - SNC (Lapland)

2. Some applications are not realizable in conventional networks
   - Seamless access to services during constrained periods (e.g. mass events)
     - Challenged networks can be used to augment capabilities on demand



A Proposed Taxonomy for Applications Enablers in Challenged Networks

A three dimensional problem

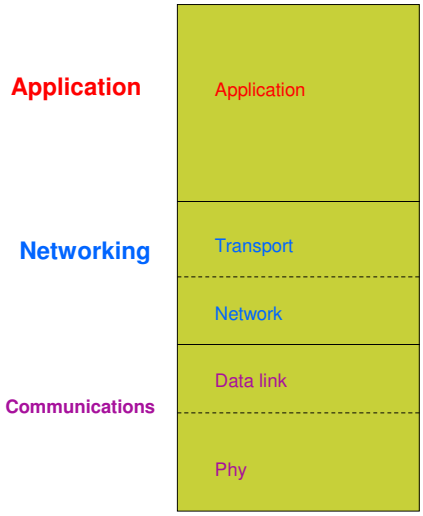


A Proposed Taxonomy for Applications Enablers in Challenged Networks

Involved level

An application enabler may be at:

- Application level
(e.g. DTN bundle overlay, ambient control space, middleware for WSN application development)
- Networking level
(e.g. Opportunistic routing protocols for MANETs such as the ones used in Daknet)
- or span application and networking levels



A Proposed Taxonomy for Applications Enablers in Challenged Networks

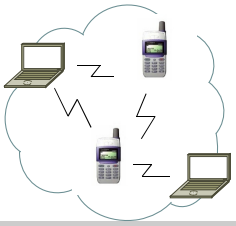
Target challenged network

An application enabler may target:

- A specific challenged network
(e.g. numerous architectures for applications in wireless sensor networks, conferencing in MANET)
- All challenged networks
(e.g. DTN bundle overlay, ambient control space)

or

A subset of challenged networks



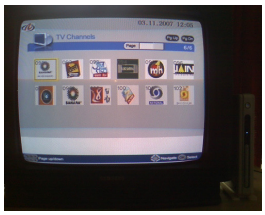
A Proposed Taxonomy for Applications Enablers in Challenged Networks

Targeted application

An enabler may target:

Specific applications
(e.g. IPTV, rural telephony, multimedia multiparty session in mobile ad hoc network)

All applications



A Proposed Taxonomy for Applications Enablers in Challenged Networks

Application Neutral Enablers

- Challenged Networks neutral Enablers
  - Application level enablers
    - e.g. DTN bundle, Ambient Control Space
  - Networking level enablers
    - e.g. TCP for wireless
- Challenged Networks specific enablers
  - Application level enablers
    - e.g. middleware for WSN application development
  - Networking level enablers
    - e.g.TCP for MANET, new transport protocols for MANETs

A Proposed Taxonomy for Applications Enablers in Challenged Networks

Application Specific Enablers

- Challenged Networks neutral enablers
  - Application level enablers
    - ???
  - Networking level enablers
    - ???
- Challenged Networks specific enablers
  - Application level enablers
    - E.g. conferencing in MANET
  - Networking level enablers
    - ???

Scoping the tutorial

State of the Art and Research Directions for Application Enablers in Challenged Networks with focus on

- Wireless sensor networks and mobile ad hoc networks as challenged networks
- Application level enablers (i.e. networking level enablers such as TCP for MANETs are excluded)
  - Challenged network neutral
  - Challenged network specific

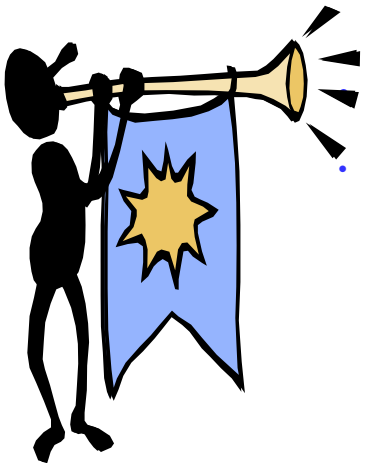
Roadmap

1 - Two examples of challenged networks

2 - Challenged network neutral enablers
IETF Delay Tolerant Network (Bundle Overlay)
Ambient networks Control Specific

3. – Challenged network specific enablers
Middleware for wireless sensor networks
Session signaling enabler for mobile ad hoc networks

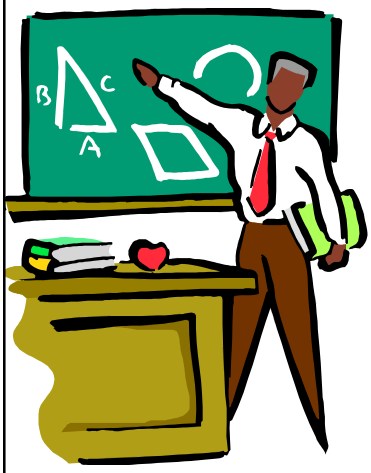
Two examples of challenged networks



1 - Wireless sensor networks

- 2 - Mobile ad hoc networks

Wireless Sensor Networking and Communications



- Wireless sensors and wireless sensor networks
- Transport
- Network
- MAC and PHY
- Standard approaches (IEEE 802.15.4 and ZigBee)

To probe further

1. I. Akyildiz, W. Su, Y. Sankarasubramaniam, Wireless Sensor Networks: A Survey. Computer Networks Journal (Elsevier), Vol. 38, No4, pp. 393 – 422, March 2002

1. P. Baronti et al., Wireless Sensor Networks: A State of the Art and the 802.15.4 and Zigbee Standards, Computer Communications (Elsevier), 30 (2007), 1655 – 1695

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Wireless Sensors

Wireless Sensors

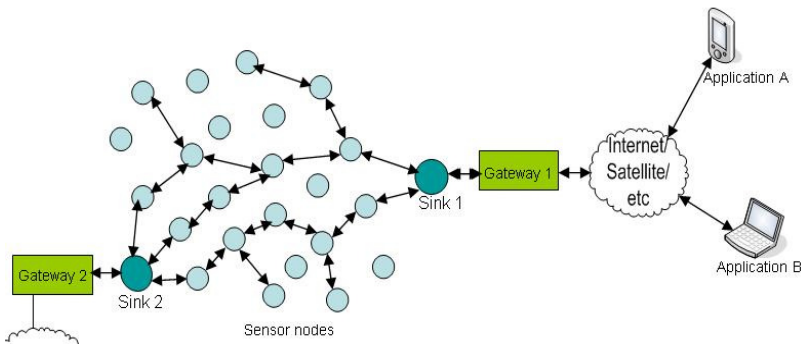
Small scale autonomous devices that can sense, compute and communicate ambient information

- Ambient information
  - Space
    - e.g. location, velocity
  - Environment
    - e.g. luminosity, level of noise
  - Physiology
    - E.g. blood pressure, heartbeat

Conventional Wireless Sensor Networks (WSNs)

- Sensors
  - Do the actual sensing
- Aggregators
  - Logical representatives of regions of interest
    - Summarize data for regions
- Sinks
  - Collect data from all sensors / aggregators
    - Interact with end – user services / applications via gateways
- Gateways
  - Dual interfaces
    - Bridge WSNs and outside world

Conventional Wireless Sensor Networks

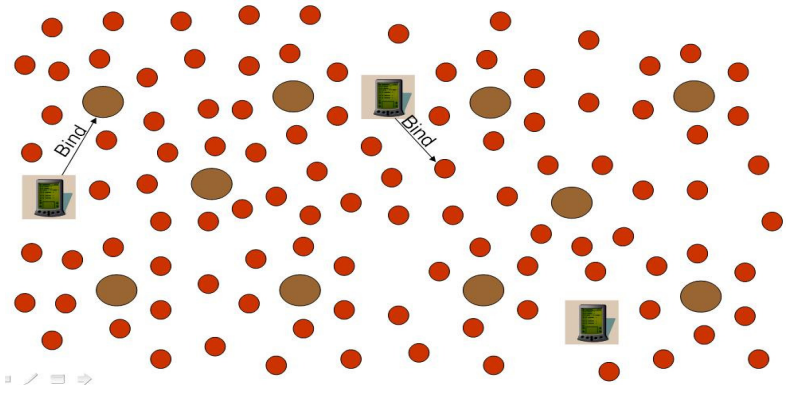


Sink-Less Wireless Sensors Networks

No sink, No gateway

- End-user services / applications interact directly with individual sensors
- Use cases
  - Battlefield assessment
    - Sensors scattered over a field to detect landmine
    - Soldiers moving in the field with application devices
  - Rescue operations
    - Indoor monitoring
      - Fire fighters

