

Going from Wireless Sensor Networks to clean slate Future Internet

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Background

- Work developed by the Wireless Networks Group (particularly by Xavier Sanchez, Josep Lluís Ferrer, Carles Gomez and Jordi Casademont) and other research groups of UPC, URL and UPF in the frame of the TARIFA research project funded by Fundació i2Cat
- Presentation done based on the article “Can Future Internet Be Based on Constrained Network Design Principles?”, published in Computer Networks: The International Journal of Computer and Telecommunications Networking, Special Issue on Architectures and Protocols for the Future Internet . Volume 55 Issue 4, March, 2011

Contents

- Problem identification
- A vision
- An alternative
- A clean slate model
 - Main concepts
 - Architecture
 - Implementation
- Conclusion

Problem identification

- Internet
 - Being evolved during the last 40 years
 - In front of new technologies
 - In front of new usages (services)
 - Results
 - Patches
 - Complexity
 - Lost of the neat principles of the original Internet
 - Cross layering
 - Corruption of the end-to-end paradigm

Problem identification

- Some open problems
 - Mobility
 - Security
 - QoS
 - ...
- Mainly due to limitation on the core

Looking for a solution

- Alternatives
 - Evolutionary
 - Darwinian
 - “Internet has evolved so far, so it can be done in the future”
 - “Evolution has allowed to move from a unicellular animal to a human being, this is a proof of the potential of evolution (except for the dinosaurs)”
 - Revolutionary
 - Clean slate
 - “to start again knowing the past and having learnt from it”
 - “man is the only animal that trips twice over the same stone”

Looking for the moment

- If revolutionary, then when to start?
 - The old car dilemma
 - Should I have to keep fixing my old car or I have to buy a new one?
 - Just in case, start saving (doing research) to be ready when urgently needed

Vision

- David D. Clark, Craig Partridge, Robert T. Braden, Bruce Davie, Sally Floyd, Van Jacobson, Dina Katabi, Greg Minshall, K.K. Ramakrishnan, Timothy Roscoe, Ion Stoica, John Wroclawski and

Small devices (sensors and actuators) will be the most numerous

The novelty is introduced by the edges

Key aspects: cost and battery life

Even the advances in processing (Moore's Law) we will suffer limitations

(Communications) a Different Place' Communication Review, Volume 35, No. 1, 2002. To think about where networking might be in 10 years, it behooves us to look at (r)evolution at the edge. In 10 years, we expect the most common devices on the network to be embedded processors, such as in sensors and actuators. Our goal would be hundreds of billions of such devices, all capable of communication. In most cases, the market for these devices will be driven by dropping costs rather than increasing speeds. There is only so much communication required to perform certain types of measurements – and in many cases, improving battery life will be more important than improving performance.

Vision

Wireless connectivity

Many of these devices will (inter)connect by radio, whether they communicate only locally or, at least intermittently, with the global network.

Required global connectivity

More control of the physical media and new ways to use it:
Ultra Wide Band,
Cognitive radio, Mesh networks

In 10 years, we should have working software radio systems that demonstrate that spectrum can be managed in revolutionary ways. We should demonstrate highly efficient use (and reuse) of spectrum, and establish a regulatory regime that permits these modes of operation.

Location will be available indoors and outdoors

In 10 years, there should be a ubiquitous, open infrastructure that allows any properly equipped device to determine its location, both inside and outside, to a suitable level of precision.

Vision

In 10 years, any physical object should be able to tag itself in a way that links it to relevant information and functions in cyberspace.

Connecting the physical world

Virtualization of the real world

In 10 years, in a wireless network, the energy cost per bit of data transferred should be 1/1000th the cost today (2005)

Consume reduction mainly in the wireless communication

In 10 years, the network itself, and critical applications that run on it, should address the special needs that arise in times of crisis.

The network should be able to work in any situation: self healing

In 10 years, the Internet should be augmented with a new set of mechanisms for diagnosis and configuration, which can improve the usability of the Internet, reduce the need for manual intervention, and provide a linkage between application intentions and network behavior.

