

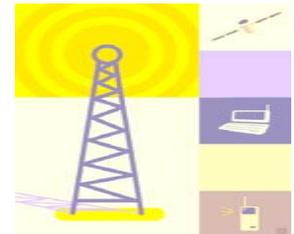


A Platform-Independent Model for Autonomously Reconfigurable User Equipment and Network Elements

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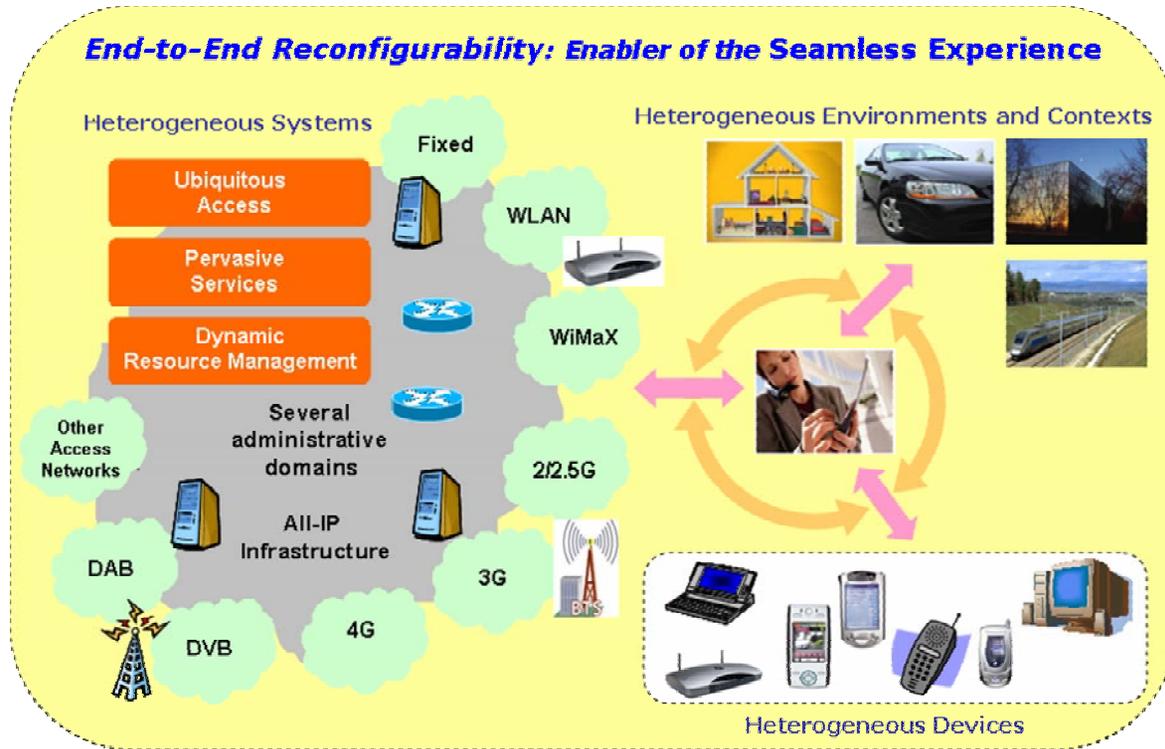
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Outline

- ✓ **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



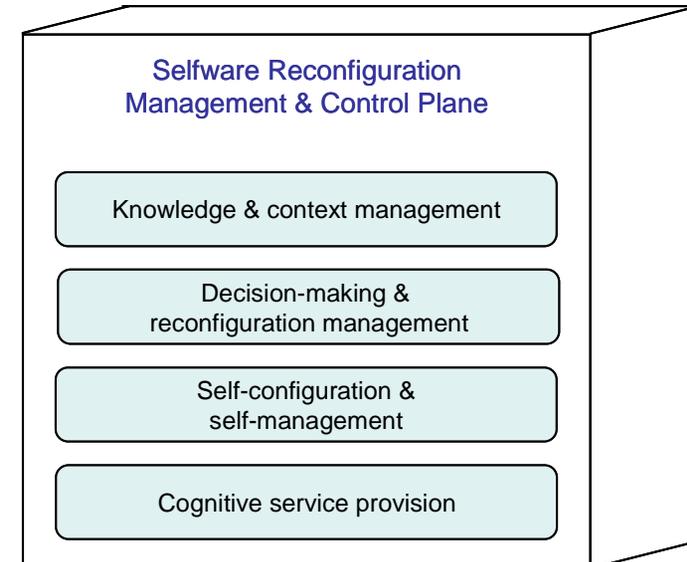
Functional Modelling (1)