Sink-Less Wireless Sensor Networks



Applications areas

Numerous

- Military
- Environment
- Health
- Home
- Industry

Transport Layer

- Transport layer in general
  - Bridge between network layer and application layer
    - Multiplexing / de-multiplexing
  - End to end data delivery with reliability required by application
    - Connection-less vs. connection oriented
  - Traffic regulation
    - Flow control / congestion control
- Unsuitability of existing protocols
  - TCP
    - Overhead due to 3 way handshaking, wireless nature of WSN
  - UDP
    - Lack of flow and congestion control mechanisms

Transport Layer

- Requirements for transport in WSN
  - Reliability (Transmission of event features from sensors to sink and transmission of commands / programming tasks from sink to sensors)
  - Congestion control (Avoid event detection impairment at sources such as aggregators)
  - Self configuration (adaptations to mobility, temporary failure, power down)
  - Energy awareness
  - Biased implementation (Fair usage of resources – heavier burden on sinks)
  - Constrained routing / addressing (No end to end global addressing)

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Transport Layer

- Two groups of protocols
  - Event to sink transport
  - Sink to sensors transport
  - Some examples
    - Event to sink protocols
      - Event to Sink Reliable Transport (ESRT)
      - Congestion Detection and Avoidance (CODA)
      - Reliable Multi Segment Transport (RMST)
    - Sink to Sensors
      - Pump Slowly, Fetch Quickly (PSFQ)
      - GARUDA

Network layer (Routing)

- Data centric
  - Sensors do not usually have specific IDs
    - Data centric protocols
      - Route based on data description
        - » Attribute naming (e.g. area where temperature > 20 degrees)
      - Data aggregation / fusion
      - Some examples
        - » Flooding
        - » Gossiping

Network layer (Routing)

- Other approaches
  - Hierarchical
  - Location based
  - QoS based (e.g minimize energy consumption)

MAC

- Requirements specific to WSNs
  - Energy efficiency
  - Application oriented traffic
    - Adaptation to generated traffic in event based applications
    - Reservation in monitoring application to exploit the periodicity
  - Topology awareness
  - Spatial correlation
- Categorization
  - Contention based protocols
  - Hybrid medium access

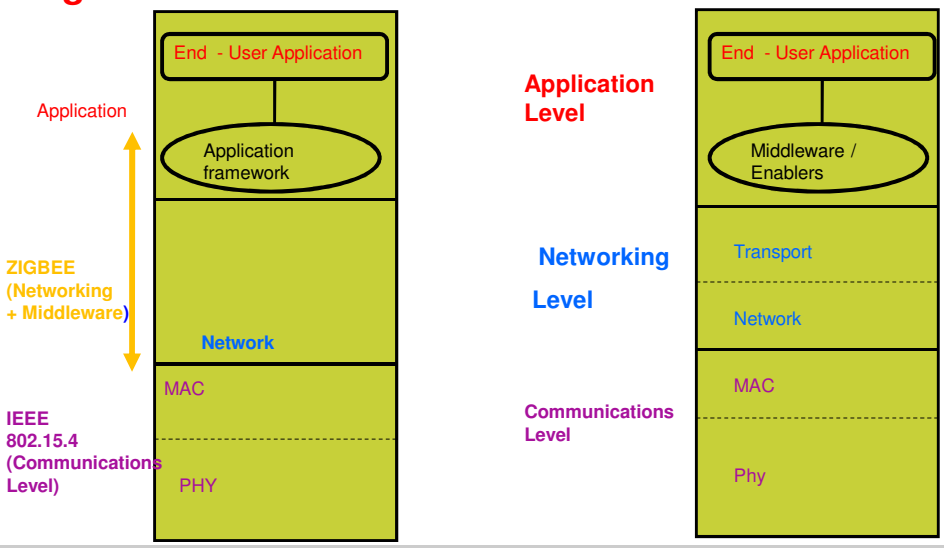
PHY

- Radio links
- Ultra wide band
- Infrared
- Optical medium

Standard approaches

- Zigbee alliance
  - Standards / products for low reliable, cost effective, low power wireless networking
    - Wireless networking
      - Network layer
    - Application layer
      - Application framework (i.e. enabler, middleware0
    - Relies on IEEE 802.15.4
- IEEE 802.15.4
  - PHY and MAC for low cost, low rate personal area networks

Zigbee



IEEE 802.15.4 PHY

- Direct Sequence Spread Spectrum (DSSS) Access mode
  - Three bands
    - 2450 MHz
    - 915 MHz
    - 868 MHz

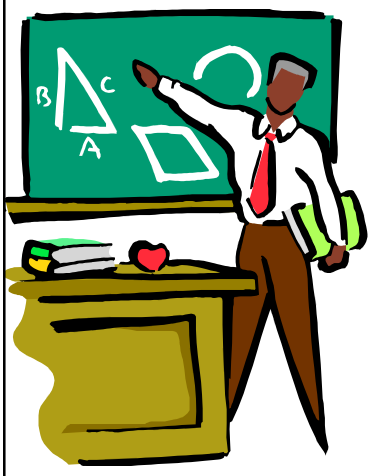
IEEE 802.15.4 MAC

- Two types of nodes
  - Full Function Devices
    - Equipped with a full set of MAC layer functions
    - Act as network coordinator and/or end-device
  - Reduced Function Devices
    - End devices only
      - Equipped with sensors/actuators
      - Interact with a single full function device
- Two topologies
  - Star (master slave)
  - Peer to peer
- Protocol
  - CSMA - CA

Zigbee

- Network layer
  - Routing over a multi hop network
    - Three types of devices
      - End device (IEEE 802.15.14 full function device or reduced function device)
      - Router (Full function device with routing capabilities)
      - Coordinator (manages the whole network)
    - Network formation and address assignment
      - Join procedure
    - Routing
      - Topology dependent
        - » Tree
        - » Mesh

Mobile Ad Hoc Networking and Communications



Mobile ad hoc networks

Off the shelf building blocks (below IP)

Network layer (Routing)

Transport layer

Mobile ad hoc networks

Networks that can be deployed, anywhere, any time

Some of the characteristics:

- Infrastructure-less
- Dynamically changing network topologies
- Physical layer limitations
- Variation in link and node capabilities
- Energy constraints

Mobile ad hoc networks

Categorization

- Stand alone

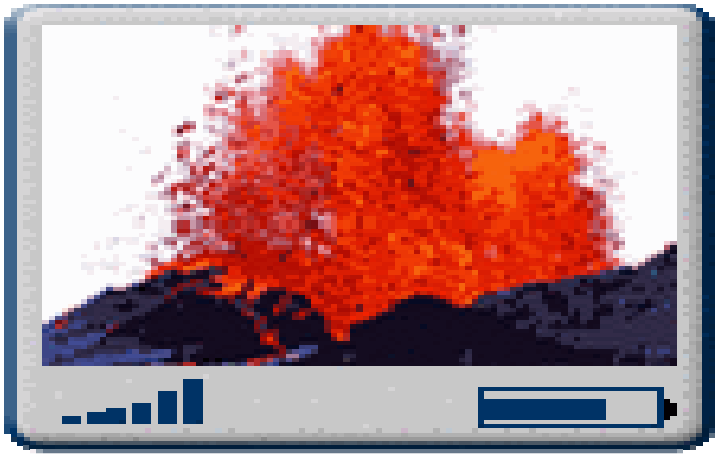
or

- Connected to a fixed infrastructure
  - Tightly coupled or loosely coupled
  - Can aid in extending 3G network coverage

On the battlefield

Rescuing in natural disasters

Rescuing in natural disasters



Below IP: The Off-the-shelf building blocks

Wireless PANs -
BlueTooth
- Piconet
  - Point to multipoint
  - 1 master controlling several slaves
- Scatternets
  - 2 or more overlapping Piconets
  - Nodes which are part of more than one Piconet act as bridges

Scatternets can be used as basis for multihop ad hoc networks
However:
- Few implementations of BlueTooth support scatternets
- Many open research issues
  - Efficient inquiry
  - Scatternet / piconet scheduling
- No working BlueTooth multihop ad hoc network test bed
- But simulators

