



# Towards Autonomic Wireless Networking for the Future Internet

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# Autonomic Wireless Networking

## Agenda

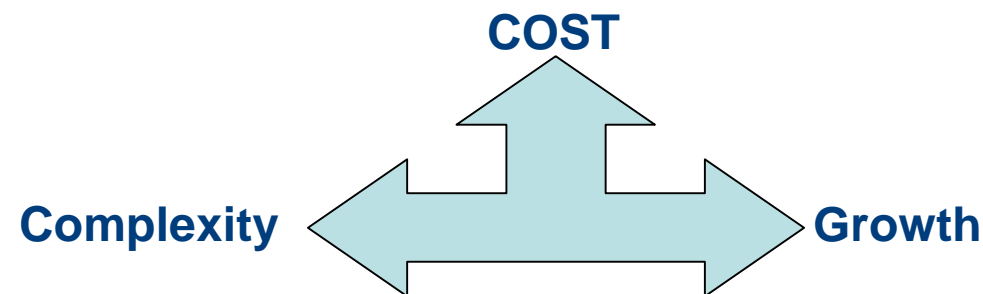


- Introduction and Motivation
- Architectural Issues
- Implementation Issues
- Conclusion



# Introduction and Motivation

- The Internet
  - Designed and optimised for **fixed** networks
  - Internet **technology**: protocols, hardware, ...
  - And Internet **economics**: business models, value networks, ...
  - Exponential growth → question of future sustainability
  - Wireless and mobile devices proliferation → new landscape
- Complexity Vs. Growth
  - “IT **complexity** has to be simplified, or **growth** will begin to be hampered by the **cost** required to support it.” [IBM Website]





# Introduction and Motivation

- “Future Internet” (FI): a federating RTDI theme
  - (a) **revolutionary** or “**clean-slate**” approaches suggest radical new architectures that are incompatible with the existing Internet
  - (b) **evolutionary** approaches aim at gradually improving the existing Internet design with new concepts
    - Research, Technological Development and Innovation
- Wireless in the Future Internet
  - Wireless and mobile/cellular networking
  - Internet-connected hosts: billions (trillions?) of wireless devices
    - from tiny sensors to powerful mobile phones
    - novel form factors not yet invented (M2M, IoT)
  - A wireless Internet of unprecedented scale is emerging.
  - Significantly important AND increasingly complicated
  - *We can't afford to overlook wireless networking*



# Introduction and Motivation

- Our motivation
  - To influence the ongoing design of the FI to fully integrate mobile & wireless networks in a simplified, automated & scalable manner
- Our aim
  - Address the lack of critical functionality from today's Internet
    - Management decentralisation
    - Seamless mobility
    - Spontaneous communications
- Our proposition
  - Seamless wireless networking in the FI will be achieved by applying “**autonomic concepts**” based on **policies**.
    - Adoption of distributed policy-based management (PBM)
    - PBM: inspired by management sciences (enterprise, government)



# Introduction and Motivation

## Requirements for future wireless networks

### 1. Address scalability

- Unprecedented numbers of wireless/mobile devices
  - several per person
- Extremely dense wireless deployments

### 2. Counter complexity and heterogeneity

- Gap: high-level management goals & low-level processes
- Technology independence – standards conformance
- Interoperability

### 3. Offer flexibility to adapt to change

- Fast and efficient adaptation to changing business policies
- Maintain profitability for owners & improved end-user experience

### 4. Maintain a user-centric character.

- “user-centricity” + openness of Internet standards → have fueled user creativity and innovation (Internet Society)
- User-centric Future Internet → Net neutrality



