A Platform-Independent Model for Autonomously Reconfigurable User Equipment and Network Elements

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Outline

✓ Scope and Vision

✓ Challenges

✓ Functional Modelling

✓ UML Model

✓ Conclusions
Scope & Vision (1)

Cognitive Reconfigurable Next-Generation Networks

Heterogeneous multi-radio systems
coupled with
all-IP core networks
integrating software/cognitive radio &
selfware capabilities
### Scope & Vision (2)

#### A. RAT/RAN evolution
- **IEEE**: WPAN (802.15.3a, 802.15.4), WLAN (802.11a/g/n), WMAN (802.16a/d/e/h (WiMAX)), WRAN (802.22), SDR/CR-oriented standards (P1900), interoperability considerations for handover between heterogeneous networks (802.21 MIH)
- ArrayComm’s i-Burst, Flarion’s FLASH-OFDM, DoCoMo Gbps downlink packet transmission in field experiments
- HSDPA, E-UL, MBMS, Super 3G
- **3GPP LTE**: higher data rates with reduced latencies, increased spectral efficiency, lower power consumption at the TE, multi-RAT support, self-configuring RANs, and flexible functional split between RAN and CN

#### B. CN Evolution & Service Domain
- **3GPP SAE**: efficient network access selection according to operator policies and user preferences, inter-access mobility, benefit from the support of reconfigurable radio interfaces in the terminal
- **3GPP IMS**: session-based CN architecture using SIP: considered as the next-generation CN paradigm for service provision to wireless devices
- **ETSI TISPAN**: system enhancements to IMS for fixed broadband access
  - Network attachment (NASS), Resource and admission control (RACS), Emulation of legacy systems (PSTN/ISDN), “Core IMS”

#### C. Software-Defined Radio & Cognitive Radio
- **SDR Forum**: set of requirements/steps for downloading radio software to UE
- **Dynamic Spectrum Access & Exchange**

#### D. Plane Mgmt = ITU-T TMN FCAPS
- **Faults/Configuration/Accounting/Performance/Security**
  - Usually network-initiated: *managed systems*

**Autonomics = S-CHOP**
- Self-Configuration/Healing/Optimization/Protection
  - => *governed systems*
Challenges

What relevant problems are being solved?

1. Centralised client-server-based decision-making relationship between reconfigurable elements and attached network infrastructure

   **Solution:**
   Autonomic decision-making and self-management facilities

2. Monolithic control & management approaches for system architecture modelling

   **Solution:**
   Modular, intermediary, multi-plane and layer-based approach allowing independent evolution paths

3. Pre-installed features on equipment during manufacturing

   **Solution:**
   Software upgrades and component-based techniques for dynamic protocol replacement

4. Limited context and resource management

   **Solution:**
   Knowledge-based self-awareness of network elements allowing dynamic resource management
Functional Modelling (1)

End-to-end reconfiguration

✓ **Reconfiguration**: A set of *policy-driven tasks* for modifying the operation of a system, network node or UE, or functional entity

✓ **End-to-end notion**: user and control plane interactions may occur from source to destination

  => Should be coordinated by a *cohesive support plane*

Reconfiguration Management Plane (RMP):

✓ **Coordinated control and management functions** for

  => *governing* the interactions between the involved entities

  ⇒ *orchestrating the decision-making*

  ⇒ *coordinating the enforcement* of reconfiguration mechanisms

✓ **Enabler of autonomously reconfigurable elements**

  => Target mid-term reconfigurable elements: UE, BS

✓ self-generated policies based on context,

✓ peer-to-peer-style-controlled (3GPP: UE-PCRF),

✓ service-based locally-enforced reconfiguration strategies and policy rules
Functional Modelling (2)

OMG MDA PIM and 3GPP IRP specification stages

1] IRP Requirements:
   Conceptual and use cases definitions

2] IRP Information Service (IS)

2a) IRP IS:: Interface IRP
   Operations and notifications in a network-agnostic, protocol-independent manner

2b) IRP IS:: NRM (Network Resource Model)
   Network-awareness; protocol-independence

2c) IRP IS:: DD (Data Definition)
   Network-awareness; protocol-independence

3] IRP SS (Solution Set)
   Network-awareness; protocol-awareness
Functional Modelling (3)