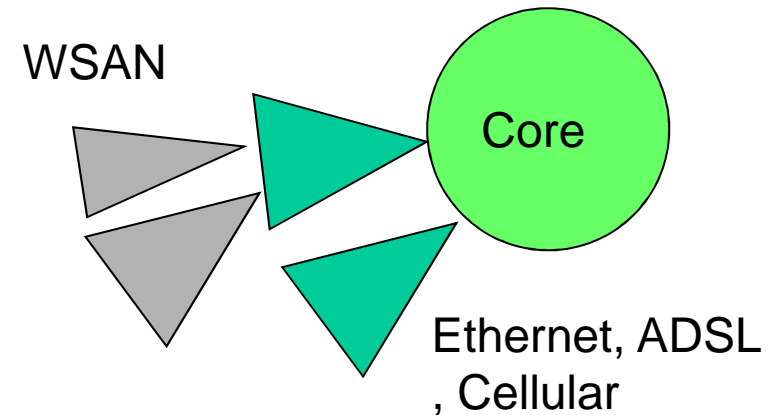
Self configuring, self healing, autonomic

Lets think in something that matches that vision

- Wireless sensor and actuator networks (WSAN)
 - Wireless
 - Ad-hoc (lack of infrastructure)
 - Self-X
 - Embedded processor
 - Handling small amount of information
 - Power consumption and cost are the key aspects to be reduced
 - Limited resources for processing and handling data

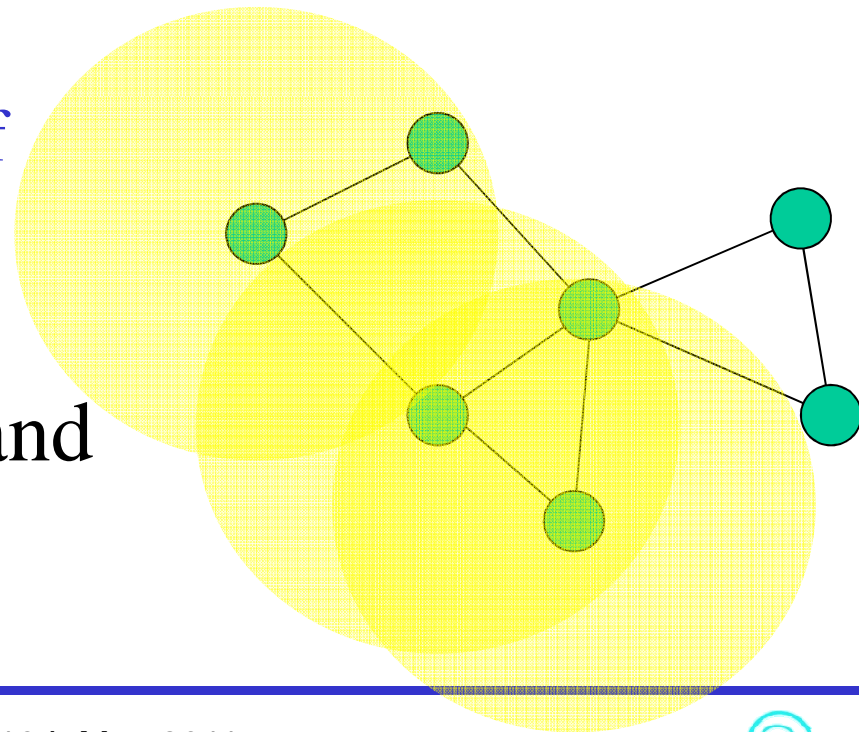
Some adds to the WSANs

- They are located at the pure edge of the network
- Mainly local communication but connected to the rest of the world with a gateway/proxy element
- There is not a standard solution for WSAN networking



Some adds to the WSANs

- Usage of Wireless Multi-hop
 - Efficient usage of the radio spectrum
 - Self configuring and self maintenance principles already used
- Usage of Ultra Wide Band
 - At least expected
 - IEEE802-15.4a



Some adds to the WSNs

- Ready to be ad-hoc
 - No infrastructure service is assumed to exist
 - No pre-assigned location is assumed
 - New addressing and routing paradigms such as the ones based on location
 - Self configuring and self maintenance principles already used
 - Mains electricity independent using batteries or energy harvesting

Some adds to the WSANs

- Context aware devices
 - Connectivity with neighbors
 - Path to the destination
 - Sensing the surrounding
 - and the battery level
 - Most of them are able to provide location
 - Relative

Other alternatives for focusing the Future Internet

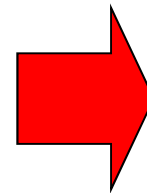
- Media
 - HD video
 - 3D
 - Virtual reality
- Networking
 - Fiber optics offering Terabps and optical switching
- User
 - Prosumer
- ..

