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Challenges and opportunities for LTE Network Management

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Outline

- Introduction
- Network Management Basics
- Autonomics and Policy-based Management (PBM)
- Policy Management and Control for LTE/4G
- Conclusions



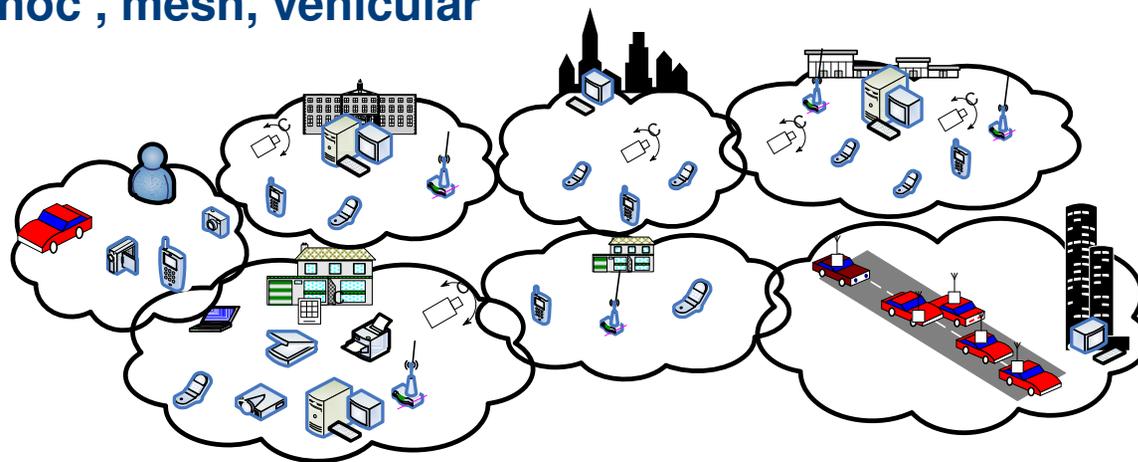
Introduction

Wireless and Mobile Networks

- They are **everywhere!**
 - WMAN: e.g. Mobile 2G/3G/LTE/LTE-A
 - WMAN: e.g. WiMax / Mobile WiMax
 - WLAN: e.g. WiFi
 - WPAN: e.g. Bluetooth, IR
 - WBAN: e.g. Zigbee, RFID

? → 4G

- Multihop Wireless Networks
→ ad hoc , mesh, vehicular





Introduction and Background

Wireless Networks' Issues

- Multiple technologies → 4G → B4G
 - **Interoperability – Mobility – Scalability**
 - Multi-interface handsets
 - Today: 2G/2.5G/3G/3.5G/3.75G/3.9G, WLAN, Bluetooth, IR
 - Tomorrow: X, Y, Z, ?, ? , ?
 - New form factors
 - tablets, netbooks, MID, smartbooks, USB dongles etc ...
 - Convergence of Fixed and Mobile Networks
- Increased scale
- Increased complexity
- Increased heterogeneity

→ **Increased Cost**



Introduction

Wireless/Mobile Networks' Issues

- Typical OPEX Breakdown for a Mobile Operator
 - ~20% on Network Operations (source: Motorola-Yankee Group)
- Typical budget for IT
 - ~70% on Labor (source: IDC study for IBM)
- Industrial initiatives to reduce costs
 - management automation → **Self-* Capabilities**
- IBM: Self-Managing Autonomic Technology (2001)
- 3GPP/NGMN: SON for LTE (2008)
 - Self-Organizing Networks (SON) Long Term Evolution (LTE) standards attempt to change the operations and maintenance paradigm
 - NGMN: Next Generation Mobile Networks Alliance
 - 3GPP: 3rd Generation Partnership Project



Introduction

Wireless/Mobile Networks' Issues

- Industry Whitepaper
 - about 17 % of wireless operator's CAPEX is spent on engineering and installation services
 - SON's self-configuring functions are expected to eliminate many on-site operations for the basic settings and subsequent updating of network equipments, and thus reduce CAPEX.
 - about 24 % of a typical wireless operator's revenue goes to network OPEX, which are the cost of network operation and maintenance, training and support, power, transmission, and site rental
 - SON's self-optimizing functions will reduce a workload for site survey and analysis of network performances, and thus reduce OPEX.
 - Moreover, SON's energy-saving functions reduce the costs of power consumed by the equipment.
 - “Self Organizing Network” “NEC's proposals for next-generation radio network management”, NEC Corporation 2009

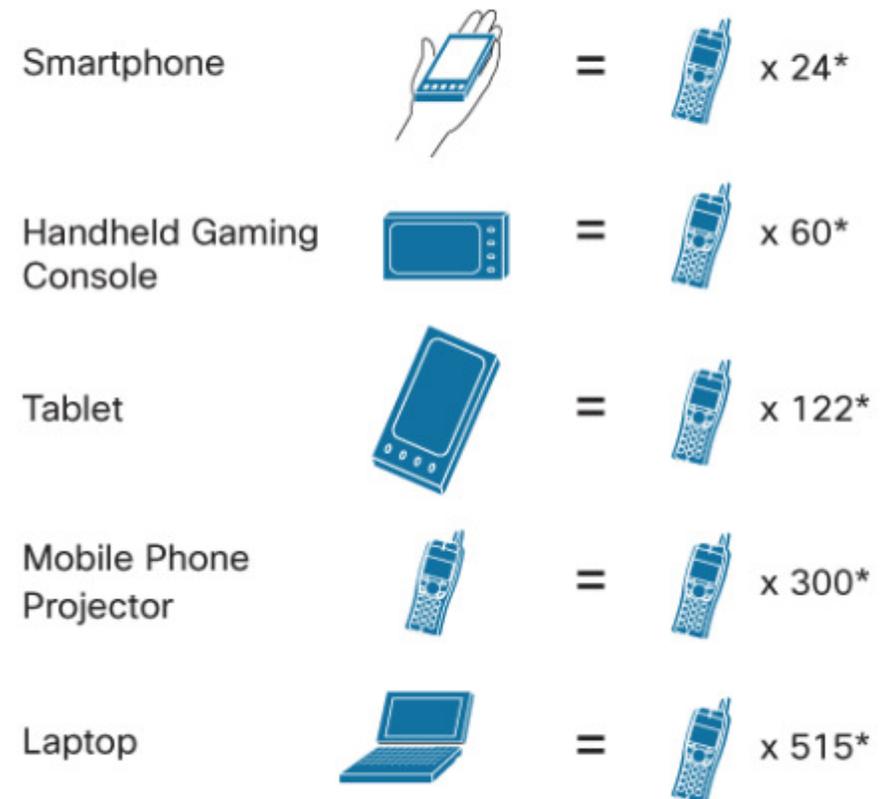


Introduction

Wireless and Mobile Networks

- Industry Whitepaper
 - Cisco VNI Mobile 2011
- Trend: Mobile Data usage explosion
- Smartphones represent only 13 % of total global handsets in use today, but they represent over 78 % of total global handset traffic.
- Mobile data traffic per month
 - Basic-feature cell phone 3.3 MB
 - Smartphone 79 MB