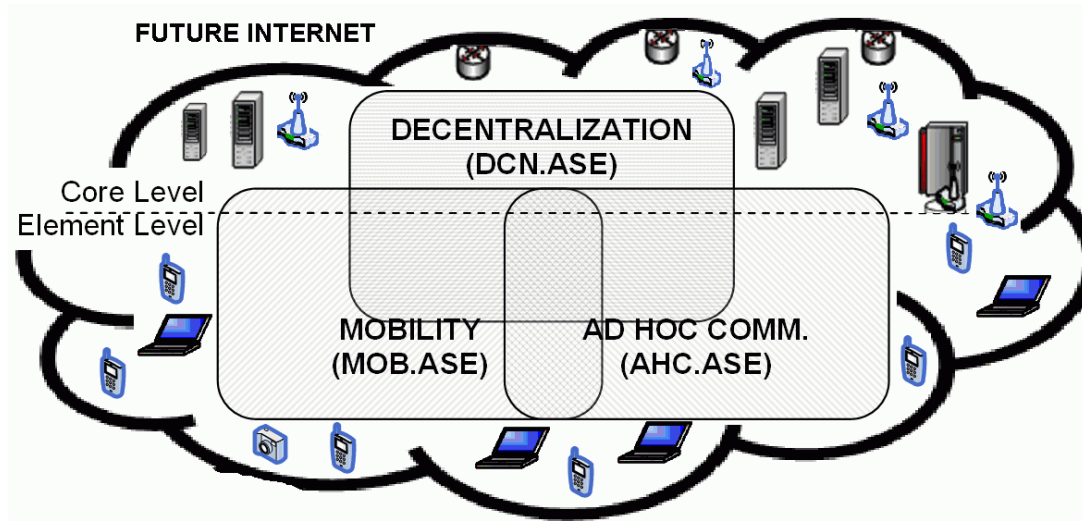
# Architectural Issues

- Autonomic management and self-organisation
  - Envisioned as a natural path for the Future Internet
  - Expected to simplify the painstaking tasks of managing complex large-scale systems through the use of automated closed-loop management
- Design of three autonomic support entity (ASE)
  - Extension of the ongoing Future Internet design
  - Maintain backward compatibility with today's Internet
    - Based on open standards and interfaces
  - We concentrate on the design of those architectural entities that would facilitate **autonomic wireless networking**
    - Following an evolutionary path
    - Rather than proposing a holistic framework for the FI
  - *This approach should ensure the interoperable and future-proof integration of ASEs with the evolving design of the FI*



# Architectural Issues

- Autonomic Support Entities for the Future Internet
  - Three cooperating ASEs
    1. Decentralisation (DCN)
    2. Mobility (MOB)
    3. Ad hoc communications (AHC)



- Entities will operate and cooperate at different levels
  - Core level: operator-owned network core
  - Element level: user-owned devices respectively.





# Architectural Issues

## Decentralisation ASE

- Purpose
  - enable collaborative management of large-scale networks: wireless access networks & their interconnection with fixed ones
- Challenges
  - efficient & scalable management of wireless PAN (WPAN).
  - secure interactions of mobile and nomadic WPANs with authorised or non-authorised WLANs, as well as WANs
- Functionality
  - based on distributed policy-based management (DPBM)
  - spans equally between core and element levels
  - Core: policy definition, conflict resolution, business planning
  - Element: policy distribution, user preference enforcement
    - For the Element-level end-user functionality, the Decentralization ASE will cooperate with the Mobility and Ad hoc communication ASEs, provisioning them with the appropriate policies that guide their autonomic behaviour



# Architectural Issues

## Mobility ASE

- Purpose
  - Enable the seamless connectivity of users between different access networks and different devices as well
- Challenges
  - Various addressing schemes → automate IP address acquisition
    - scenarios involving different wireless technologies
  - Fast and efficient handoff mechanisms → seamless connectivity
    - not only between technologies but between devices as well
- Functionality
  - Spans between core and (mainly) element levels
  - End-devices host the required processes and algorithms to autonomically manage their mobility, complemented by limited functionality from the network core and the cooperating Decentralization ASE



# Architectural Issues

## Ad Hoc Communications ASE

- Purpose
  - cater for the users' need for spontaneous communications
  - enable easier user to user wireless interactions, either for leisure, socialising or work
- Challenges
  - proliferation of peer-to-peer technologies and social networking
  - unique combination of location-awareness, user-generated content and variable user density
  - → deployment of new services based on wireless ad hoc comm.
- Functionality
  - spans between core and (mainly) element levels
  - To facilitate spontaneous communications in an autonomous ad hoc manner, without requiring significant intervention from the network core. Limited cooperation with the Decentralisation ASE will allow e.g. security and privacy policies to be retrieved and used during user communications.