Below IP: The Off-the-shelf building blocks

Wireless LANs -

1. IEEE 802.11 (a, b, c, d, e, f and g) – WiFi

- Most popular Off-the-Shelf building block
- 1 – 54 Mbps
- Two modes:
  - Infrastructure Mode Basic Service Set (IM-BSS)
    - Access points
    - Connections to a fixed network (e.g. 3G, Internet)
  - Independent Basic Service Set (IBSS)
    - No access point
    - Stand alone mode
    - Used to build mobile ad hoc networks

IP Layer: Routing

Pro-active approaches -

- Each node maintains the route to every other node
- Periodic updates
- Derived from wireline traditional routing approaches
- Examples
  - Distance sequenced distance vector (DSV)
  - Optimized link state routing (OLSR)

Reactive approaches -

- On-demand (built when needed)
- Some examples
  - Ad hoc On Demand Vector Routing (AODV)
  - Dynamic Source Routing (DSR)

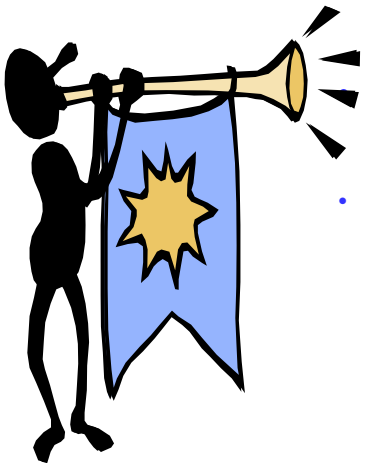
Transport Layer

Examples of reasons for which TCP does not perform well in MANETs
- Misinterpretations
- Interpret "wrongly" as congestion:
- Packet loss
- frequent path breaks

Network partitioning and re-merging
- Due to randomly moving nodes

Potential solutions:
- Enhanced TCP
- Brand new transport protocols
- Application level enablers

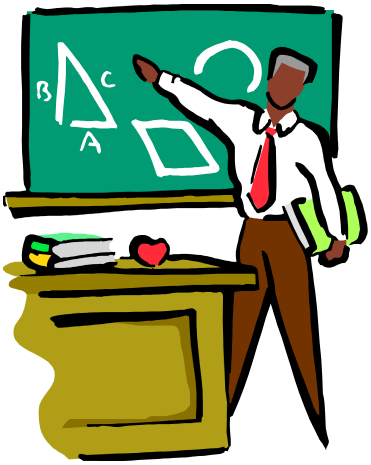
Challenged Network Neutral Enablers



1 - IETF Delay Tolerant Network (DTN) Bundle Overlay

- 2 - EU 6FP Ambient Network Control Space (ACS)

DTN Bundle Overlay



- Genesis and overall structure
- Interactions applications / overlay
- Overlay structure
- Case studies
- Research directions and open issues

To probe further

1. K. Fall and S. Farrell, DTN: An Architectural Retrospective, IEEE JSAC, Vol. 26, No5, June 2008
2. L. Pelusi, A. Passerella and M. Conti, Opportunistic Networking: Data Forwarding in Disconnected Mobile Ad Hoc Networks, IEEE Communications Magazine, November 2006
3. http://www.snc.sapmi.net/
4. A. Pentland, R. Fletcher and A. Hasson, Daknet: Rethinking Connectivity in Developing Nations, IEEE Computer, February 2009

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DTN Bundle Overlay

An application neutral, challenged network neutral, application level enabler

- Originated from the Interplanetary Internet work
- Started as deep space network specific then got generalized

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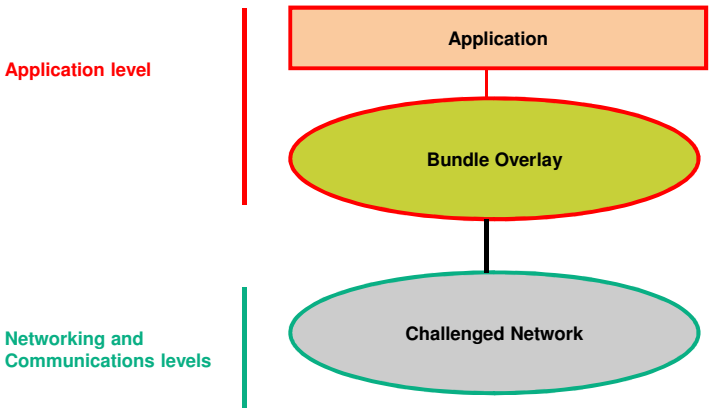
DTN Bundle Overlay

An application neutral and challenged network neutral application level enabler



DTN Bundle Overlay

An application neutral and challenged network neutral enabler

- Interactions between applications and bundle overlay
  - Application Data Units (ADUs)
    - Arbitrary length
    - Fragmented in bundles by the bundle overlay
    - May not be delivered in order
  - Priority scheme
    - Bulk, normal, expedited
  - Delivery options
    - Custody related (i.e. keeping copies of bundles till delivery)
    - Bundle delivery related

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DTN Bundle Overlay

An application neutral and challenged network neutral enabler

- Bundle overlay
  - Three nodes
    - Host (Host end user services)
    - Router
    - Gateway (Bridges DTN that use different transport protocol)

DTN Bundle Overlay

An application neutral and challenged network neutral enabler

- Bundle overlay
  - Convergence layer adapter
    - Maps to specific trasport layer
  - Persistent storage
    - Distributed across the overlay
  - Bundle protocol
    - Very challenging routing issues
      - Persistent, on-demand, scheduled and opportunistic contacts

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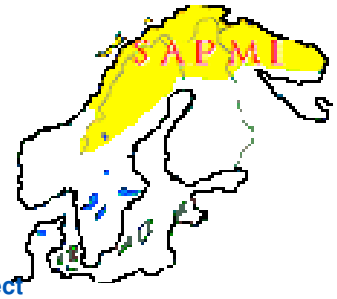
DTN Bundle Overlay



A Case Study:
Saami Network Connectivity Project

DTN Bundle Overlay

- A case study
  - Environment
    - Saami herders: nomadic resident of Lapland
    - Very heterogeneous means for Internet access
      - Conventional
        - » Fixed lines, GSM,
      - Challenged
        - » Satellite, power lines
      - No access at all

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DTN Bundle Overlay

- A case study
  - Applications provided in the first phase
    - Email
    - File transfer
    - Cached Web access

DTN Bundle Overlay

- A case study
  - Implementation: A pure DTN approach
    - DTN hosts located in communities
    - Each community has a DTN gateway
    - Bundles travel back and forth to Internet via relays
      - Fixed relays (e.g. GSM, satellite)
      - Mobile relays may travel periodically between gateways and fixed relay
        - » Antennas mounted on vehicles

DTN Bundle Overlay

Another Case Study:
Daknet
(or how to solve a problem similar to SNC problem with a different approach)

DTN Bundle Overlay

- A case study on a non DTN bundle based approach
  - Environment
    - Villages in India
    - Very heterogeneous means for Internet access
      - Conventional in distant cities
        - » Fixed lines, GSM,
      - But none in some villages

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DTN Bundle Overlay

A case study on a non DTN Based approach
- Applications provided
  - Email
  - Audio video messaging
  - Mobile e-commerce
  - Public health announcements

DTN Bundle Overlay

- A case study on a non DTN based approach
  - Approach
    - Kiosks in villages
      - Digital storage
      - Short range wireless communications capabilities
    - Mobile access Points (MAP) mounted on buses, bicycles pass periodically to exchange data with the kiosks and communicate with access points (AP) in nearby cities to exchange data with Internet

  An application neutral, challenged network specific and network level enabler is used (i.e. Opportunistic routing in mobile ad hoc networks)

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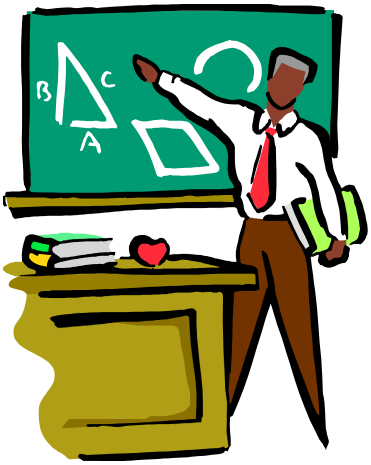
DTN Bundle Overlay

- Some research directions / open issues from architectures for end user service perspective
  - Experimentation / evaluation of DTN bundle overlay in challenged networks other than deep space / satellite networks
  - Service creation environments
    - Programmatic interfaces (e.g. APIs)
    - Tools
    - Integration with other application development environments
  - Alternatives to the DTN bundle overlay

Ambient Control Space Overlay



- Genesis and overall structure
- Ambient Control Space for Media Delivery
- Ambient Control Space for Network Composition
- Research directions / open issues