Why WSANs as an alternative

- In addition to the already mention we have to:
 - Pay attention to the restricted
 - Satisfy the most of the users
- WSANs

Why WSANs as an alternative

- Already need a new networking paradigm
 - Scarce resources
 - Minimize the size code and complexity
 - So far existing solutions are adapted versions that requires help to interoperate with the global network



Cross layering is needed to improve the efficiency

- No layered model

End to end paradigm is broken

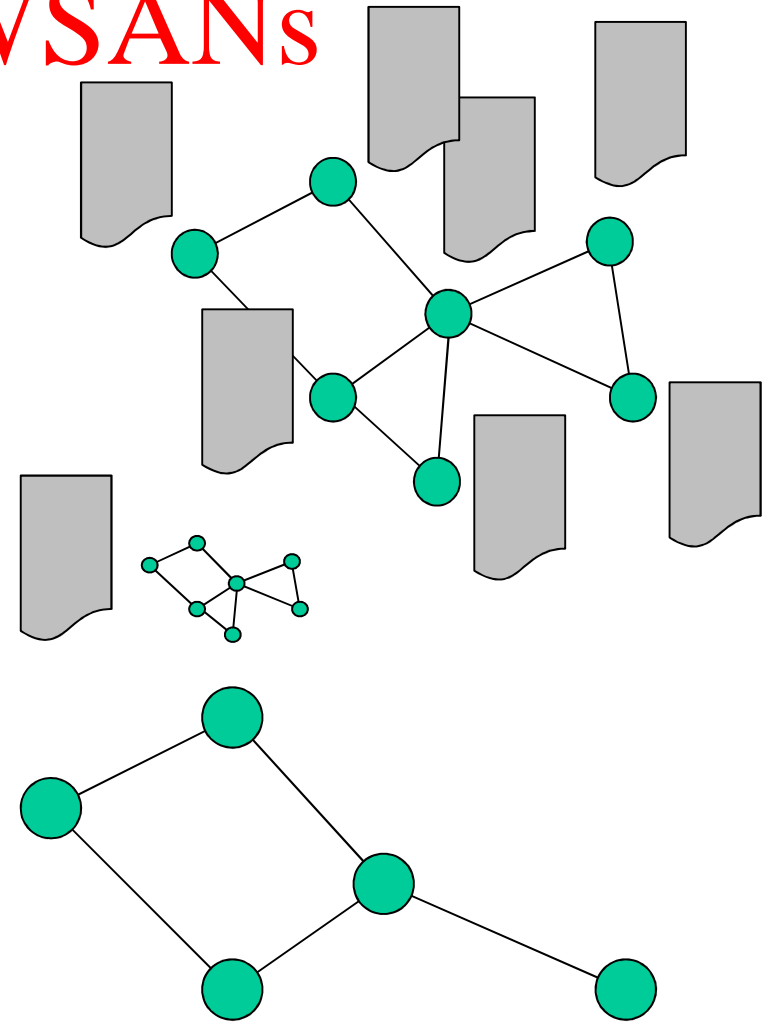
- Proxies
- Gateways

A Future Internet proposal inspired in WSNs

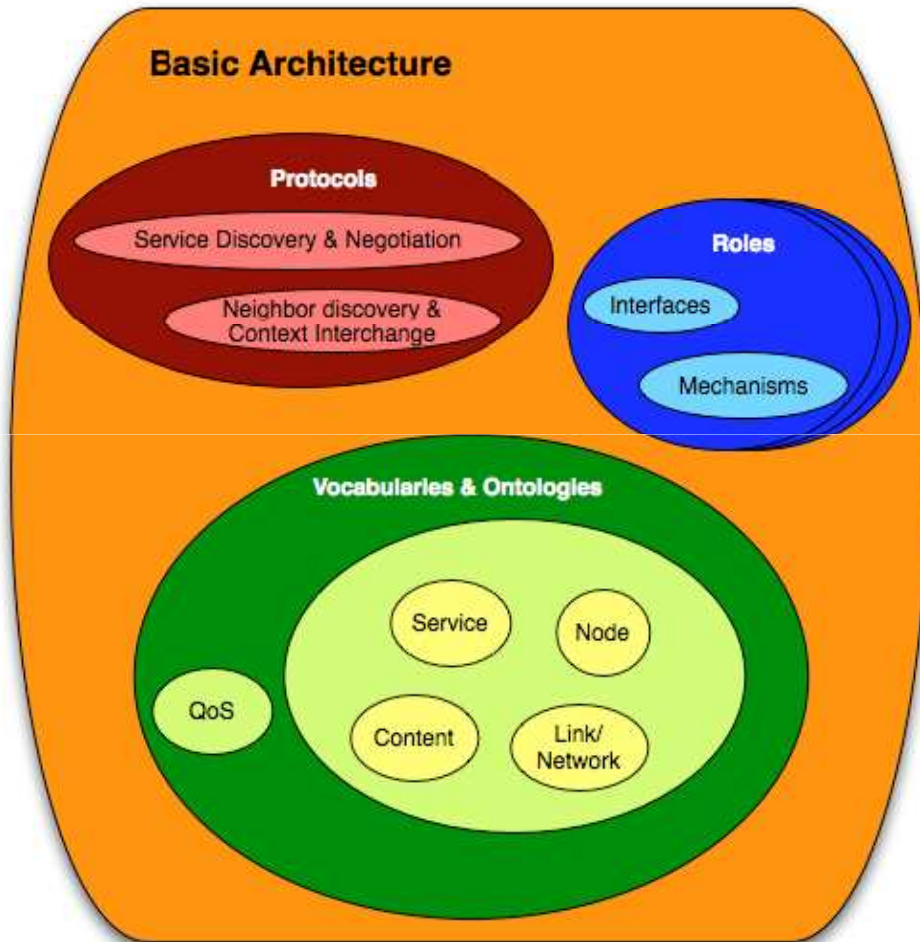
- Key aspects