RMP Functional Model

Knowledge & Context Management (KCM)
- Performance Management (PeM)
- Profile Management (PrM)
- Resource Management (RsM)

Decision-Making and Reconfiguration Management (DM-RM)
- Autonomic Decision-Making & Reconfiguration Management (ADM&RM)
- Policy-Management and Self-Governance (PMSG)

Self-Configuration & Self-Management (SC-M)
- Self-Configuration (SeCo)
- Cognitive Self-Healing (CoSH)
- Software Download Management (SDM)
- Pervasive Access and Security Control (PASeC)
- Reconfiguration Charging Control (RCC)

Cognitive Service Provision (CSP)
- Content and Service Adaptation (CSA)
- Reconfiguration Services Discovery (RSD)
Functional Modelling (4)

Overall Functional Model & Reference Points

Legend
- ADM&RM: Autonomic Decision-Making & Reconfiguration Management
- CoSH: Cognitive Self-Healing
- CPC-C: Cognitive Pilot Channel Controller
- CSA: Content and Service Adaptation
- DNPM: Dynamic Network Planning and Management
- JRRM: Joint Radio Resource Manager
- MM: Mobility Management
- PASEC: Pervasive Access and Security Control
- PeM: Performance Management
- PMSG: Policy Management and Self-Governance
- PrM: Profile Management
- RCC: Reconfiguration Charging Control
- RSD: Reconfiguration Services Discovery
- RsM: Resource Management
- SAM: Spectrum Allocation Manager
- SDM: Software Download Management
- SeCo: Self-Configuration
- SEM: Spectrum Economic Manager
- STM: Spectrum Trading Manager
- TE: Traffic Estimator
Knowledge & Context Management module

**PrM: Profile Management**
- Aggregates profile information:
  - User profile
  - Business profile
  - Application & service profile
  - QoS profile of specific reconfiguration sessions
  - Profile of discovered RATs & NW profile
  - Device profile
- Evaluates all profile data and generates the **reconfigurability classmark**: a dynamic label that describes the capabilities of the entity in terms of supported reconfiguration actions
  - Profile retrieval/update
  - Component-based profile information representation

**RsM: Resource Management**
- Resource monitoring (including CPC monitoring)
- Resource allocation
- Global resource optimization

**PeM: Performance Management**
- Performance report generation
**Decision Making & Reconfiguration Management**

**ADM&RM**
- Autonomic production of definitive reconfiguration actions (to be executed and enforced by other functional entities)
- Orchestration of mobility signalling
- Reconfiguration session management
- Negotiation control loop functionality
- Peer membership functionality

**PMSG**
- Self-generation of policy rules
- Legacy policy decision point & caching (prioritization, filtering, caching)

**Interfaces**
- KCM
- SC-M
- CSP
Self-Configuration & Self-Management

**SDM**
- Software-download transfer
- Reliable software-download mode switching from many-unicast to multi-cast and broadcast mode
- Local post-download procedures

**SeCo**
- Protocol- and cross-layer reconfiguration
- Protocol-mode switching
- Self-optimization of resources

**CoSH**
- BS auto-configuration
- Notification of mis-configurations
- Self-recovery

**PASeC**
Access control, authentication, and authorisation:
- Mutual authentication of autonomous entity and its peer (e.g., the reconfigurable terminal and the network attachment server)
- Authorisation to attach or connect to peers
- Verification of authorisation to download
- Determination of security control mechanisms (e.g., agreement on security keys) prior to the transfer of downloadable software

**RCC**
- Generation of charging records due to reconfiguration events (SW DL; DSA, etc.)
Conclusions

Overall Approach

✓ Modelling approach *in line with OMG MDA PIM practice*

✓ System Architecture:
  ✓ Captures *SDR/CR/autonomics* aspects (but *not the kitchen sink syndrome…*)
  ✓ *Separates control vs. management* plane functions
  ✓ Introduces *reference points / interfaces*

Ongoing & future work

✓ Network Architecture
  ✓ Separation between *functional modelling* (system architecture) and *physical configurations* (network architecture)
  ✓ NW architecture introduces domain/topology issues

✓ Generation of a set of PSMs (PIM to PSM transformation)
Thank You!

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