To probe further

1. F. Hartung et al., Advances in Network – Supported Media Delivery in Next Generation Mobile Systems, IEEE Communications Magazine, August 2006
2. F. Belqasmi, R. Glitho, R. Dssouli, Ambient Network Composition, *IEEE Network Magazine*, July/August 2008, pp. 6-12

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Ambient Control Space Overlay

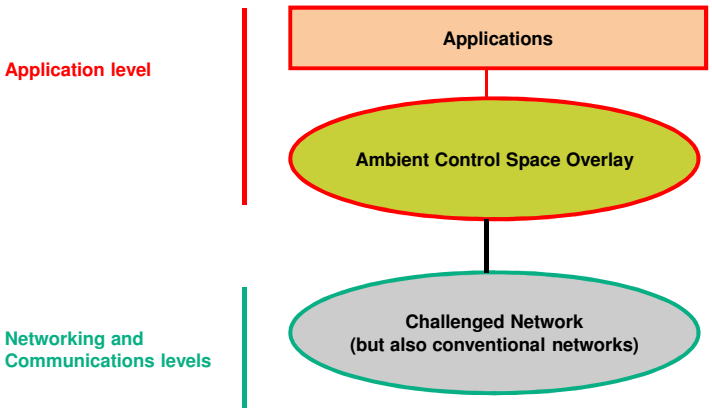
An application neutral, challenged network neutral, application level enabler

- Originated from the ambient network project (EU 6FP)

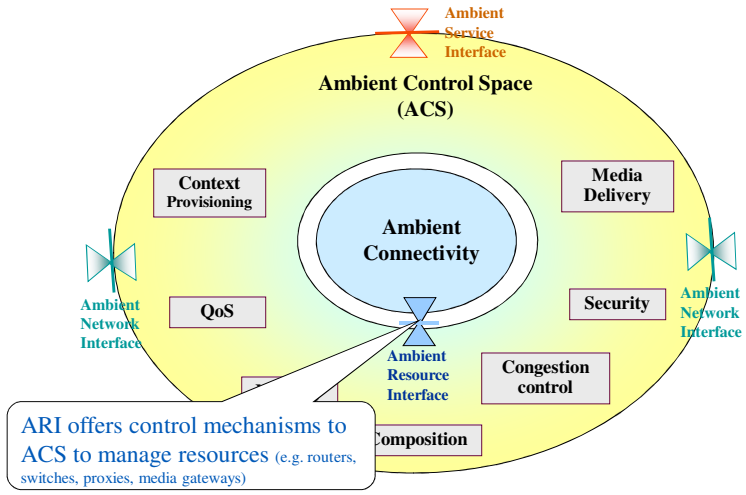
- Target all networks including challenged networks

Ambient Control Space Overlay

An application neutral and challenged network neutral application level enabler



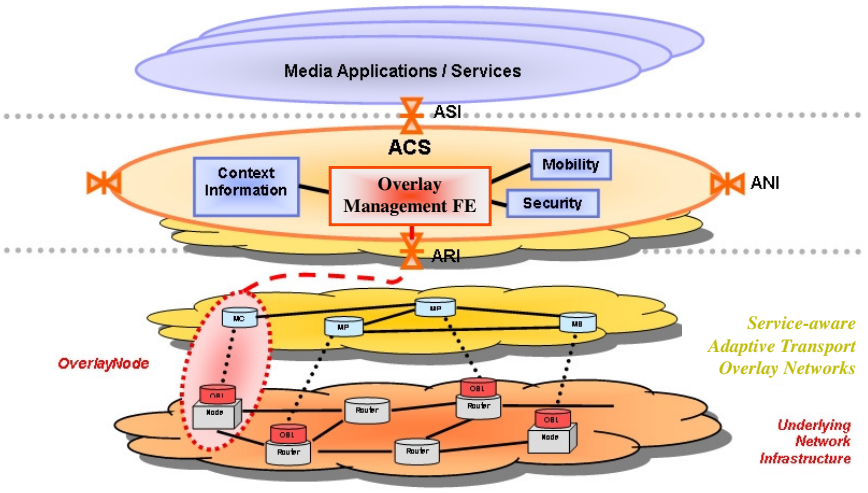
Ambient Control Space Overlay



Ambient Control Space Overlay

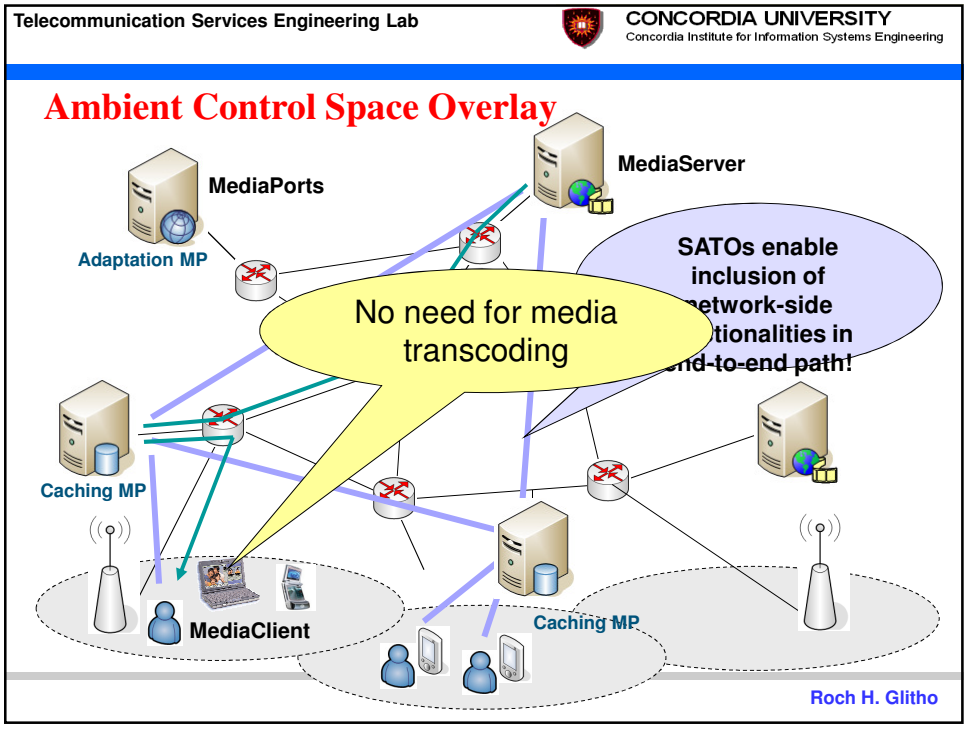
- **Media delivery**
  - Use Service-Aware Transport Overlay (SATO)
  - SATO is useful for customization or adaptation of content to end-users' context but also for providing new value-added services like: virus scan, mitigation of SPAM.
  - The SATO network is service aware and supplies special support for each service.
  - SATO supports all types of services
    - Today content delivery networks and overlay systems are limited to a certain service (e.g. skype for voice and instant messaging but not for IPTV).