Figure 4. High-End Devices Can Multiply Traffic



* Monthly basic mobile phone data traffic

Source: Cisco VNI Mobile, 2011



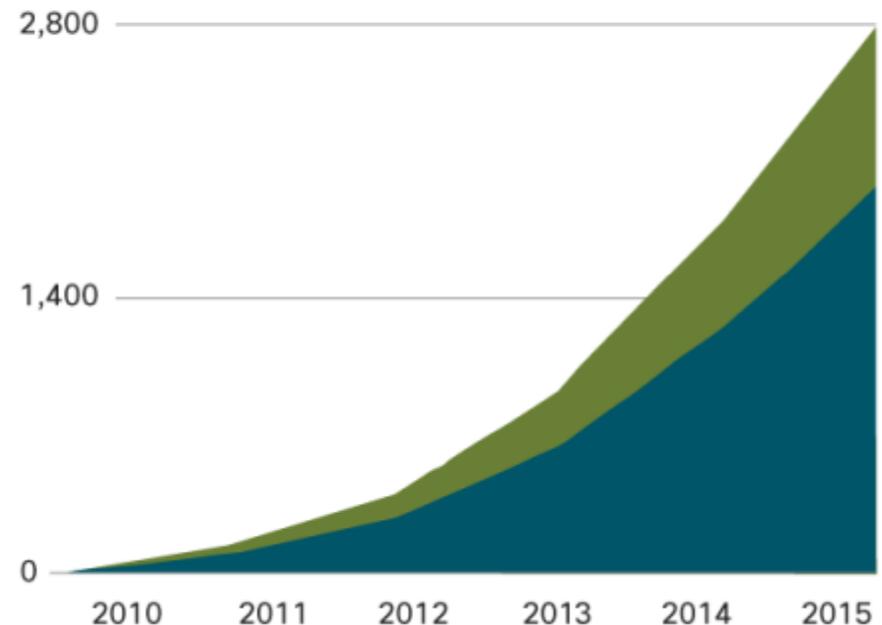
Introduction

Wireless and Mobile Networks

- Industry Whitepaper
- Trend : Traffic Offload from Mobile Networks to Fixed Networks
- Cisco's survey: Much mobile data activity takes place at home
 - user's home 40 %
 - "on the move" 35 %
 - at work 25 %
- The relatively high percentage of home-based mobile data use suggests that operators may be able to offload traffic onto a fixed network
- Globally, 31 % of smartphone traffic was offloaded onto the fixed network through dual-mode or femtocell in 2010.

Figure 6. 39 Percent of Smartphone and Tablet Traffic will be Offloaded I

Petabytes per Month



Source: Cisco VNI Mobile, 2011

- Smartphone and Tablet Traffic Offloaded to Fixed
- Smartphone and Tablet Mobile Network Traffic



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Network Management Basics

Why should you care?

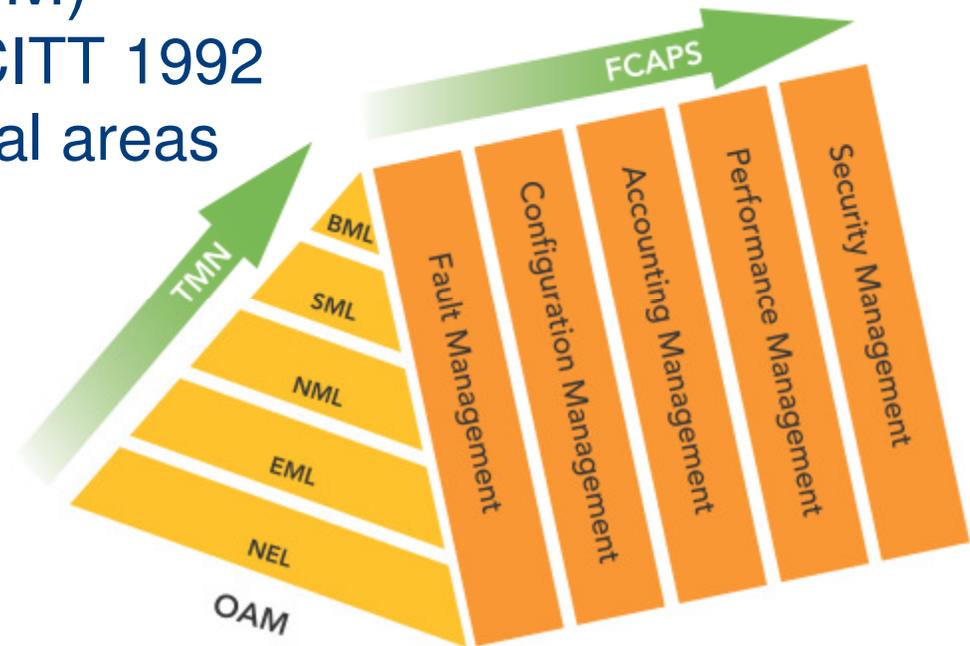
- Networks and systems management technologies and standards
 - As with most technologies and standards, they were, are, and will be influenced by non-technical factors!
 - We can learn from history
 - And history is repeated...
 - Better estimation/prediction of the Future



Network Management Basics

Functional areas of management

- Open Systems Interconnection (OSI) Systems Management (OSI-SM)
 - ITU-T Rec.X.700, CCITT 1992
 - Five generic functional areas
- FCAPS operations
 - **F**ault
 - **C**onfiguration
 - **A**ccounting
 - **P**erformance
 - **S**ecurity



Legend :

- NEL: Network Element Layer (devices)
- EML: Element Management Layer (device-level functions)
- NML: Network Management Layer (topology management)
- SML: Service Management Layer (Service Level Agreements (SLAs))
- BML: Business Management Layer (budgeting and billing)

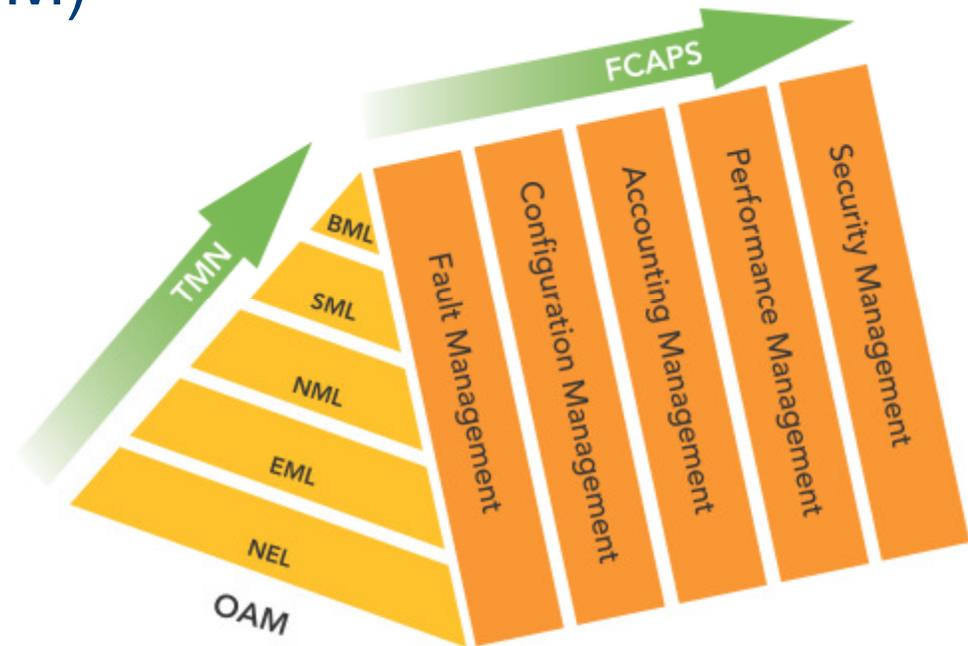


Network Management Basics

Functional areas of management

- Open Systems Interconnection (OSI) Systems Management (OSI-SM)

New aspects
SLA Management
Event Management
Energy Management



Legend :

- NEL: Network Element Layer (devices)
- EML: Element Management Layer (device-level functions)
- NML: Network Management Layer (topology management)
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Network Management Basics