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*

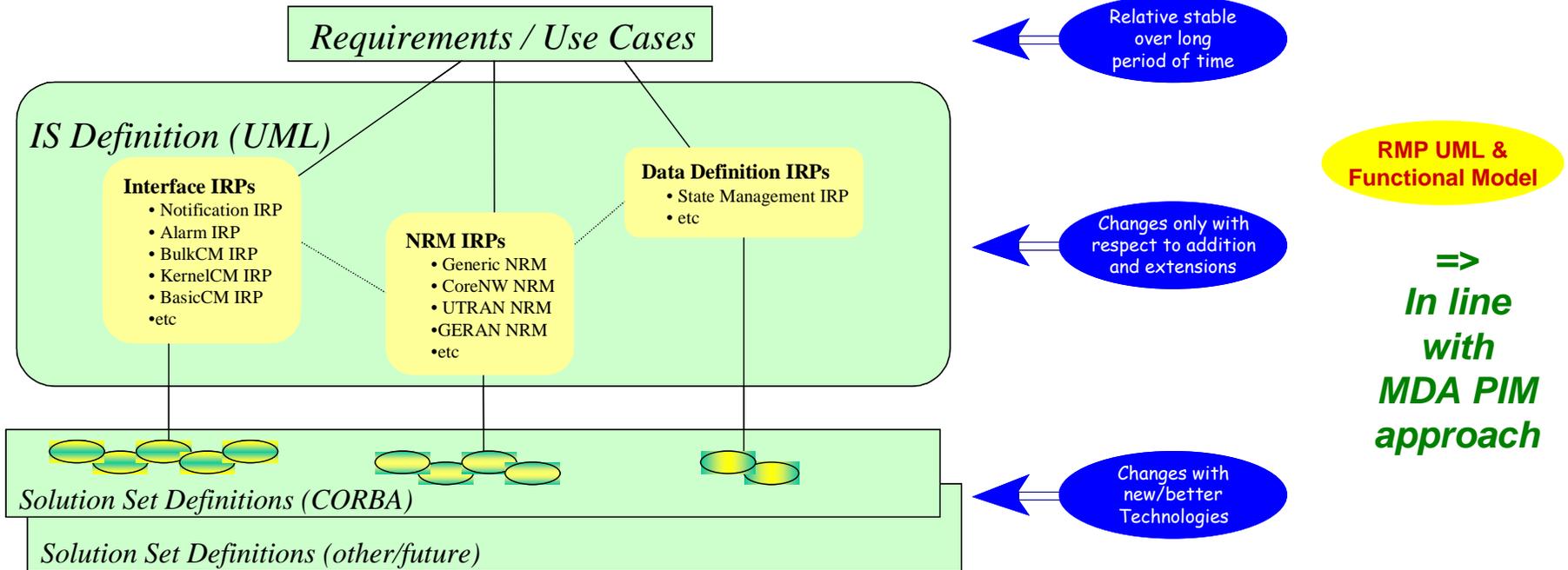
Reconfiguration Management Plane (RMP):