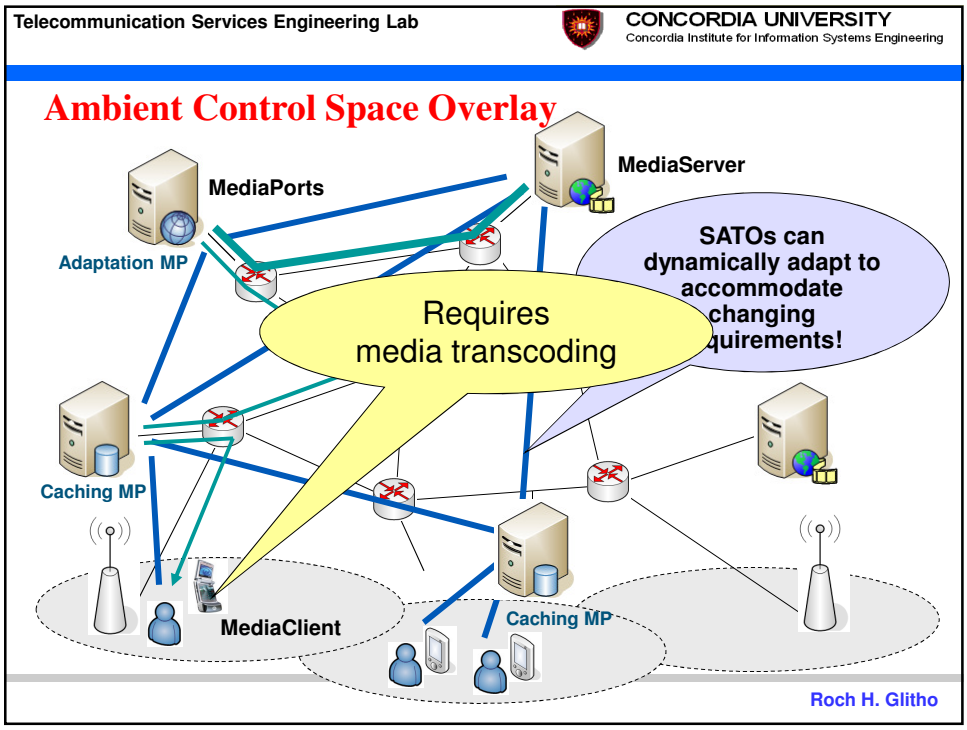
Ambient Control Space Overlay



Ambient Control Space Overlay

- **Overlay node and overlay service layer**
  - Overlay
    - An ambient network node with media processing capabilities
      - Caching
      - Adaptation
    - Maybe
      - Media server
      - Media client
      - "Independent" node
  - Overlay service layer
    - Distributed over overlay nodes
      - Data delivery to upper layers
      - Interconnection of overlay
      - Routing


Telecommunication Services Engineering Lab
CONCORDIA UNIVERSITY
Concordia Institute for Information Systems Engineering
Ambient Control Space Overlay
MediaPorts
MediaServer
Adaptation MP
SATOs enable inclusion of network-side tionalities in nd-to-end path!
No need for media transcoding
Caching MP
MediaClient
Caching MP
Roch H. Glitho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MediaPorts
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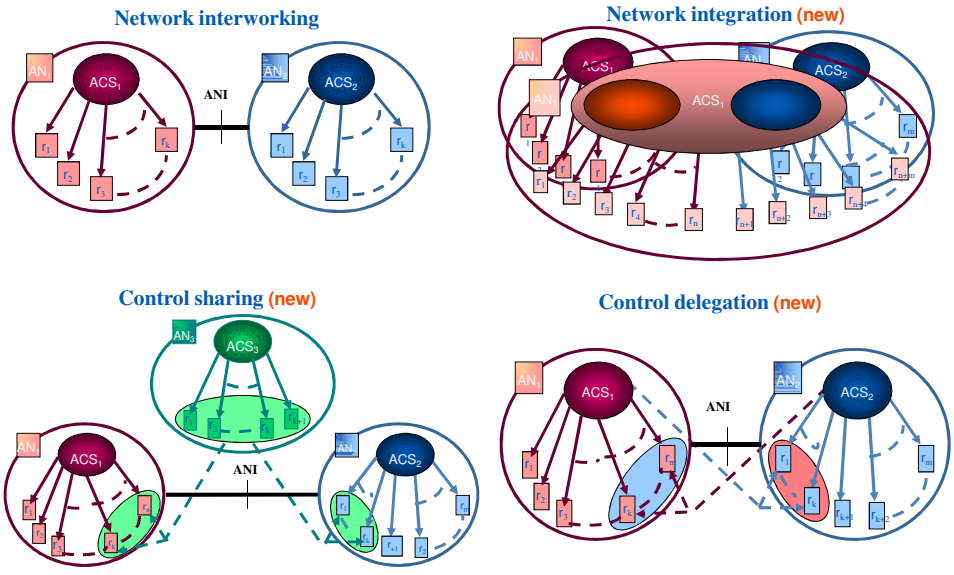
SATOs can dynamically adapt to accommodate changing quirements!
Requires media transcoding
Caching MP
MediaClient
Caching MP
Roch H. Glitho

Ambient Control Space Overlay

- Network composition
  - Enable autonomous cooperation between heterogeneous networks
  - Overcomes today's network cooperation limitations
    - Bring the possibility of new applications that were not possible including applications in challenged networks

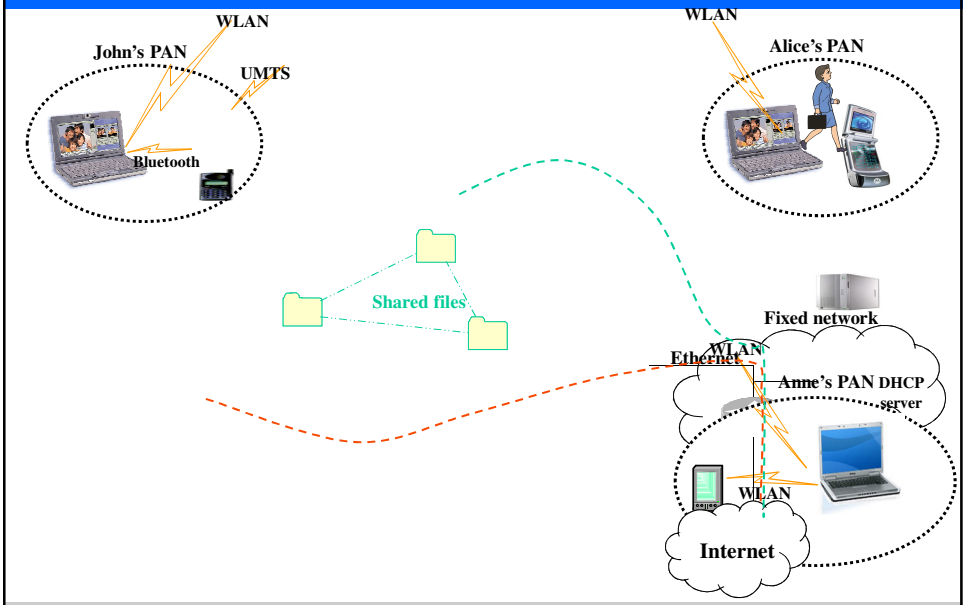


Ambient Control Space Overlay

An application neutral, challenged network neutral, application level enabler

- Case study 1

Several PANs build a dynamic ad-hoc network for a conference, where they share some files and the same internet access.



Ambient Control Space Overlay

An application neutral, challenged network neutral, application level architecture

- Case study 2

Session mobility with autonomous connections to existing Internet access facilities

Telecommunication Services Engineering Lab
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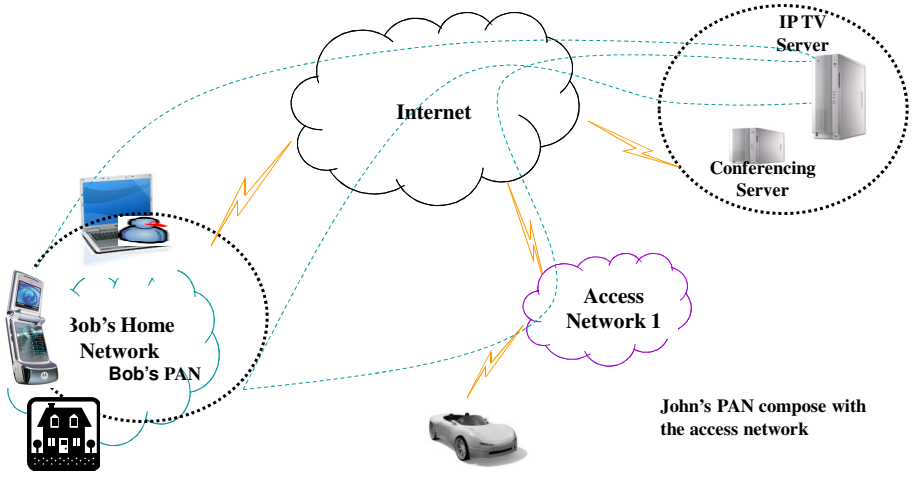
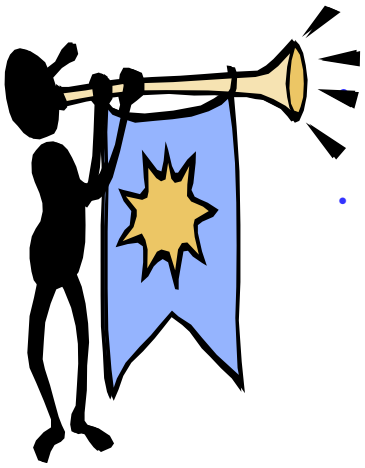


Ambient Control Space Overlay

- Some research directions / open issues from end user service architecture perspective
  - Most of the key issues have not yet been addressed
    - Ambient Service Interface (ASI) for interactions between applications and ambient control space overlay
    - Feasibility of implementation on specific networks especially challenged networks (i.e. ARI interfaces)
    - Relationship to and interactions with the bundle overlay