 - Role based solution
 - Solves cross-layering issues
 - Minimize the resources
 - Helps to support the heterogeneity in the network due to variety of nodes and communication links
 - Combined use of routing (finding the path) and service/resource discovery
 - Support to datagram and virtual circuit

A Future Internet proposal inspired in WSNs

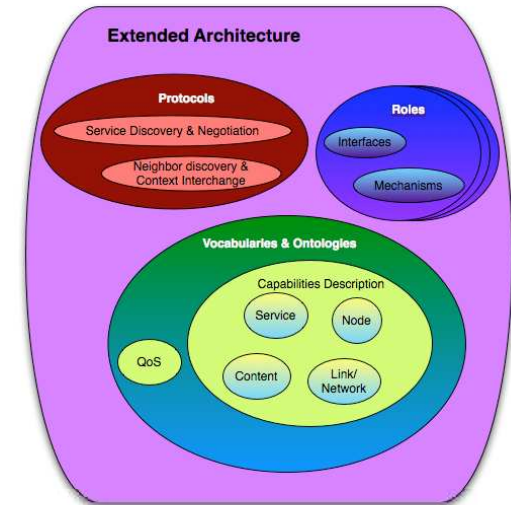
- Key aspects
 - Based on context
 - Service
 - Link
 - Node
 - Cluster
 - Use semantic description/addressing of resources and services
 - Basic
 - Extended



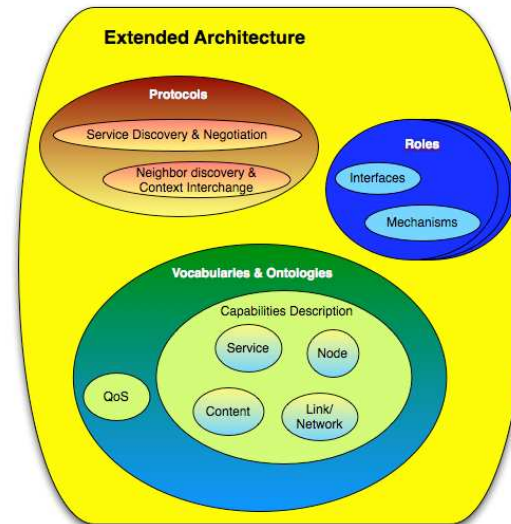
Future Internet Design



Internet of X →



Internet of Y →



Why a new proposal?