Functional areas of management

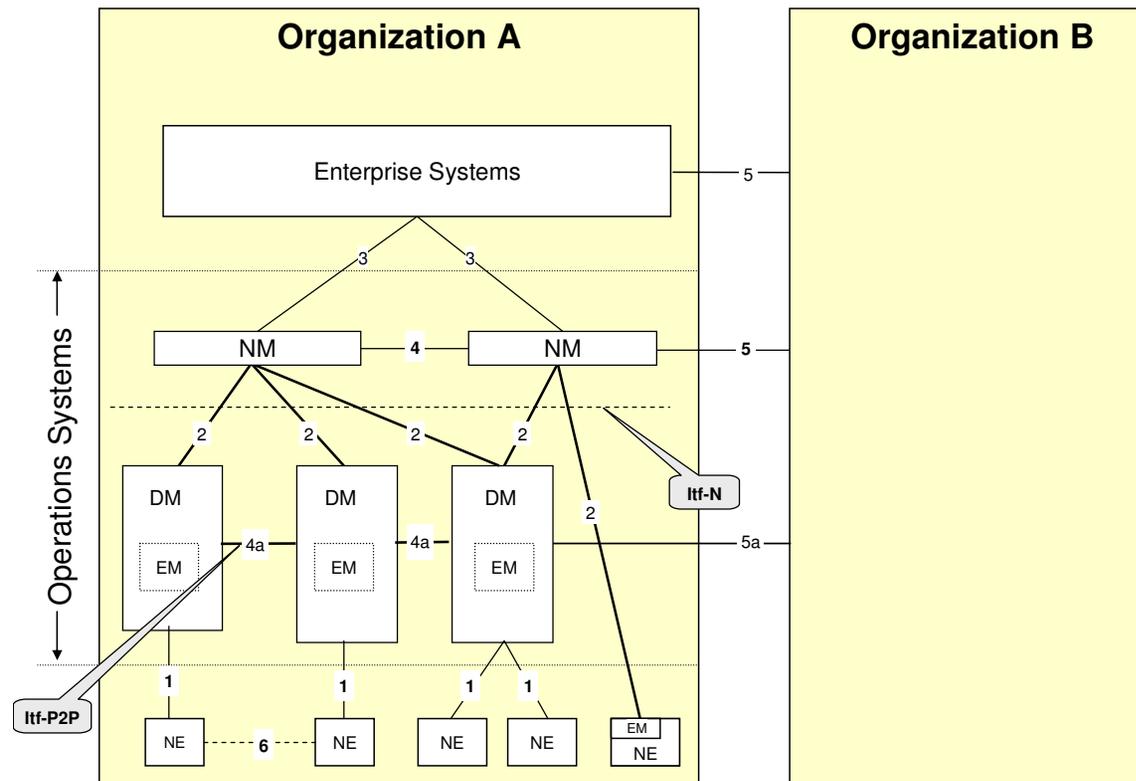
- Next Generation Networks (NGN)
 - *ITU-T Rec. Y.2011 (2004), "General principles and general reference model for Next Generation Networks"*.
 - Next Generation Networks (NGN) are essentially about delivering new services that are available any place, any time, and on any device, through any customer-chosen access mechanism.
 - The decoupling is reflected in the NGN architecture as the separation of the **Transport and Service strata** and shown as two independent stratum.
- Management of Next Generation Networks
 - *ITU-T Rec. M.3060/Y.2401 (2006): "Principles for the Management of Next Generation Networks"*
 - NGN Management (NGNM) supports the aims of the NGN by decoupling and make independent, the service creation/deployment infrastructure from the transport infrastructure.
 - NGNM also introduces the **NGN management plane, union of the NGN service stratum management plane and the NGN transport stratum management plane** and may include joint management functions



Network Management Basics

Functional areas of management

- 3GPP Telecommunication management; Principles and high level requirements (TS 32.101, 32.102)
 - Management Infrastructure: the collection of systems (computers and telecommunications) a PLMN Organisation has in order to manage its network.





Network Management Basics

Functional areas of management

- 3GPP Telecommunication management; Principles and high level requirements (TS 32.101, 32.102)
 - The PLMN management architecture will facilitate the ITU-T NGN Management principles where necessary and suitable.

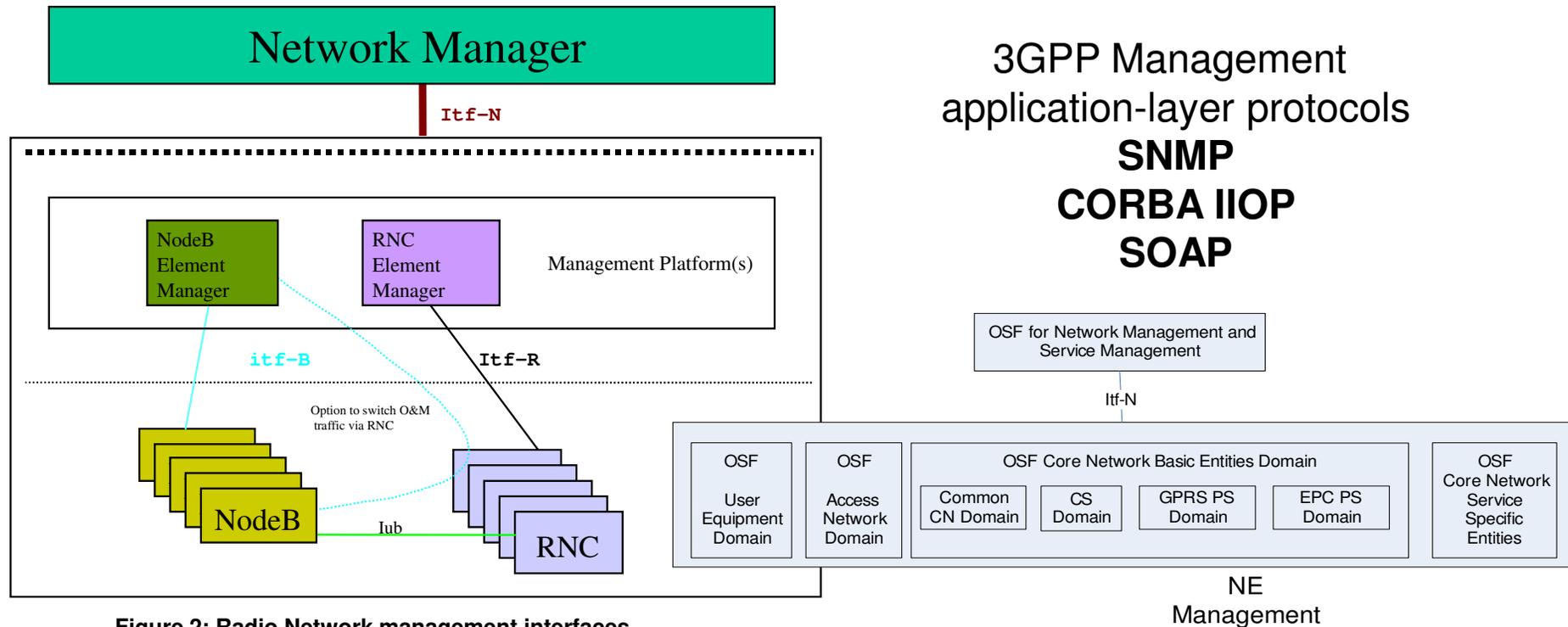


Figure 2: Radio Network management interfaces



Network Management Basics

Taxonomy and Protocols

- Network and Systems Management Approaches
 - High-level Taxonomy and Protocols
- Remote Invocation (RI)
 - Manager-Agent
 - SNMP, COPS, NETCONF
 - Distributed Object/Service Interfaces
 - CORBA, Web Services
- Management by Delegation (MbD)
 - Code mobility
 - ScriptMIB, Mobile Agents



Network Management Basics

Taxonomy and Protocols

- Remote Invocation (RI)
 - Established and dominant approach
 - Simple, efficient, predictable
 - Sometimes too simple
- Management by Delegation (MbD)
 - Failed to gain market acceptance
 - Reprogrammable but unpredictable with code mobility
- Is there a middle ground?
 - Policy-based Management
 - Controlled programmability



Network Management Basics

Evolution of Protocols & Technologies

- Milestone for network and systems management
 - The standardisation of two open protocols (1980's)
 - Common Management Information Protocol (CMIP)
 - Simple Network Management Protocol (SNMP)
- CMIP
 - used by OSI-SM framework, targeting OSI intermediate and end systems.
 - first object-oriented management approach
 - adopted by ITU-T as the basis for its Telecommunications Management Network (TMN)
 - established in the Telecommunications (Telco) community



Network Management Basics

Evolution of Protocols & Technologies

- SNMP
 - SNMPv1 completed around 1990 by IETF
 - final version: SNMPv3 (2002)
 - efficient and simple: “variable-based” information model and limited set of operations
 - adopted by the Internet (IP, Internet Protocol) community to manage local area networks, wide area networks and intranets
 - storming adoption and deployment on the majority of IP-capable devices
 - IETF shifted interest to new Internet management technologies
 - IETF: Internet Engineering Task Force
 - “*rough consensus and running code*”