- ✓ **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

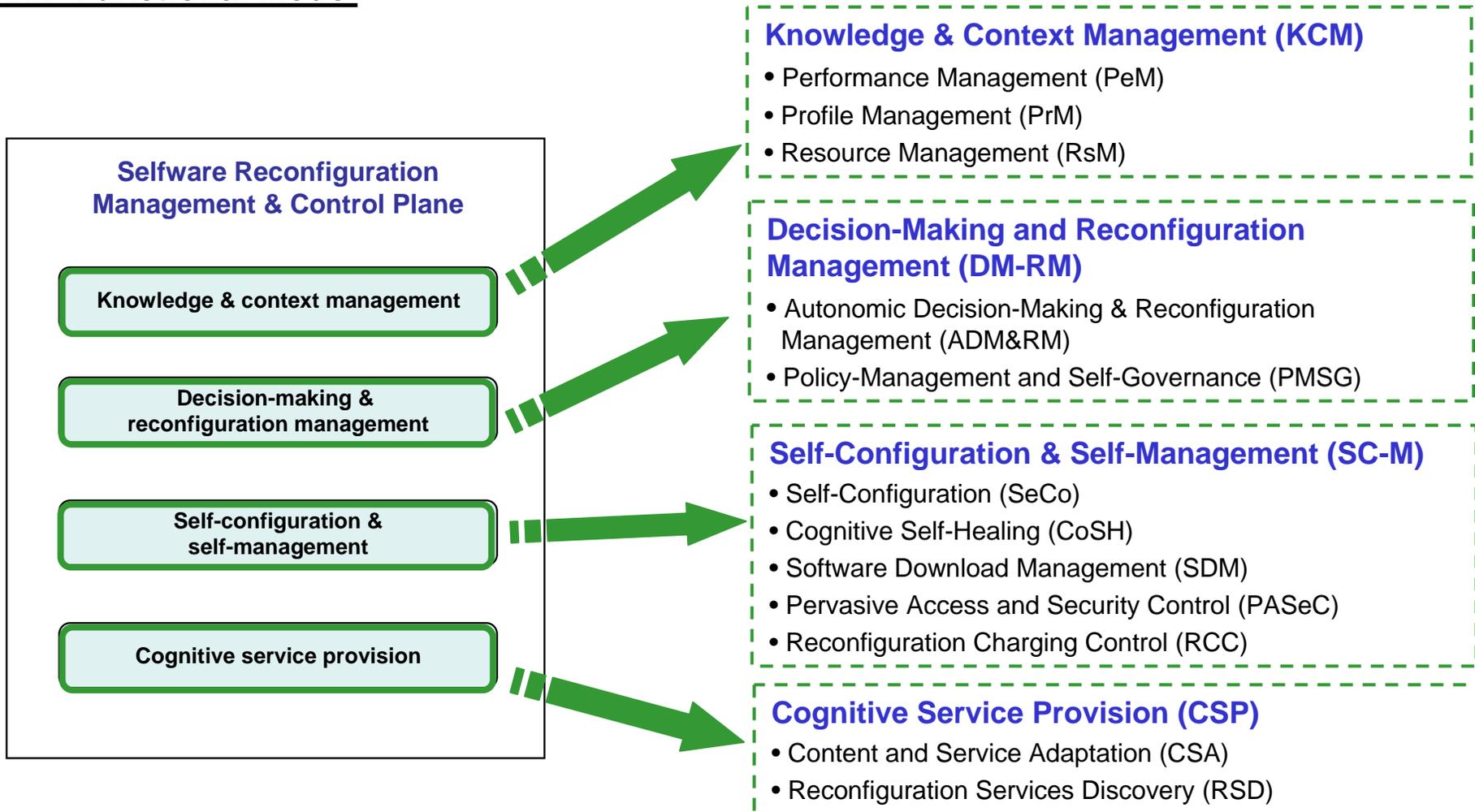
3) IRP SS (Solution Set)