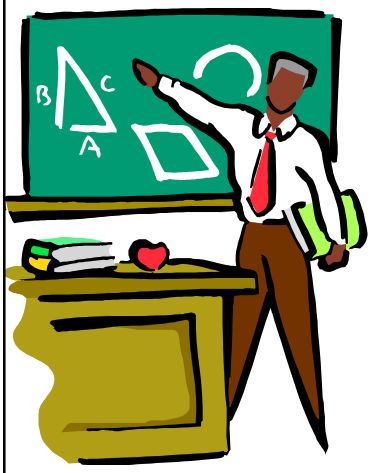
Challenged networks Specific Enablers



1 - Wireless sensor networks specific enablers

- **2 - Mobile ad hoc networks specific enablers**

Wireless Sensor Network Specific Enablers (Middleware)



- Specific challenges
- Evaluation framework
- Some examples
- A Case study on ambient awareness

To probe further

1. S. Hadim and N. Mohamed, Middleware: Middleware Challenges and Approaches for Wireless Sensor Networks, IEEE Distributed Systems OnLine, 1541 – 4922, Vol. 7, No3, March, 2006
2. N. Othman, S. Chebbine, R. Glitho, F. Khendek, A Web Services Based-Architecture for the Interactions between End-User Applications and Sink-less Wireless Sensor Networks, IEEE Consumer Communications & Networking Conference 2007 (IEEE CCNC 07), Las Vegas, January 11-13, 2007
3. . Ta, N. Othman, R. Glitho and F. Khendek, Using Web Services for Bridging End-User Applications and Wireless Sensor Networks, I*EEE Internaltional Symposium on Computers and Communications (ISCC'06*), June 26-29, Sardinia, Italy

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Some specific challenges

- Limited power and resources
- Scalability, mobility, dynamic network topology
- Heterogeneity
- Dynamicity (e.g. energy, processing power)
- Real world integration (e.g. on volcanoes)

Evaluation Framework

- Classification scheme
  - Programming support
    - Development paradigms
    - Tools
    - Run time mechanisms

Evaluation Framework

- Evaluation criteria
  - Ease of use
    - Prior familiarity of developers
  - Openness
    - Ability to modify and extend
  - Publication / discovery
  - Mode of interactions (Synchronous and/or asynchronous)
  - Overhead
  - Ease of integration with existing applications

-Low level commands

- Low level commands
  - Used for debugging/configuring/upgrading firmware/retrieving data readings
  - Commands sent by a proprietary client / standard text interfacing application (i.e telnet)
  - Requires a full understanding of the particular instance of WSN (algorithms or technology)

Slide 88

t1 give desc of appraoch
what reasearch work uses this
MAIN drawback

APIS
- low level: specifying ip/port, special flags, programming construct, following a sequence of prog operations

tt, 13/12/2005

-Low level APIs

APIs

- Based on high level programming languages or specialized languages (i.e. NesC)
- Relatively low level of abstraction
- Some security features, no publication/discovery
- Ex: MIT crickets, Sensoria sGate, EmberNet

Data Bases

- Treat the WSN as a data base
  - May use a standard query language or an extension
  - Queries are sent to the sink
  - Can be used with most programming languages
  - Some examples
    - TinyDB
    - MICA2
    - COUGAR

Slide 89

t2 give desc of appraoch
what reasearch work uses this
MAIN drawback

APIS
- low level: specifying ip/port, special flags, programming construct, following a sequence of prog operations

tt, 13/12/2005

Data bases

Ease of use
- Yes
- Most developers are familiar with data base

– Openness
- To some extent

– Mode of interactions (Synchronous and/or asynchronous)
- Both

– Overhead (Limited)

– Ease of integration with existing applications (To some extent – Too many different data base approaches)

Mobile agent

- Injected code migrate from sensor to sensor and carry out specific tasks while migrating
  – Mobile agent platform required
  – Data may be collected from individual sensors or sinks
  – Some examples
    - Impala
    - Aguila
    - SensorWare

Mobile agents

- Ease of use
  - Not really
  - Most developers are not familiar with the paradigm
- Openness
  - To some extent
- Mode of interactions (Synchronous and/or asynchronous)
  - Both
- Overhead - Yes
- Ease of integration with existing applications (No – very few applications are based on mobile agents)

Web services

- Expose the sensed data as web services
  - Promising
    - Easy to use
    - Open
    - Enable several business models
    - Synchronous and asynchronous
    - Easy to integrate with other applications
    - Only drawback: Overhead
  - Examples
    - Open Geospatial consortium
    - Our own prototypes

Web Service Basics

Today		Tomorrow
• Publication of documents	→	• Publication of "reusable business logic"
• Human interaction	→	• Automated P2P interaction
• Proprietary ad-hoc interfaces	→	• Industry standard interfaces

XML Technology

Basics

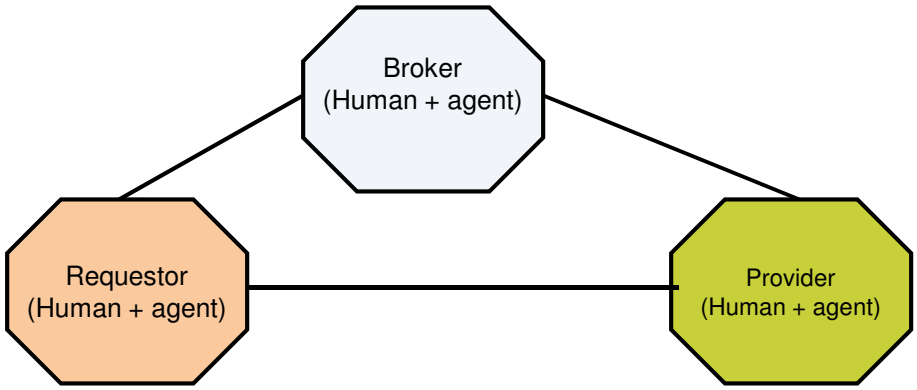
"The term Web Services refers to an architecture that allows applications (on the Web) to talk to each other. Period. End of statement"

Adam Bobsworth in ACM Queue, Vol1, No1

The three fundamental principles, still according to Adam Bobsworth:

1. Coarse grained approach (I.e. high level interface)
2. Loose coupling (e.g. application A which talks to application B should not necessarily be re-written if application B is modified)
3. Synchronous mode of communication, but also asynchronous mode

Architecture



Entities

Requestor

- Person or organization that wishes to make use of a Web service.
- Uses an agent (I.e requestor agent) to exchange messages with both broker agent and provider agent.

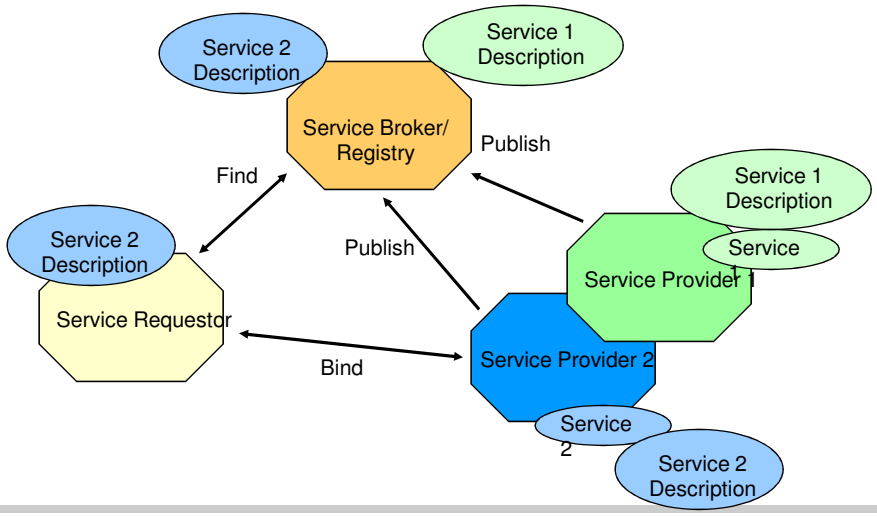
Provider

- Person or organization that owns a Web service it wants to make available for usage
- Use an agent (I.e provider agent) to exchange messages with broker agent and requestor agent.
- The provider agent is also the software piece which implements the Web service (e.g. mapping towards legacy)