- RBA is a good starting point...
 - But needs further development
- SILOS
 - Limited scope (Cross-layering)
 - Lack of negotiation, rigid allocation/composition of silos
- RNA
 - Layered model
 - Some valid ideas that could be translated to SoA and RBA

Why a new proposal?

- 4WARD
 - Too complex solution
 - Lack of dynamism in role allocation and composition
 - Too focused on virtualization
- RINA
 - Simplistic: solves certain problems, lack of evolvability (lack of long term vision)
 - Lack of context-awareness, flexibility
- SONATE
 - SoA/RBA architecture with a similar approach
 - Oriented to micro-protocols and service composition
 - No negotiation

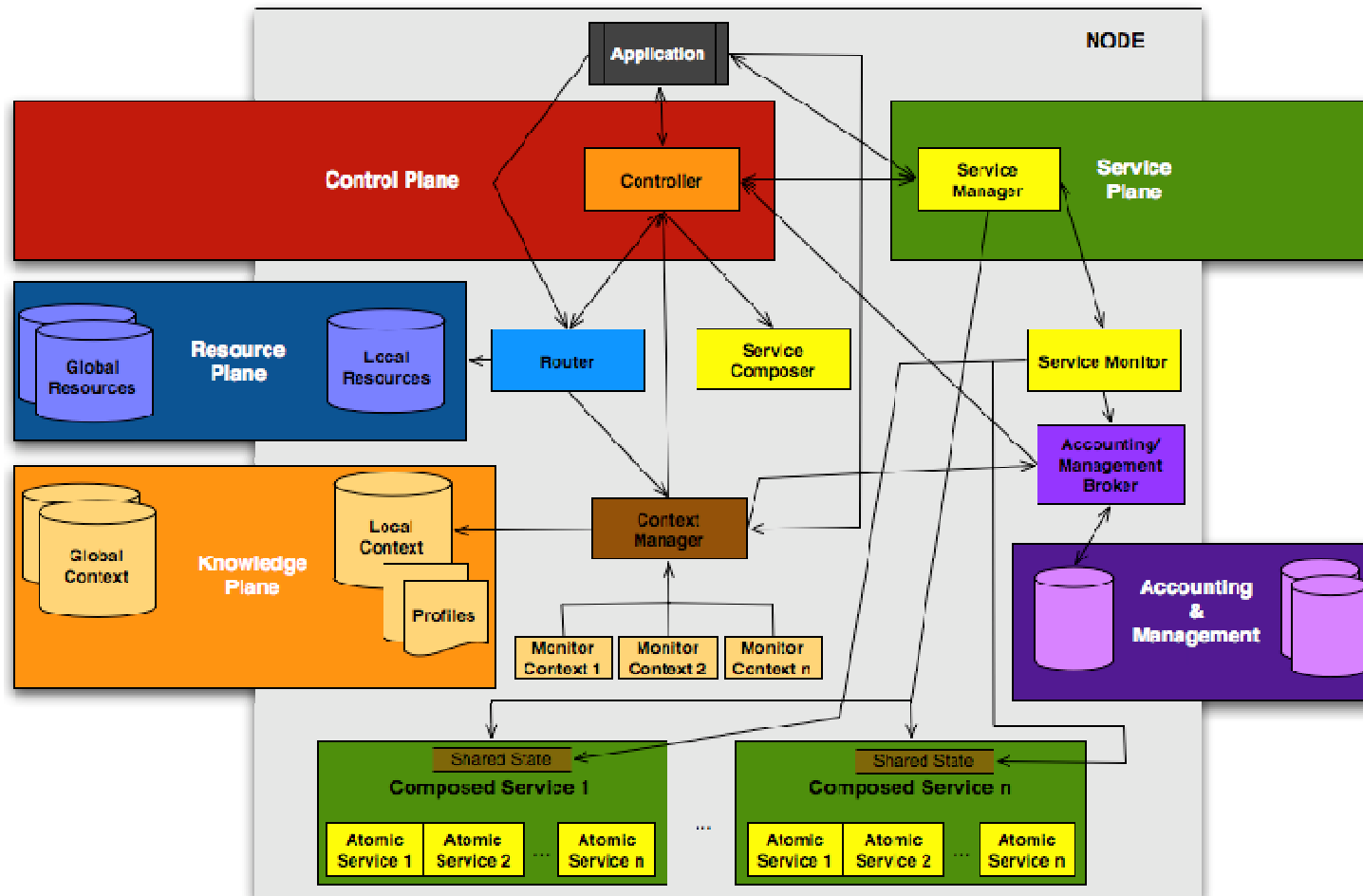
Proposed architecture

- Roles = atomic services
 - Compassable elements implementing basic services used in networking such:
 - Fragmentation and reassembly
 - Data modification detection and handling
 - Sequencing
 - Message retransmission
 - Congestion control
 - Transcoding
 - Data forwarding
 - ...

Proposed architecture

- Roles = atomic services
 - Operate on:
 - Symbol
 - Bit
 - Frame
 - Chunk
 - Object
 - Flow of bits