Network-awareness; protocol-awareness



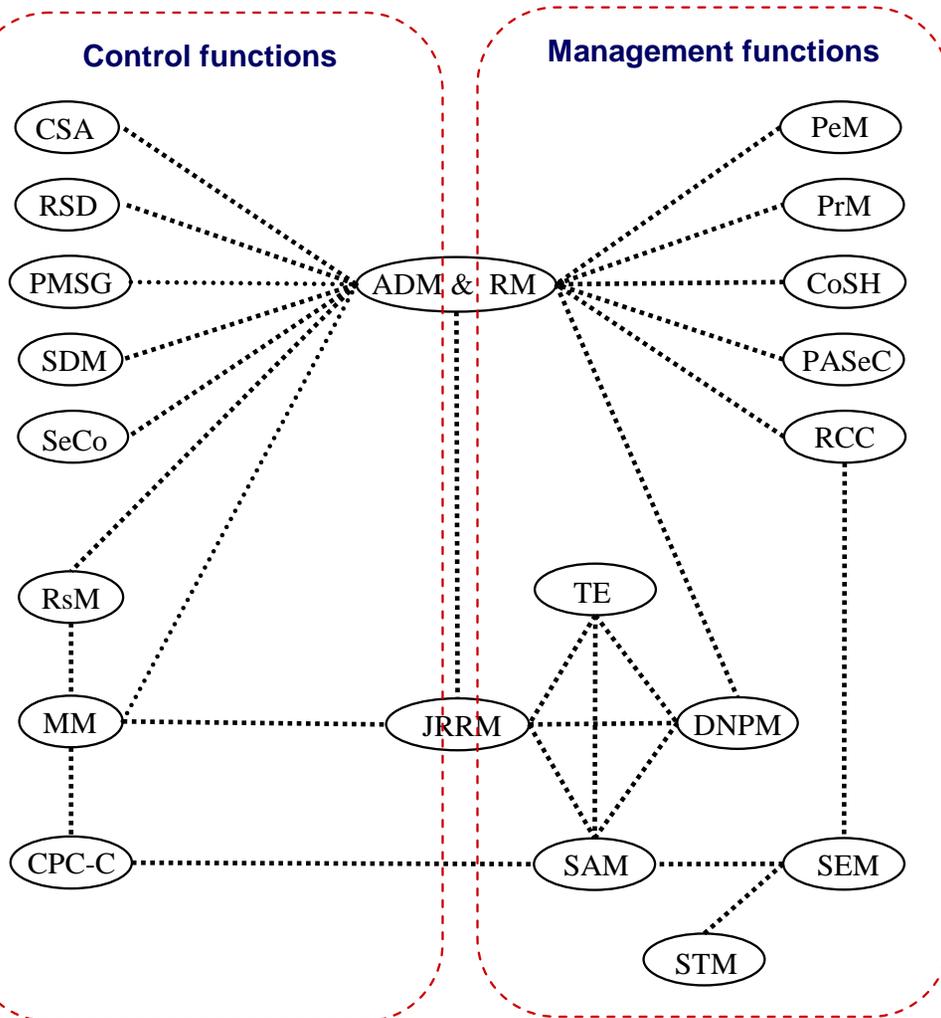
Functional Modelling (3)

RMP Functional Model



Functional Modelling (4)