Network Management Basics

Evolution of Protocols & Technologies

- Common Object Request Broker Architecture (CORBA)
 - Outcome of research on the use of distributed object technologies (1990s) by OMG
 - OMG : Object Management Group
 - Fully object-oriented information model
 - Objects defined through their interfaces in IDL
 - Interface Definition Language (IDL)
 - Internet Inter-Operability Protocol (IIOP)
 - Remote call protocol mapping over TCP/IP
 - Gradually phased out OSI-SM/CMIP in Telco
 - ITU-T translating original specifications to CORBA's IDL



Network Management Basics

Evolution of Protocols & Technologies

- CORBA
 - Benefits: application interoperability independent of platform, operating system, programming language.
 - Drawbacks: relatively heavyweight nature and expensive deployment
 - Critical requirements of network management were not satisfied – not widely adopted for NM
 - Established for service and application management in Telco industry
 - Continued use given the prior investment in this area
- Service management
 - Business process reengineering and automation
 - CORBA technology well suited
 - Trend towards Web Services (SOAP-based) solutions



Network Management Basics

Evolution of Protocols & Technologies

- The future of Internet management technologies
 - J. Schoenwaelder, A. Pras, J-P. Martin-Flatin, “On the future of Internet management technologies”, *IEEE Commun. Mag.*, Vol.41, Iss.10, pp.90-97, Oct 2003.
 - Authors identify the significant deficiencies and challenges of existing technologies.
 - Two approaches from the Internet community
- *Evolutionary* approaches
 - Aimed at solving problems by gradually improving the existing Internet management framework
 - Main problems of SNMP were targeted
 - elementary information model
 - use of unreliable UDP for transport
 - lack of transaction support
 - By 2003, “evolutionary” approaches abandoned
 - Admittedly had failed or had limited market acceptance



Network Management Basics

Evolution of Protocols & Technologies

- *Revolutionary* approaches
 - Since 2001, hardware vendors had been shipping products that offered XML-based interfaces
 - After 2003, the Internet management community focused its interest on “revolutionary” approaches
 - Aim: replace existing management-specific technologies with standard distributed systems technologies
 - Industry focus towards XML-based approaches was adopted by Internet community
 - IETF Network Configuration (NETCONF) working group was chartered May 2003
 - Trend towards standardised Web Services and XML/HTTP-based management
 - currently embraced and deployed by the network management community and industry



Network Management Basics

Evolution of Protocols & Technologies

- Web Services (WS)
 - an Internet-oriented technology, developed and standardised by the WWW Consortium (W3C)
 - WS were seen as the successor of distributed object technologies due to their strong analogies to CORBA
 - Candidate technology for network management, in spite of XML's verbosity leading to increased overheads compared to SNMP and CORBA
 - Main advantage: the use of XML, due to its universal adoption as an interoperable data interchange format
 - Open standards available based on SOAP, WSDL
 - DMTF Web-Based Enterprise Management (WBEM)
 - OASIS Web Services Distributed Management (WSDM)



Network Management Basics

Evolution of Protocols & Technologies

- Network Configuration Protocol (NETCONF)
 - provides mechanisms to install, manipulate, and delete the configuration of network devices. It uses an Extensible Markup Language (XML)-based data encoding for the configuration data as well as the protocol messages. The NETCONF protocol operations are realized as remote procedure calls (RPCs).
 - RFC6241-6242 obsoletes RFC 4741-4742

NETCONF uses a simple RPC-based mechanism to facilitate communication between a client and a server. The client can be a script or application typically running as part of a network manager. The server is typically a network device.

RFC 6241

NETCONF Protocol

June 2011

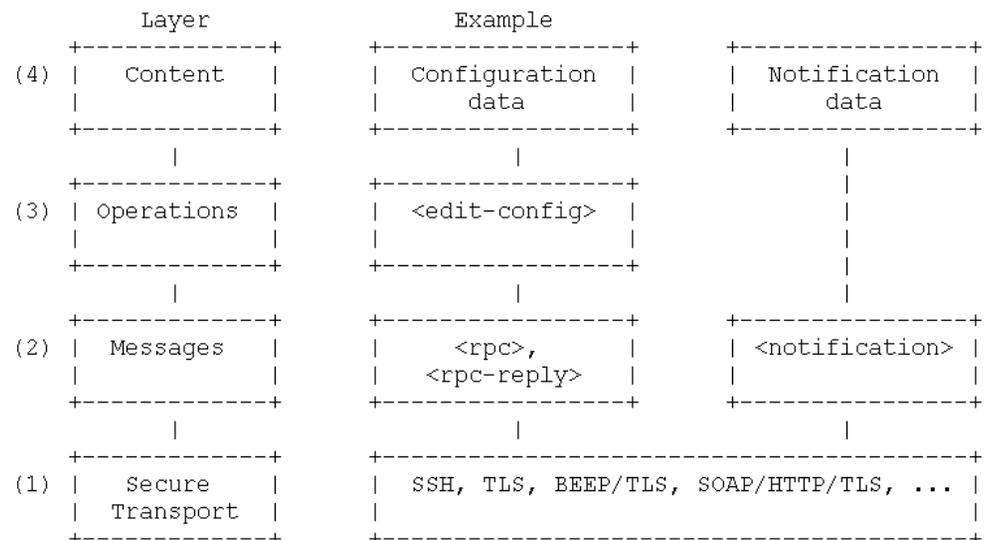


Figure 1: NETCONF Protocol Layers



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- Conclusions



Autonomics and Self-Management

Motivation

- In one sentence
 - Reduce complexity, increase automation, reduce OPEX
- Networks and Systems today
 - progressively more complex, interconnected networking infrastructure
 - explosive growth of the Internet
 - proliferation of mobile technologies
 - fixed-mobile convergence
 - difficulty in managing multi-vendor environments
 - current communications service offerings are inflexible



Autonomics and Self-Management

Motivation

- Telecommunications actors faced with difficulties
 - Direct impact on the OPEX and CAPEX
- Current communications service offerings are inflexible in nature:
 - rigidly defined and exhibit static functionality
 - closely coupled to specific network technology
 - Largely manually deployed and managed, requiring highly labor-intensive support structures,
 - consequent inflexibility & significant time to market constraints
- ***“Autonomic Computing and Networking, The operators' vision on technologies, opportunities, risks and adoption roadmap”, (Eurescom P1855 D1) Editors: Bruno Dillenseger, Sven van der Meer, Stein Svaet***



Autonomics and Self-Management

First steps and definitions

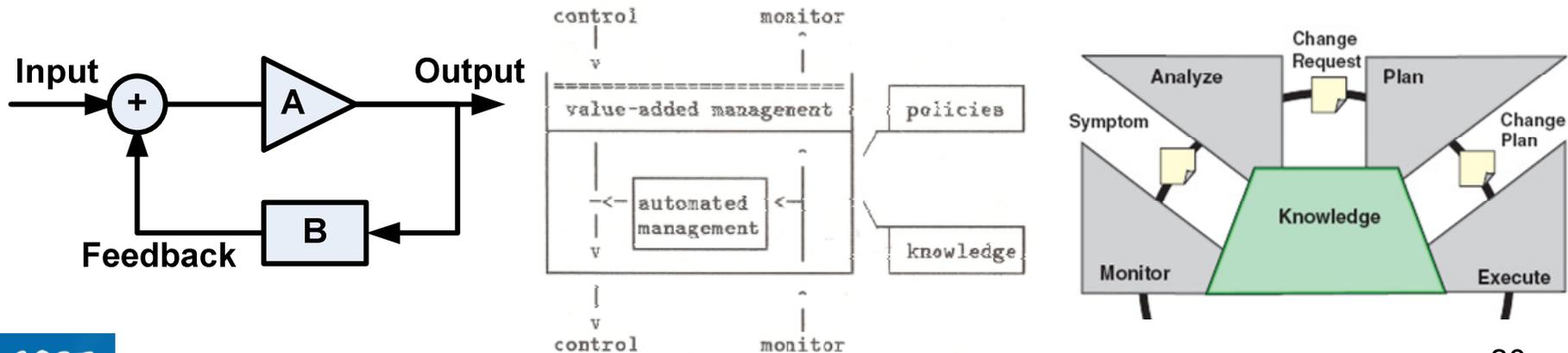
- **Autonomic Computing:**
 - a computing environment with the ability to manage itself and dynamically adapt to change in accordance with business policies and objectives [IBM2001]
 - “*Grand Challenge*: building and deploying computing systems that regulate themselves and remove complexity from the lives of administrators and users”
- **Self-management:**
 - the ability of independently achieving seamless operation and maintenance by being aware of the surroundings
 - Autonomic Management