Architecture



Protocols

- Resource/service discovery with negotiation
 - Based on AODV/DSR

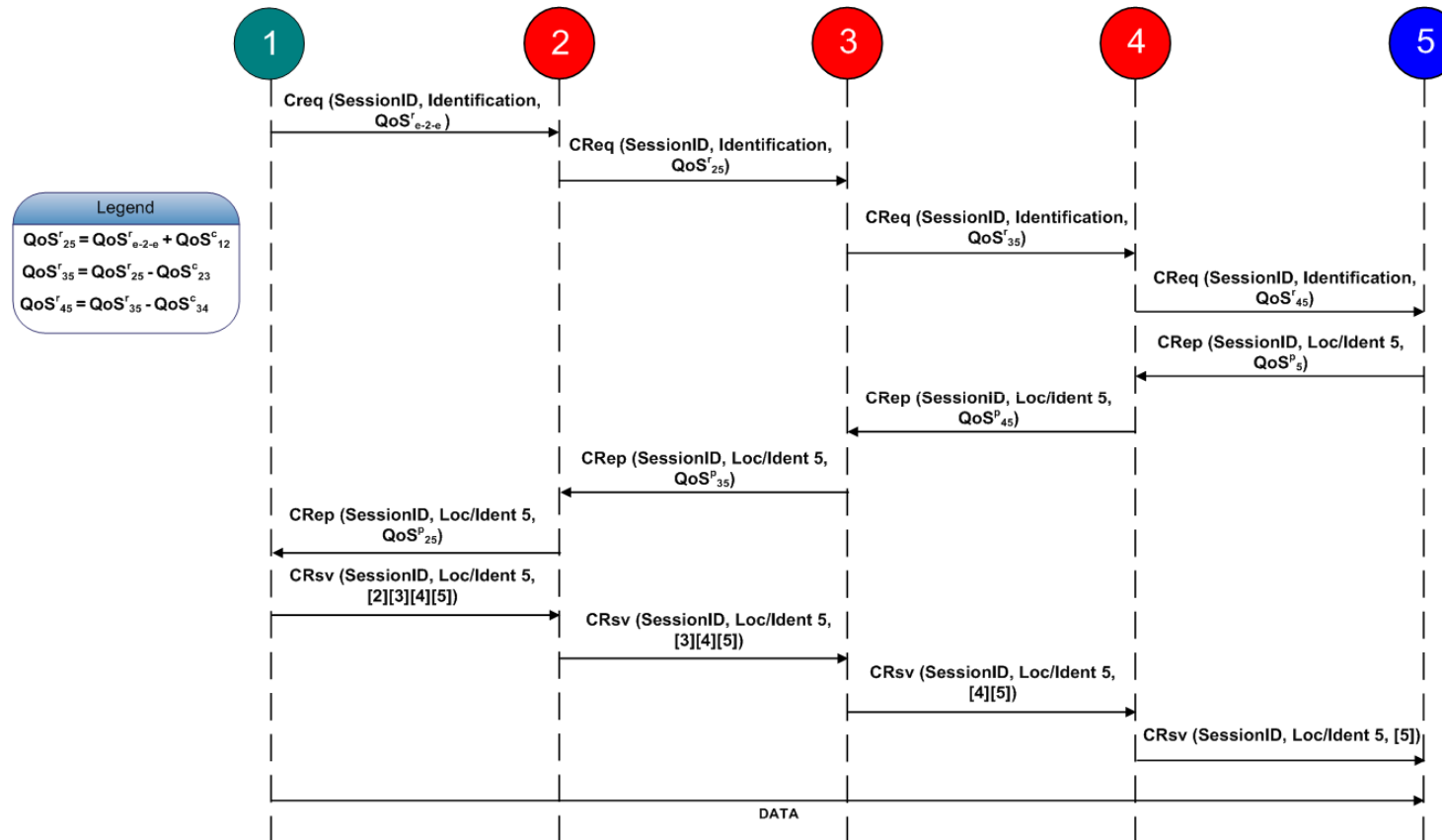
AODV

- Flooding with address
- Route information stored on the node
- Two way signaling
- Can discover several routes
- Route monitoring
- Local repair

Approach

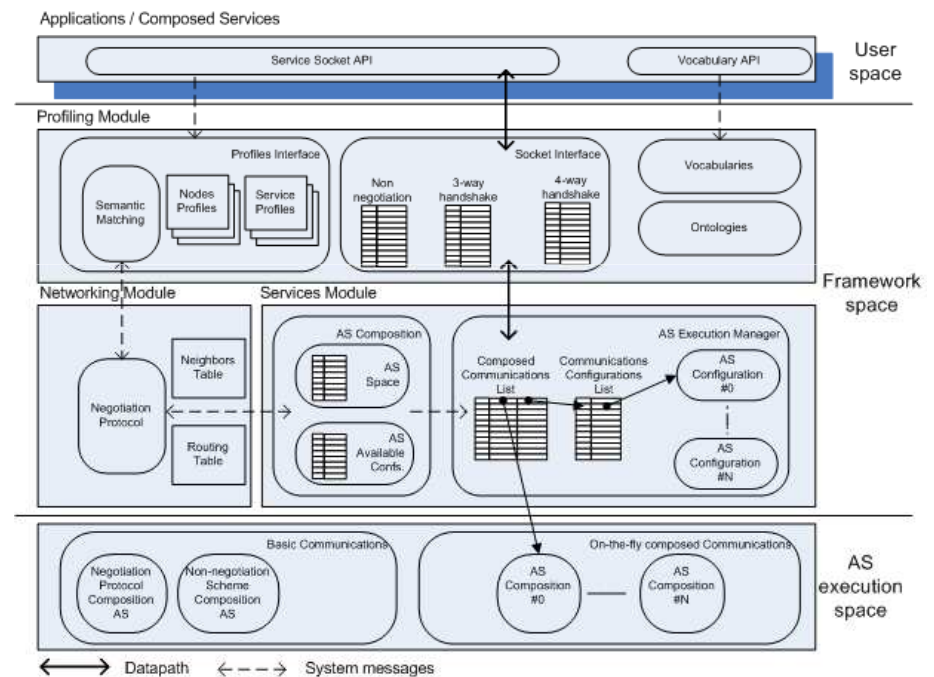
- Controlled based on attributes
- Resource reservation
- More than two ways for a complex negotiation
- Metrics to compare the routes
- Self monitoring
- Self healing

Route/service discovery with route creation and negotiation



Implementation

- Two platforms
 - Sensor platform
 - Subset of the architecture. Oriented to protocol validation
 - Using CC2430
 - Linux machine
 - Not yet functional
 - Debian
 - Mac OS



Implementation

- Data about implementation on CC2430

Task name	Code size (bytes)	RAM (bytes)
Profile Module	9031	972
Network Module	29652	562
Service Module	8536	391
MAC Layer	24915	270
OSAL system	11807	4279
Vocabulary API	1165	
Service Socket API	5251	
Total	90357	6474



Conclusions

- New vision of the Future Internet identified
- Complete architecture defined.
 - See the project web page for further documentation
<http://www.i2cat.cat/es/projecte/tarifa>
- Open source implementation for Linux platforms available soon (July)

Future and ongoing work

- Atomic service allocation according service requirements (QoS) and link/node characteristics
- Service composition
- Introduction of flexible physical and links layers for a complete atomic service allocation
- Emulation of layered services such IP, TCP, IP/TCP
- Migration strategies
- Inter-domain service/resource discovery/route creation
- More complex implementation
-

Questions, comments or suggestions