# Implementation Issues

## Decentralization ASE

- New functionality in the form of extensions
  - Implementation hurdles
  - Adoption hurdles
  - Outline towards their integration to the FI
- Decentralization ASE
  - Distributed Policy-Based Management (DPBM) Tools
    - Need to address the issues of collaborative policy definition, policy distribution and replication, and distributed policy enforcement
  - Implementation of DPBM → assessed, based on the overheads induced on the managed network
  - Critical issue: distributed enforcement and monitoring
  - Examples of software that may be used are OpenLDAP Directory Server, Apache Axis Web Services Framework, DMTF Common Information Model (CIM), and CIM Simplified Policy Language (CIM-SPL)



# Implementation Issues

## Mobility and Ad Hoc Comm. ASEs

- Mobility ASE
  - **IPv6** is expected to gradually replace **IPv4** at the Internet's core, but the complete phasing out of IPv4 cannot be estimated yet
    - need for **coexistence** and interworking of hosts with either protocol, as well as dual stack hosts, emphasising the implications on wireless connectivity and user mobility
    - Fast and efficient **handoff** mechanisms will need to be investigated to enable seamless connectivity for users
    - not only between different **technologies** but also **between devices**
- Ad Hoc Communications ASE
  - **User-to-user** wireless interactions are expected to increase in the Future Internet, either for leisure, socialising or work.
  - Increasing complexity and **heterogeneity** of networks and devices, coupled with security concerns, can hamper the wider adoption of ad hoc networking.
  - Implement simplified **user-oriented wireless networking**



# Implementation Issues

## Cooperating self-\* Entities

- Mobility ASE & Ad Hoc Communications ASE will cooperate with Decentralisation ASE and Internet core
  - To acquire the appropriate policies that will guide their autonomic behavior
- Policies will be defined to enable self-\* properties
  - i.e. self –configuration –optimisation –protection –healing
  - E.g.: updated policies by AHC.ASE can assist the self-protection of users from malicious ad hoc connections in their vicinity
  - E.g. Self-configuration: provision of policies to the MOB.ASE, to transparently assign IP addresses to wireless hosts (conflicts)
- The combination of self-\* capabilities will gradually lead towards fully **self-managing wireless networks**
  - **Autonomic vision** for wireless networking



# Conclusion

- We have attempted to identify important issues for the integration of autonomic wireless networking to the FI
- Revisiting the identified Future Internet requirements
  - **Scalability**: should be addressed by employing a well-designed and lightweight distributed PBM infrastructure
  - **Complexity and heterogeneity**: anticipated by high-level policies, employing technology agnostic middleware to bridge the gap between management goals & low-level algorithms
  - **Flexibility**: with the adoption of a policy-based architecture → providing non-expert managers a high-level business policy-based interface with descriptive parameters
  - **User-centricity**: should be maintained by offering unrestricted communication options for users to autonomously deploy their own autonomic wireless networks.



# Conclusion

## Summary and Outlook

- Approach: based on three autonomic support entities (ASE) that cooperate based on policies
  - entities will address the lack of management decentralization, seamless mobility, and spontaneous communications from today's Internet
- We envision the expected impact from the successful integration of the proposed architectural extensions
  - The implementation and adoption of the proposed concepts are expected to enhance the FI with the self-managing deployment for wireless networks and future paradigms for mobile networking
  - Research efforts can offer opportunities for novel services, such as location-based wireless social networking or wireless P2P.
  - Continued proliferation of personal wireless technologies and networking, encompassing the scalable growth of a Wireless Future Internet.





# Towards Autonomic Wireless Networking for the Future Internet

Thanks for your attention...

Questions?

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