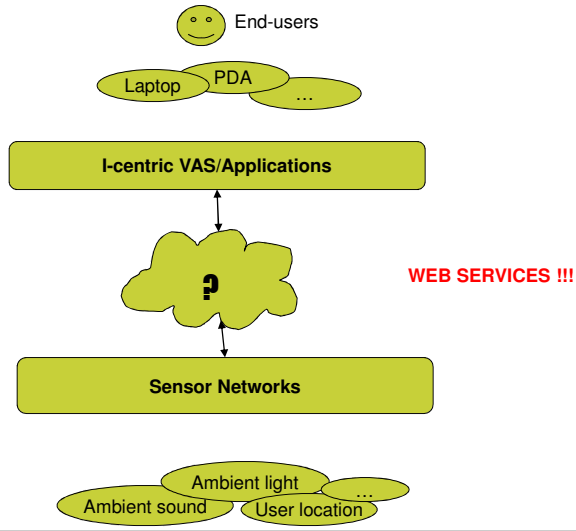
Broker

- Person or organization that puts requestors and providers in contact
  - Providers use brokers to publish Web services
  - Requestors use brokers to discover Web services
- Use an agent (I.e broker agent) to exchange messages with requestor agent and provider agent

Interactions …



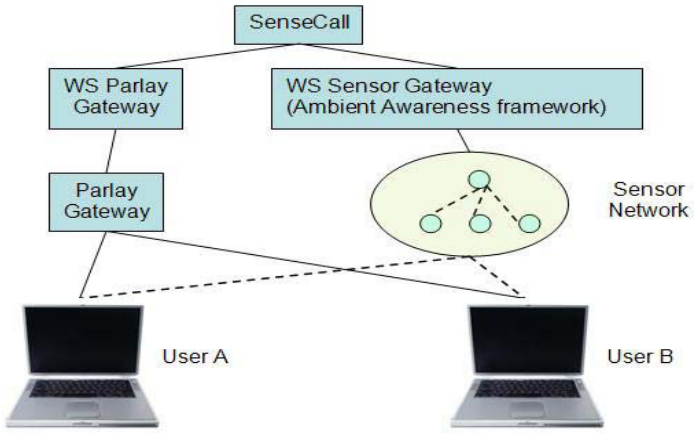
Ambient Awareness



Ambient awareness

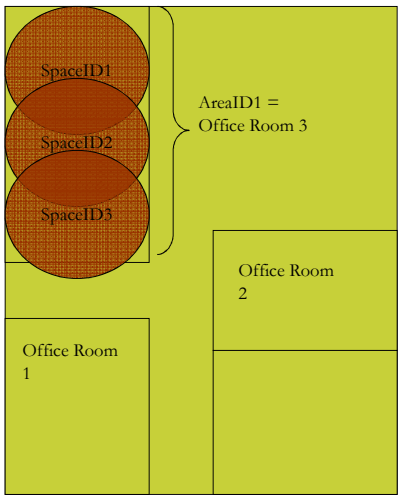
- Sensecall application
  - Initiate automatically a call between two users when they are in specific places (e.g. offices)
    - Ambient awareness aspects
      - "Refined" locations of end-users
        - » Sensed by wireless sensor networks

Ambient awareness

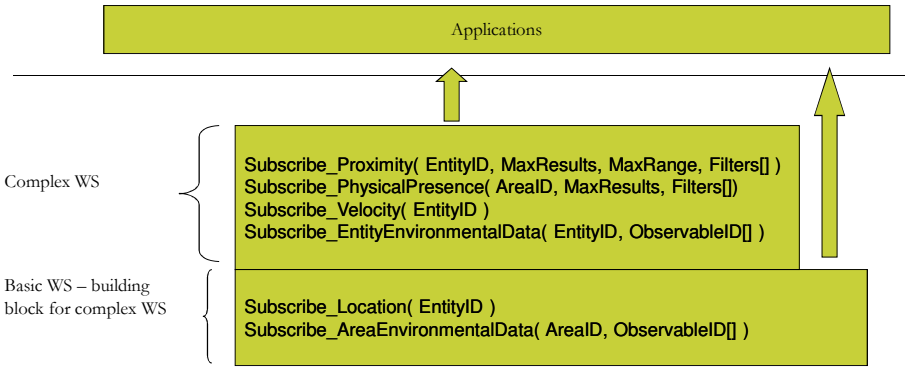


World model

- Space:
  - SpaceID, range, center coordinates, description
- Area:
  - AreaID, Set of SpaceID, description
- Entity:
  - EntityID, Entity type, description, owner
- Observable:
  - ObservableID, observable name, observable description, default units



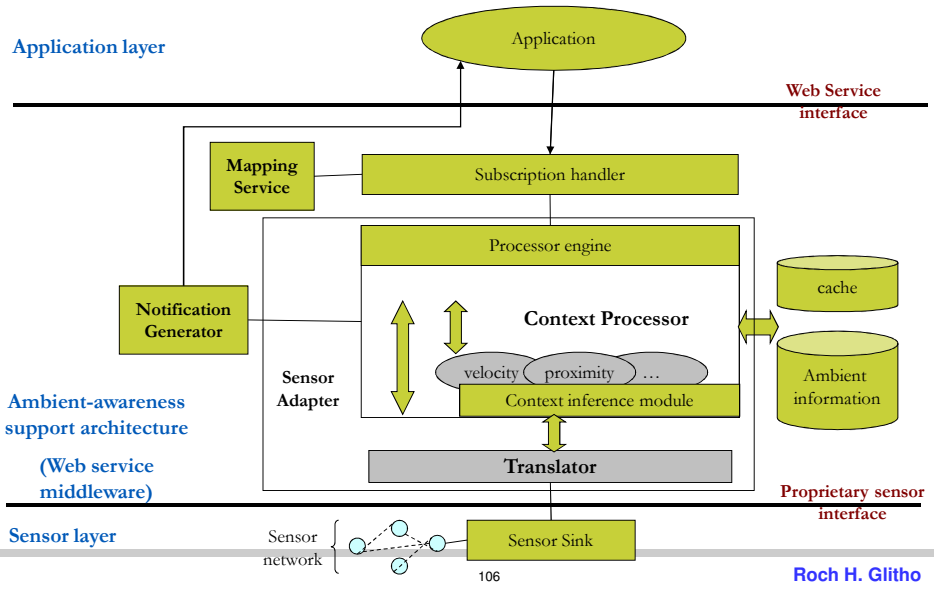
Web service methods



Web service methods

- *QualityOfContext* defines the desired minimum freshness of the sensed information
- *OnetimeOnly* specifies if the Web service should automatically unsubscribe after sending one response
- *NotificationTrigger* specifies a condition, based on the value of the sensed data, in which a notification (or service response) is necessary.
- *NotificationTriggeChangeSensitivity* specifies the minimum amount of variation in the sensed value that will trigger a notification.
- *RateOfNotification* indicates the maximum and minimum rate for the notifications
- *Granularity* specifies the desired level of detail in the presentation of the ambient data.
- *UnitsType* is the metric used in the representation of the sensed data

Functional architecture



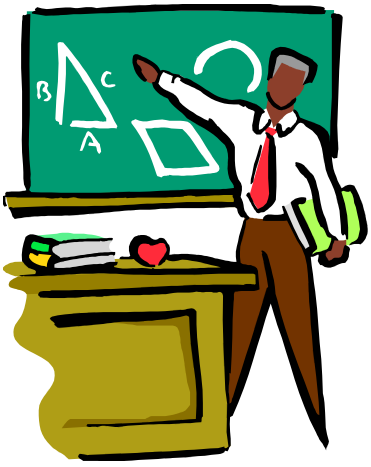
Prototype Implementation

- WSN used
  - MTS300/Mica2: sense ambient light, temperature, sound. Database approach
  - MIT crickets: provides location in the form of space identifiers or coordinates. API-based approach
- Mapping to sensors
  - Heterogeneity of sensors
  - Mapping Service is modeled as relational database
    - i.e.: Relationship defined between an Entity and a LocatorTechnology (crickets, activeBat, etc). This relationship points to a particular table which has all the parameters to retrieve the location of that Entity (i.e. API parameters, IP/port).

Some research directions

- Full blown application development environments
- Integration with widely used application development environment
- Experimentation with new paradigms (e.g. RESTFul Web services)

Mobile ad hoc network specific enablers



- An enabler for a specific application (i.e conferencing)
  - Conferencing
  - Specific challenges
  - The enabler (a new signaling system)

To probe further

1. C. Fu, R. Glitho and F. Khendek, Signaling for Multimedia Conferencing in Stand Alone Mobile Ad Hoc Networks, *IEEE Transactions on Mobile Computing*, Vol. 8, No7, July 2009
2. D. Ben Kheder, R. Glitho, and R. Dssouli, Media Handling Aspects of Conferencing in Broadband Wireless Ad Hoc Networks, I*EEE Network*, March/April 2006, pp. 42-49.