Autonomics and Self-Management

First steps and definitions

- Basic underlying concept
 - Control Theory for Network/Systems Mgt.
 - **Closing the management loop!**
 - L.Fehskens [IFIP/IM 1989]
 - IBM's Autonomic Vision [2000]
- Self-^{*}
 - Configuration – Healing – Optimisation – Protection

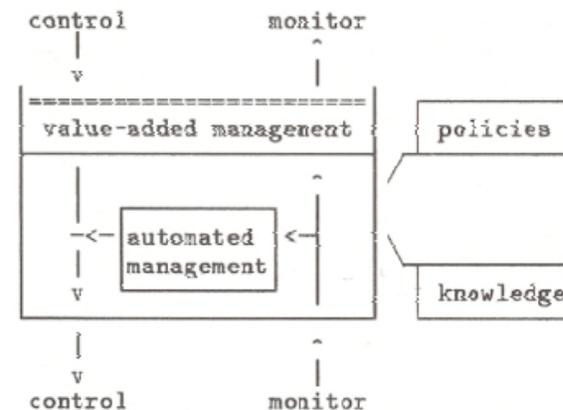
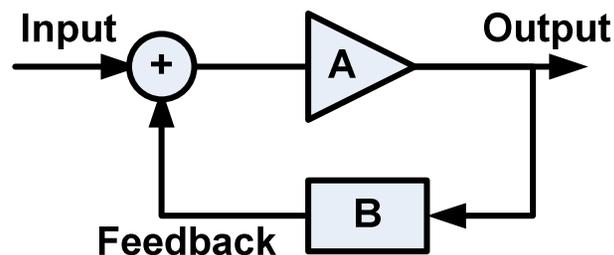




Autonomics and Self-Management

First steps and definitions

- Two main functions for self-management
 - A. Provide the logic and directives to achieve seamless operation and maintenance (→policies)
 - B. Provide the means to sense and evaluate their operating surrounding environment (→knowledge)
 - interrelated and interdependent,
 - forming a closed control loop with feedback





Autonomics and Self-Management

First steps and definitions

- Self Organizing Network and Self-configuration

- deployment of new network elements should be automated to as large extent as possible and only require a single visit to the installation site

- The network elements shall automatically create the logical associations with the network
- DHCP for auto-configuration and EAP or SIM-card-based security parameter configurations
- initial configuration for the element. by using NETCONF protocol server
- self-test to determine that everything is working as intended.
- active service and self-optimization.

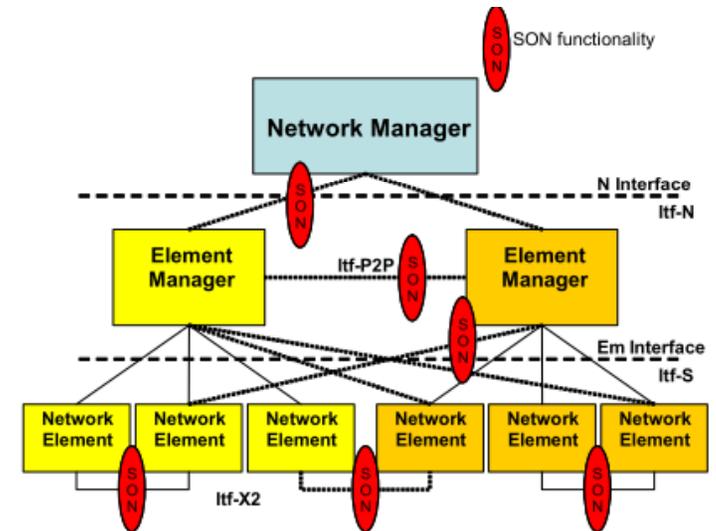


Figure 2. Simplified view of LTE network management structure.

•“Self Organizing Network” “NEC's proposals for next-generation radio network management”, NEC Corporation 2009



Policy-based Management (PBM)

Expectations and Potential

- PBM and policies
 - Envisioned as encapsulating business objectives which in turn are automatically applied to managed systems, requiring minimal human intervention
 - Initially overestimated expectations from policies
 - Practice has shown that what was initially conceived as the instant panacea of network management is in fact a long journey towards self-managing networks
 - Research on PBM has gradually verified its enormous potential and showed that it can simplify complex management tasks of large-scale systems.



Policy-based Management (PBM)

Overview

- Basic concept
 - high-level policies are translated to low-level element operations for monitoring the network and automatically enforcing appropriate actions
 - Intense interest, fuelled by IBM's vision in Autonomic Management
- The PBM paradigm
 - Policies capture high-level management objectives
 - Means to integrate self-management capabilities
 - PBM offers controlled programmability
- First steps on PBM from IETF
 - Policy Framework WG (POLICY) RFC3198, RFC3460
 - Resource Allocation Protocol WG (RAP) RFC2753
 - Reference framework, aimed for QoS provisioning



Policy-based Management (PBM)

Overview

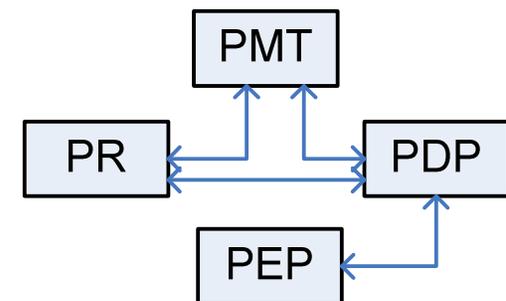
- Main advantages of a policy-based system
 - Controlled programmability to the managed system, without compromising its overall security and integrity
 - Extends the functionality of a system dynamically in combination with its pre-existing management logic
 - re-programmable and adaptable management system, based on the supported general policy types.
 - Policies can be introduced to the system and parameterised on the fly, based on management goals and contextual information.
 - Policy decisions prescribe appropriate actions, to realise and enforce those goals.



Policy-based Management (PBM)

IETF's Policy Framework

- IETF Definition of Policy
 - a set of rules to administer, manage and control access to network resources
- Policy rules: building blocks of complex logic
 - Defined as Event-Condition-Action (ECA) clauses
 - on event(s) E, if condition(s) C true, then action(s) A is executed
- IETF's policy-based framework
 - Policy Information Model (PCIME)
 - LDAP Data Model (PCELS)
 - Does not define a policy specification language
 - “Condition-Action” specification of policy rules

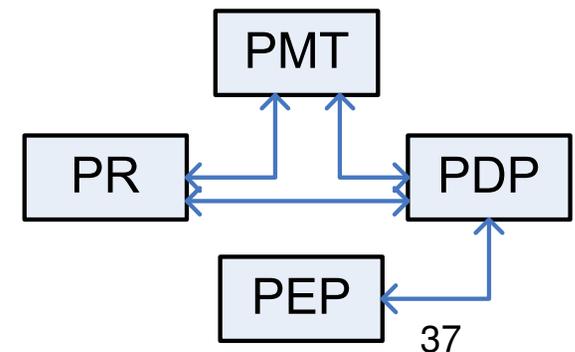




Policy-based Management (PBM)

IETF's Policy Framework

- Policy Management Tool (PMT)
 - the interface between the human manager (e.g. a consultant or network administrator) and the underlying PBM system
- Policy Repository (PR)
 - the blueprint of policies that a PBM system is complying with at any given moment
 - encapsulates the operational parameters of the network
 - one of the most critical elements