Overall Functional Model & Reference Points

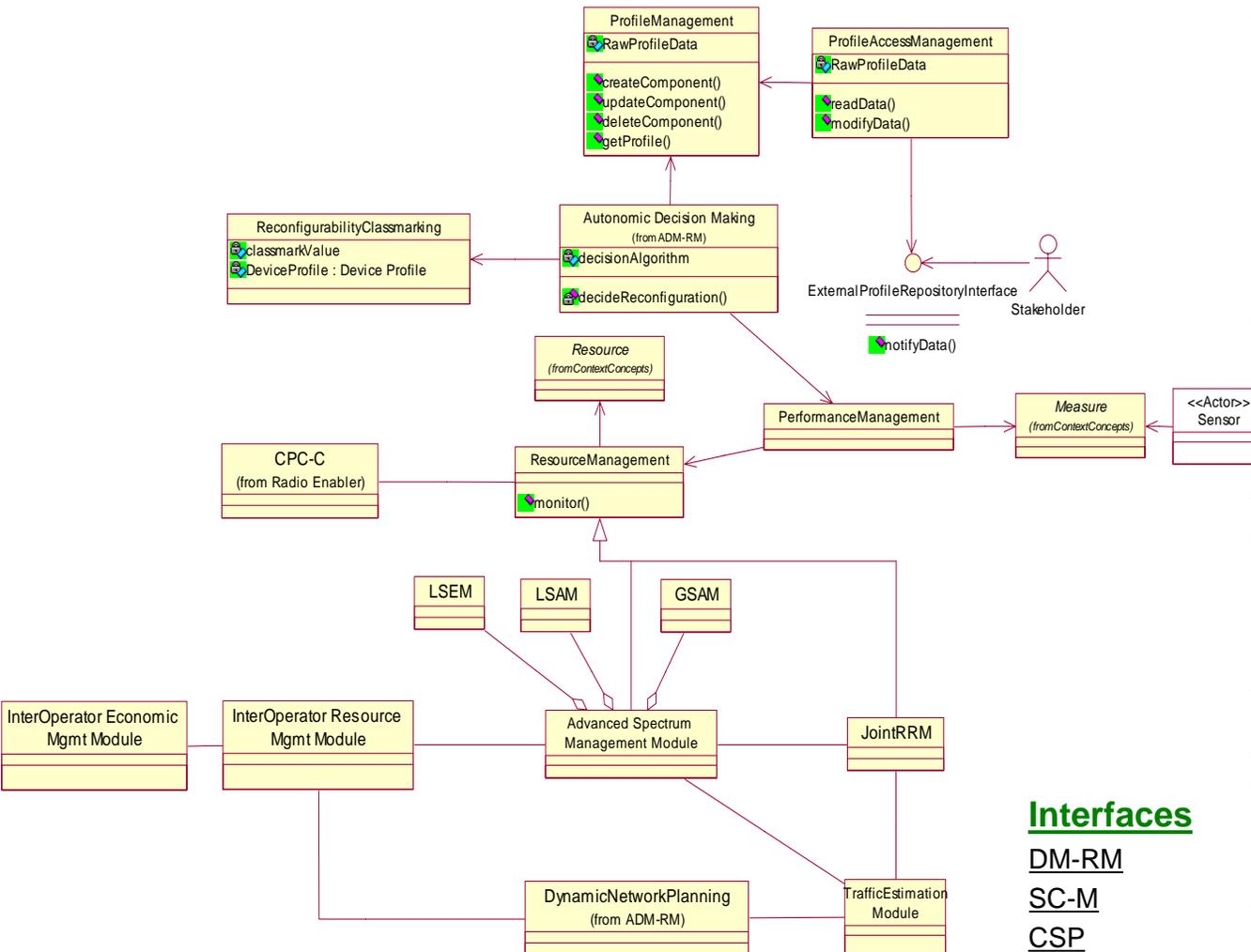


Legend

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

UML Model (1)