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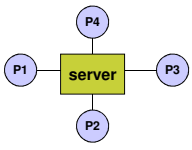
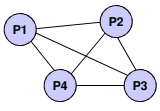
Conferencing

- Conferencing
  - The conversational exchange of multimedia content between several parties
  - Three components:
    - Signaling: session establishment, modification and termination
    - Media handling: media transmission, mixing, trans-coding
    - Conference control: policy, floor control

Conferencing

- Classifications
  - Open/close, pre-arranged/ad hoc
  - With/without sub-conferencing
  - With/without floor control
  - Topology: tightly coupled, loosely coupled, fully distributed

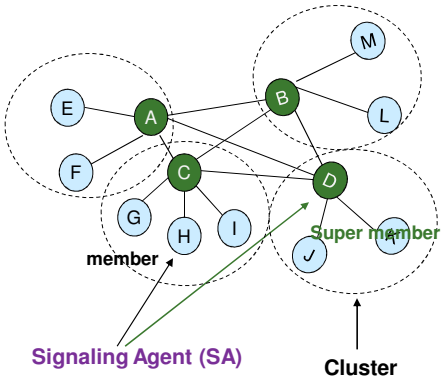




Signalling challenges

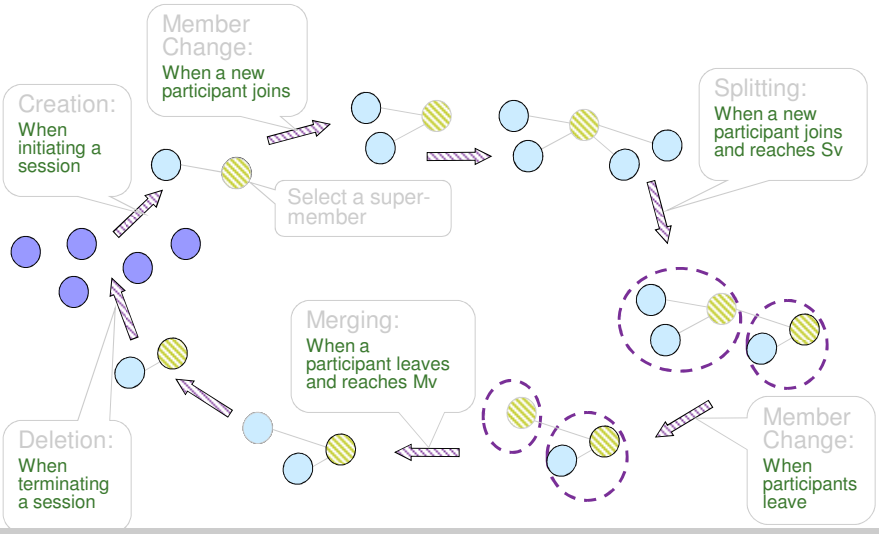
- Challenges are mainly due to the characteristics of MANETs
  - Signaling architecture
    - How to organize the signaling structure in a transient, distributed environment?
  - Session control
    - How to handle the frequently changing conference membership?
    - How to propagate session-related information?
  - Implementation
    - How to deploy a signaling system in a real MANET environment?
    - How conference participants discover and locate each other?
  - Performance
    - How to optimize the use of limited network resources and viable node capabilities?

The Signalling System



- Application-layer clustering
  - Dynamic clustering
    - Life cycle: formation, membership change (including super-member leaving, split, merge), deletion
  - Size of a cluster is controlled by
    - Split value, Merge value and
    - Capability of super-member
  - Super member elected based node capabilities
    - Using an application-layer capability exchange protocol
  - Unintentionally departures detected
    - using a heartbeat mechanism
    - Session can be recovered

The Signaling System



The Signaling System

Examples of issues:

- Sub-optimal routing at network layer
  - Clusters members may be too far from cluster-head
- Re-discovering node capabilities / resource level (when electing cluster-head) at application level
  - Information may exist at lower layers

Example of solutions:

- Cross layer design (i.e. violates the independence between layers – allow for instance the application layer to get information from the network layer)

The Signaling System

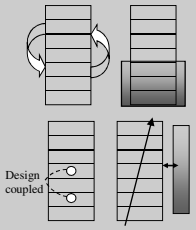
- Cross layer design
  - Active exploitation of the dependence between protocol layers to obtain performance gains**.
  - Motivations
    - Layered design works well in wired networks
    - Characteristics of wireless network are different
      - Physical layer may affect MAC and routing decision (e.g. transmission power/ rate)
      - TCP congestion may be caused by a link break

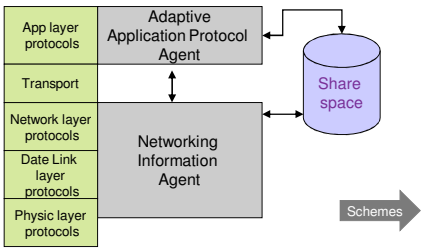
** *Vineet Srivastava and Mehul Motani, "Cross-Layer Design: A survey and the Road Ahead", IEEE communication Magazine, Dec 2005, Page 112- 119*

The Signalling System

- Performance issues
  - Overhead of heartbeat
  - Overhead of node capability exchange
  - Sub-optimal routing
  - CGW deployment

- Cross-layer design in MANETs
  - Solving performance issue of existing protocols
    - Example: TCP
  - Obtaining performance gain

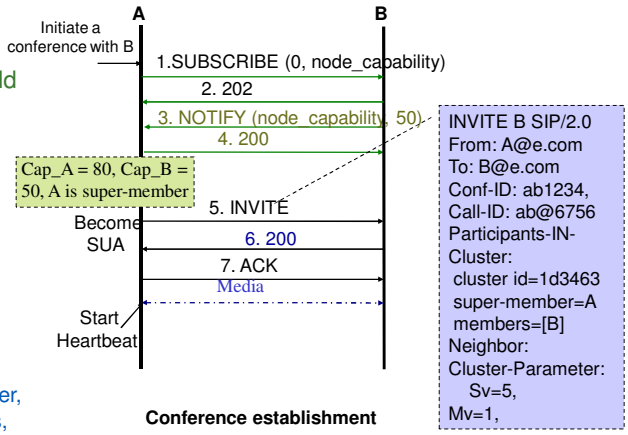




- Link break handling optimization scheme
- Capability usage optimization scheme
- Sub-optimal routing optimization scheme
- Super-member election based on clustering scheme
- CGW deployment optimization scheme
- Super-member selection based on signal power scheme

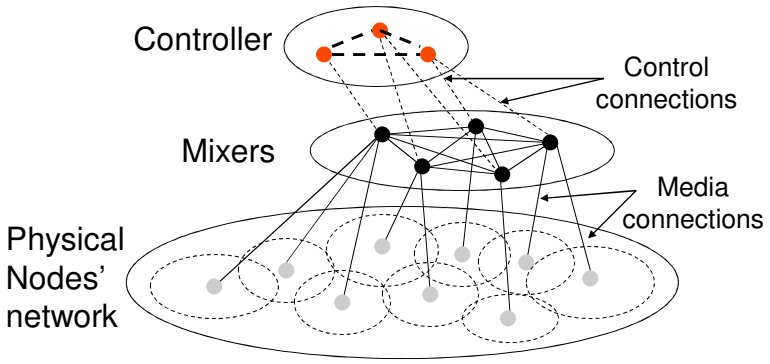
Realization (Technology) of the System for Standalone MANETs

- SIP as realization technology: lightweight, allows for extensions
- Our SIP Extension
  - "Clustering" in SIP Supported header field
  - Entities:
    - User Agent (UA)
    - Super User Agent (SUA)
  - New concepts:
    - Dialog (old)
    - Conference
    - Cluster
  - New header fields:
    - Participant-In-Cluster, Cluster-Parameters, Neighbor, Conf-ID



Conference establishment

A Word on the Accompanying Media Handling System: Hierarchical overlays



Research directions / open issues

- Specific to conferencing in mobile ad hoc networks
  - Only the basic “plumbing” is done (signalling enabler, media handling enabler)
    - Examples of missing enablers
      - Conference control (e.g. floor control)
      - QoS
- Integration of conferencing enablers with other MANET middleware
- Other application specific and challenged network specific enablers