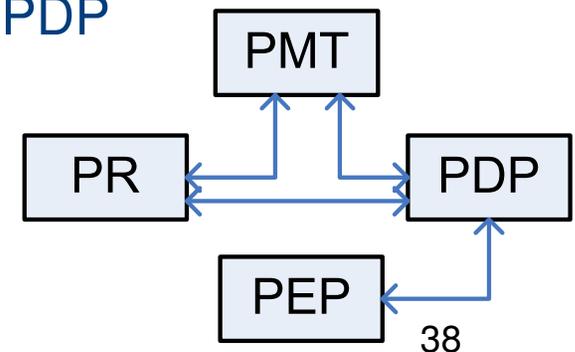




Policy-based Management (PBM)

IETF's Policy Framework

- Policy Decision Point (PDP)
 - a logical entity that makes policy decisions for itself or for other network elements
 - evaluation of policy rule's conditions
 - provisioning of actions' enforcement when conditions are met
- Policy Enforcement Point (PEP)
 - a logical entity that enforces policy decisions
 - Traditionally, the sole task of PEP is to execute policy decisions, as instructed by the controlling PDP





Outline

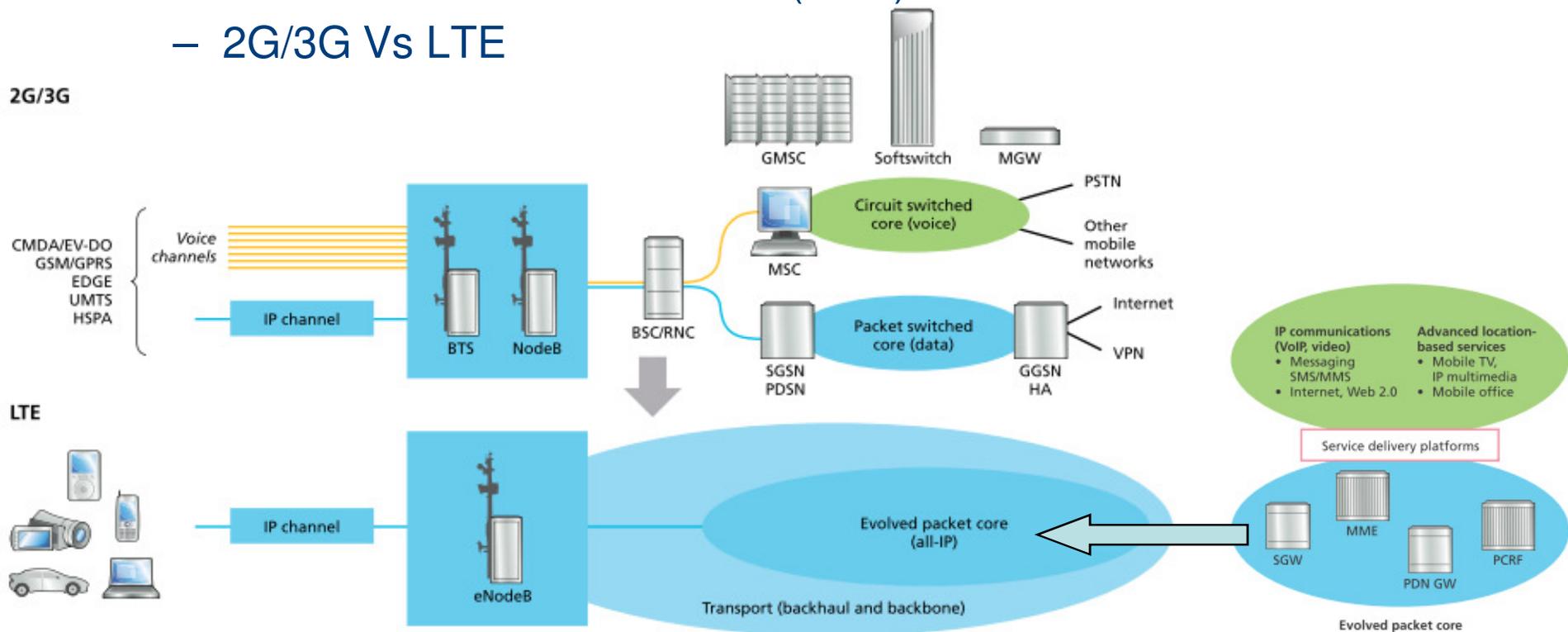
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Policy-based Management (PBM)

Policy Management and Control for LTE/4G

- Mobile Internet and Policies in Long Term Evolution (LTE)
 - LTE: Enhanced Packet Core (EPC) + LTE Radio Access Network
 - 2G/3G Vs LTE

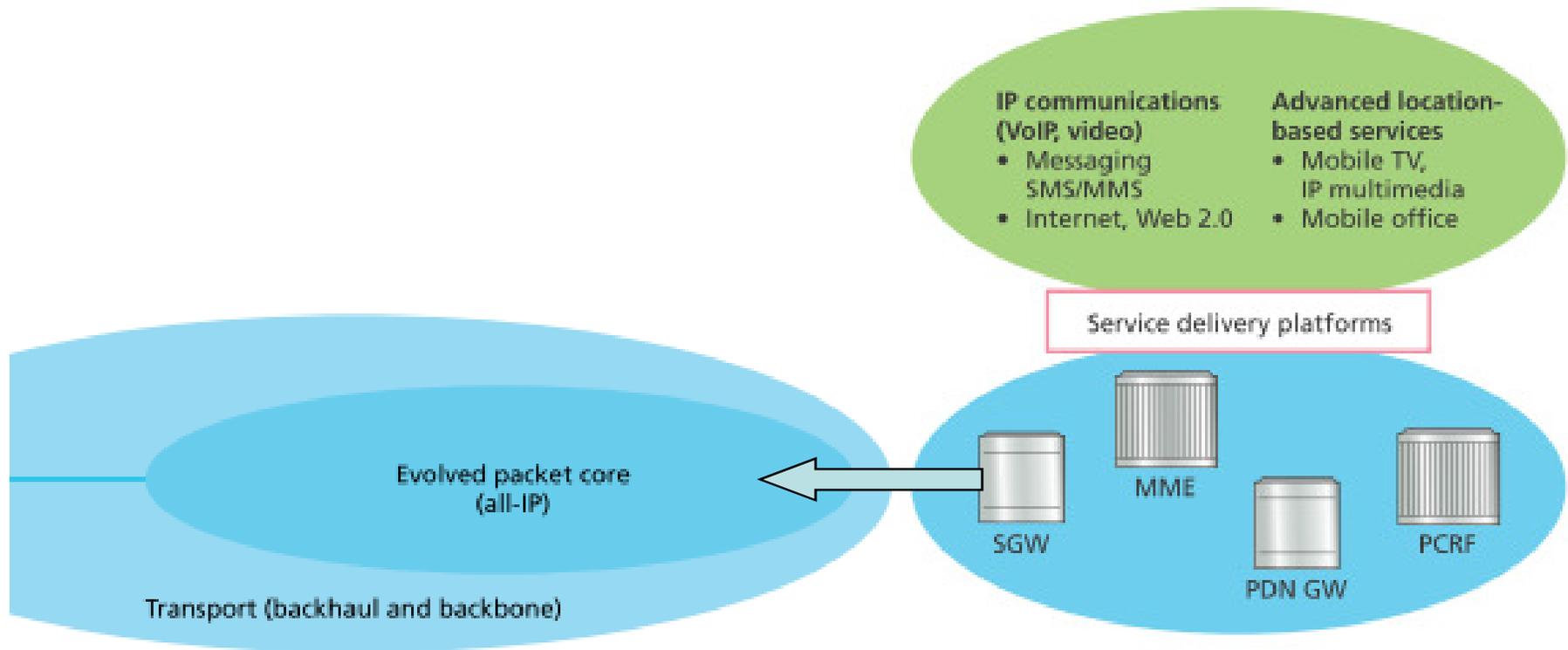




Policy-based Management (PBM)

