Thoughts for the Future Internet (FI) Reference Model:

Consideration of Autonomic/Cognitive Mechanisms for Managing Wireless and Wireline Segments

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Overview

- Requirements in the Future Internet era call for efficient/intelligent management and the exploitation/integration of various networking schemes,
  - Autonomic/cognitive management of the infrastructure
  - Schemes for accessing the Future Internet: operator-governed opportunistic networks and respective cognitive management systems
  - The basis includes the achievements in the area of autonomic/cognitive management of wireless technologies

- Provisions should be made for representing the management functionality and the additional access structures in the FI reference model
Requirements in FI era:
- Demanding situations in terms of Quality of Experience - Quality of Service, in order to adequately support a wide range of applications, including video, voice, data flows, etc.
- Changing situations (potentially unpredictably)
- Efficiency in QoE and QoS provision in terms of total cost of ownership, e.g., OPEX, CAPEX, etc., decisions with “green” footprint
- Evolution of existing and emergence of new business models (roles and entities), in order to utilize new opportunities opened by the FI
- Coherence, convergence, stability, scalability

Main direction:
Autonomic network elements in infrastructure (access points, routers, gateways, etc.): behaviour determination based on
- Context changes (alterations in environment or internal system status)
- Policies (rules), capabilities (profiles)
- Optimization mechanisms
- Knowledge, experience development/sharing

Intelligence evolution and deployment
- Distributed reactive/proactive situation handling based on knowledge development and sharing
- Wireless self-organized networks exploiting cognition techniques
- Distributed traffic engineering in wireline segments exploiting cognition techniques

Federation
- Existence of autonomic systems for (specialized in) managing particular technologies/segments/networks
- Federation of these autonomic systems for end-to-end, optimal provision of applications
- Interface definition and standardisation

Validation
- User-oriented criteria; Business drivers
- Approach based on prototyping, experiments, trials, pilots: Result analysis and system fine-tuning
- Consolidation and trust generation
Further Schemes for Wireless Access to the Future Internet

- **Main direction:** Opportunistic networks and cognitive management systems for efficient application provision in the Future Internet

- **Opportunistic networks**
  - Operator governed (through resources, policies, and information/knowledge)
  - Coordinated with the infrastructure
  - Comprise network elements of infrastructure and devices (envisaged in the Future Internet)
  - Building on: spectrum management, secondary usage, infrastructure-less networks, social networks
  - Context, profile, policy, knowledge-aware routing

- **Cognitive management systems**
  - Provide the means for feasibility determination, creation, maintenance, handling of forced terminations

- **Control Channels for the Cooperation**
  - Information definition, signalling flows, protocols (packet structures, exchange)

**Requirements:**
- Numerous diversified applications, social networking, prosumer concept -> applications with a “localized” interest
- Increased interest for wireless
- Utmost efficiency in resource provision (resource utilization, “green” decisions, further lower costs)
- Resolve potential congestion situations, expand infrastructure coverage when/where temporarily needed, efficiently offer localized applications and content

Thoughts on FI Reference Model
Autonomic/cognitive elements (to be further developed - perhaps beyond current FI RM discussion)

- **Structure**
  - Context
  - Profiles
  - Policies
  - Cooperation
  - Knowledge - Learning
  - Decision Making

- **Context-Profiles**
  - Representation (traffic, mobility, radio quality, element status)
  - Identification (unsupervised, supervised techniques)
  - Reasoning
  - Profiles: Elements, users, applications

- **Knowledge-Learning**
  - Contexts encountered in time and space
  - Algorithms and solutions (configurations) applied per context
  - QoS offered per context and configuration

- **Cooperation**
  - Knowledge sharing
  - Joint handling of contexts

- **Decision Making**
  - Classical optimization algorithms
  - Decisions based on knowledge developed and shared with other elements
  - Output: configuration actions related to routing, congestion control, air-interface configuration, etc.

- **Policies**
  - Which objective to be pursued per context
  - Which constraints to be respected per context
  - Strategies to be used for context handling
  - Concrete suggestions/rules (including also solutions) for handling various contexts
Conclusions

- Requirements in the Future Internet era call for efficient/intelligent management technologies and the exploitation/integration of networking schemes

- Provisions should be made for representing the management functionality in the FI reference model

- Blending with other FI initiatives and concepts, e.g., IoT, IoS, SaaS, etc.