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**

Interfaces

DM-RM

SC-M

CSP

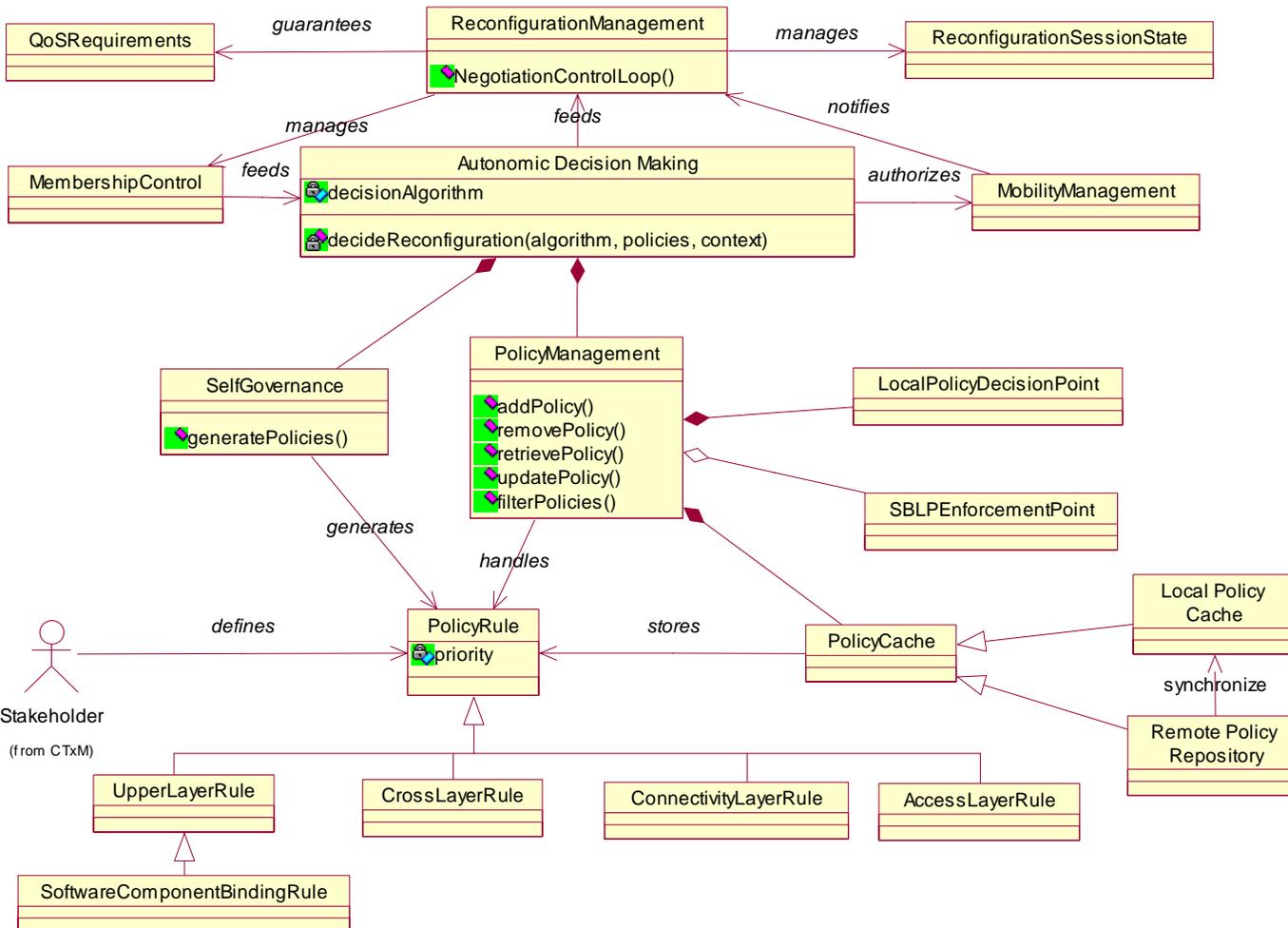
PeM: Performance Management

- **Performance report generation**



UML Model (2)

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

Conclusions

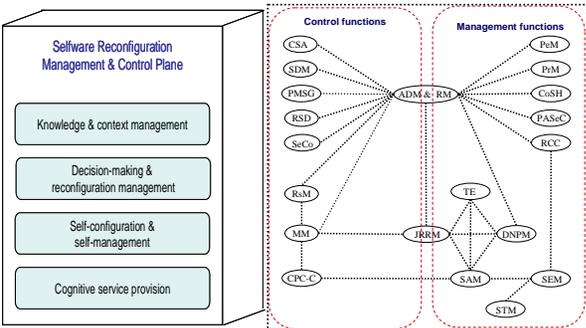
Overall Approach

- ✓ 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**

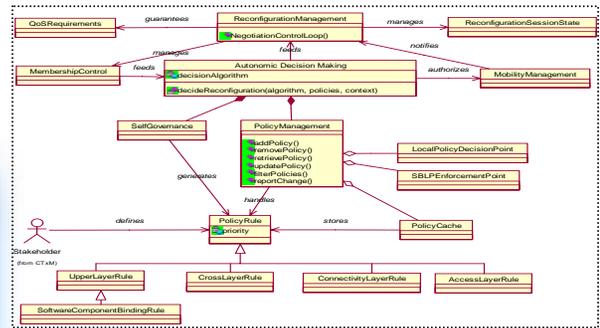
Ongoing & future work

- ✓ 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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