Policy Management and Control for LTE/4G

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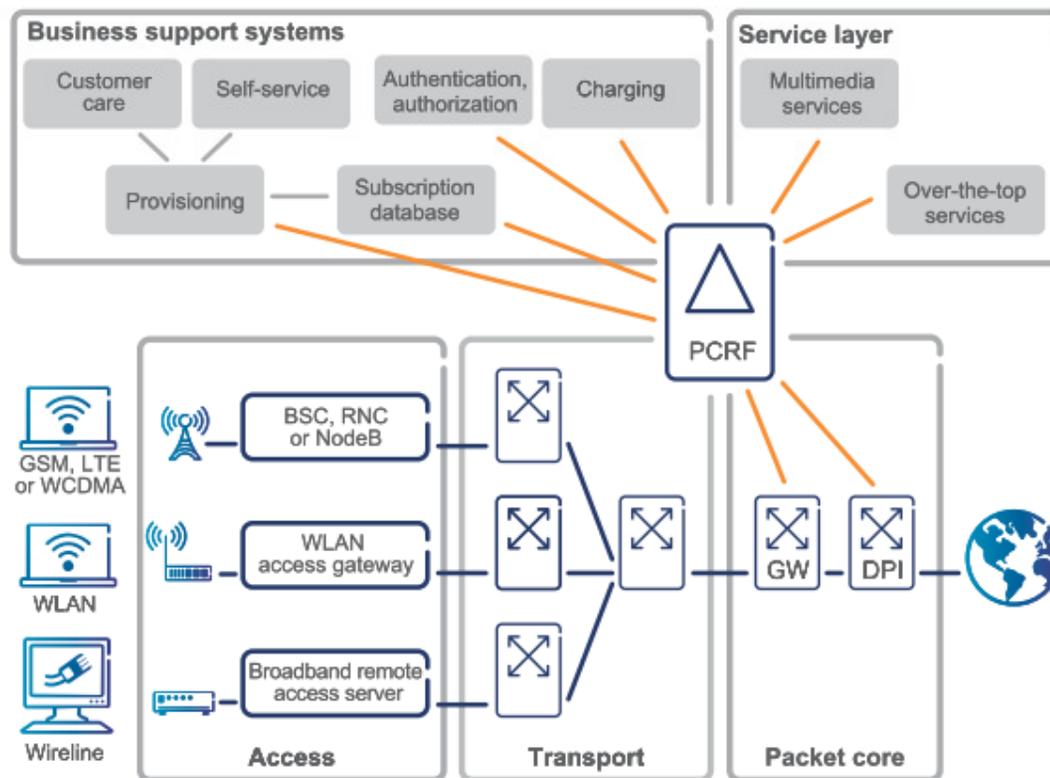




Policy-based Management (PBM)

Policy Support in Mobile Networks

- What do operators need?
 - intelligent policy decisions, e.g. prioritize delay-sensitive apps
 - ensure the delivery of a high-quality service to premium subscribers



ERICSSON WHITE PAPER
284 23-3158 Uen | May 2011

PERFECTING
POLICY CONTROL –
STRATEGIES FOR
END-TO-END SUPPORT
AND CONVERGENCE



Policy-based Management (PBM)

Policy Support in Mobile Networks

Mobile Internet and Policies in Future Mobile Internet

- First generation of policy control solutions
 - designed for fixed broadband networks
 - only enforce policies in the core network
 - Not sufficient to manage congestion effectively
- Congestion in mobile networks typically occurs in the radio access or mobile backhaul networks
 - subscribers compete for a limited supply of shared capacity
 - data sessions use bursty applications
- Centralized solutions lack good, timely feedback mechanisms for their policy decisions
 - may result in instabilities



Policy-based Management (PBM)

Policy Support in Mobile Networks

- End-to-end versus centralised challenges
 - E2E requires integration of more network elements
 - E2E much more effective in managing traffic
- Ericsson study
 - Investigates how peak-hour traffic patterns and trends affect the need for investment in network capacity
 - Compares the impacts of applying centralized policy control and end-to-end policy control as the proportion of sites requiring upgrades
 - No traffic management: 20%
 - Centralized policy control: 14 %
 - End-to-end policy control: 9 %
 - The end-to-end approach is four times more profitable



Policy-based Management (PBM)

Policy Support in Mobile Networks

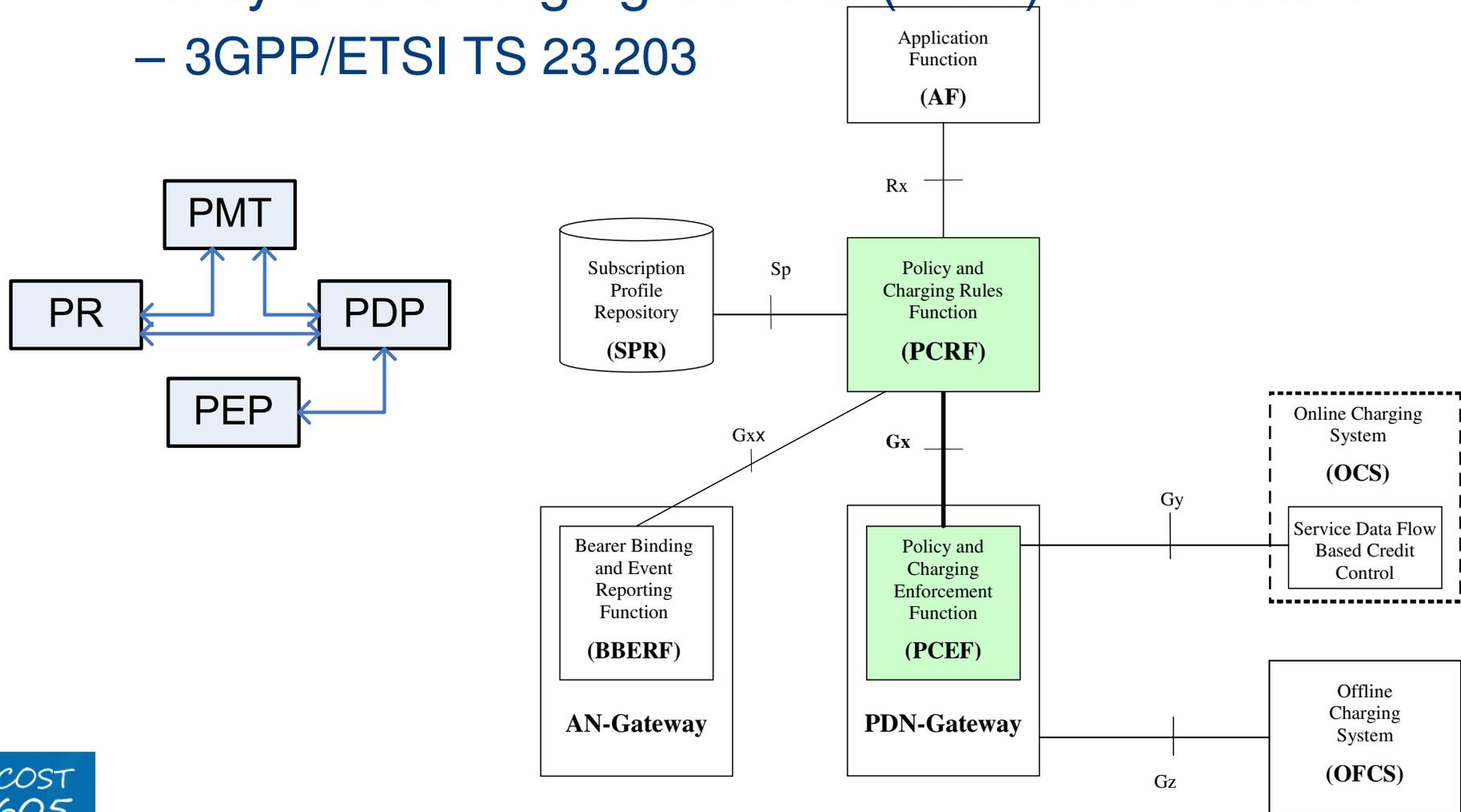
- 3GPP Policy and Charging Control (PCC)
 - encompasses high level functions for IP CANs
 - Flow Based Charging, including charging control and online credit control to allow for more granularity for end-user charging, accounting and online credit control
 - Policy Control (e.g. gating control, QoS control, etc.) to allow the operator to perform service based QoS policy control
 - (IP Connectivity Access Networks)
 - From Release 7 onwards PCC supersedes FBC and replaces the SBLP architecture and functionality.
 - An evolution of Flow Based Charging (FBC) and a replacement for Service Based Local Policies (SBLP) from Releases 5 and 6



Policy-based Management (PBM)

Policy Support in Mobile Networks

- Policy and Charging Control (PCC) architecture
– 3GPP/ETSI TS 23.203

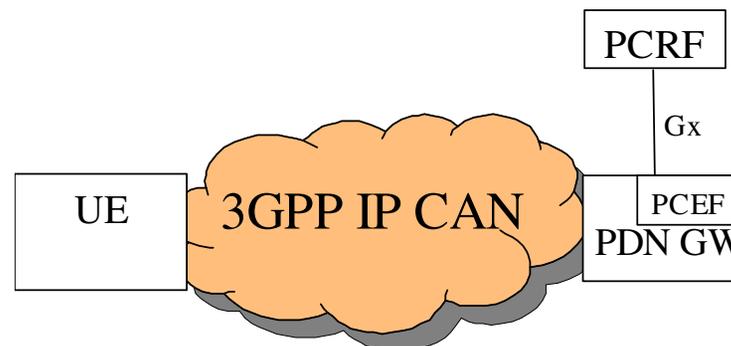




Policy-based Management (PBM)

Policy Support in Mobile Networks

- Definitions
 - PCC rule: A set of information enabling the detection of a service data flow and providing parameters for policy control and/or charging control.
 - Pre-defined Vs Dynamic
 - PCC decision: A decision consists of PCC rules and IP CAN bearer attributes, which is provided by the PCRF to the PCEF for policy and charging control.

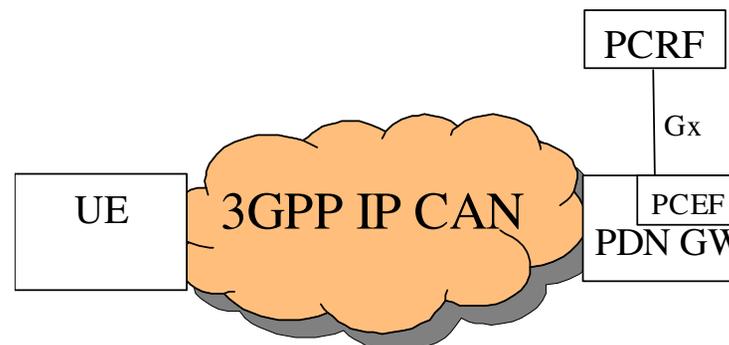




Policy-based Management (PBM)

Policy Support in Mobile Networks

- Definitions
 - IP CAN bearer: An IP transmission path of defined capacity, delay and bit error rate,
 - IP CAN session: The association between a UE and an IP network, (e.g. GPRS IP CAN)
 - service data flow (SDF): A set of packet flows that matches the set of service data flow filters in a PCC rule
 - service data flow filter: A set of packet flow header parameter values/ranges used to identify one or more of the packet flows constituting a service data flow



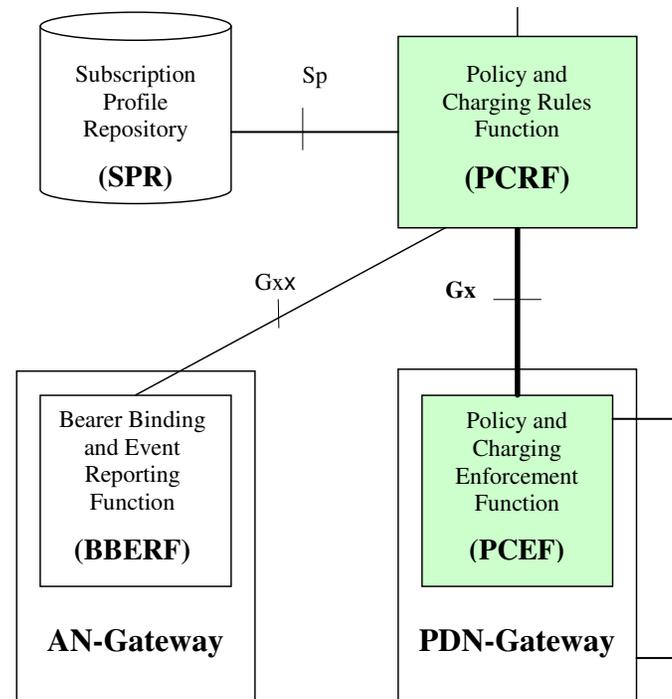


Policy-based Management (PBM)

Policy Support in Mobile Networks

- Policy control

- The process whereby the PCRF indicates to the PCEF how to control the IP CAN bearer (QoS control and/or gating control)
- the PCEF is a functional entity in the Gateway node implementing the IP access to the PDN. The allocation of the BBERF is specific to each IP CAN type.

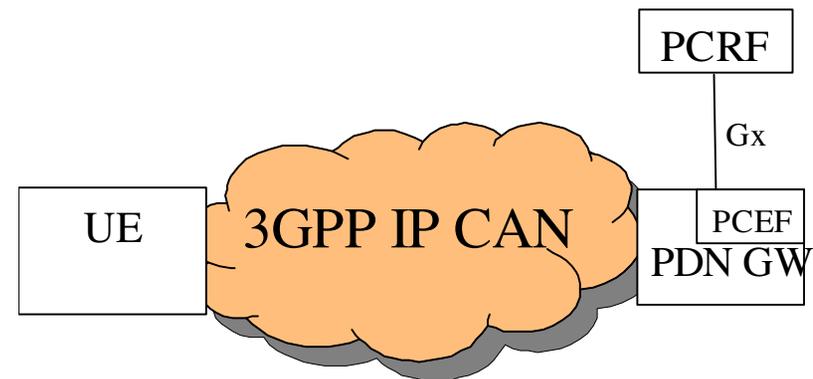
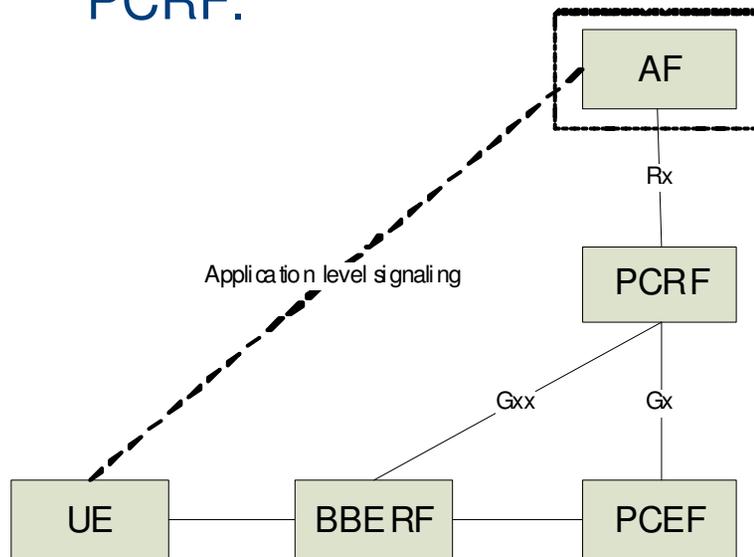




Policy-based Management (PBM)

Policy Support in Mobile Networks

- Gating control: The process of blocking or allowing packets, belonging to a service data flow, to pass through to the desired endpoint.
 - applied by the PCEF on a per service data flow basis.
 - To enable the PCRF gating control decisions, the AF shall report session events (e.g. session termination, modification) to the PCRF.





Policy-based Management (PBM)

Policy Support in Mobile Networks

- QoS control
 - the authorisation and enforcement of the maximum QoS for a service data flow or an IP CAN bearer
- QoS Conflict Handling
 - It shall be possible for the PCC architecture to support conflict resolution in the PCRF when the authorized bandwidth associated with multiple PCC rules exceeds the Subscribed Guaranteed bandwidth QoS
 - KEY OPEN ISSUE!



Policy-based Management (PBM)

Policy Support in Mobile Networks

- QoS control
 - on a per service data flow basis in the PCEF
 - Criteria such as the QoS subscription information may be used together with policy rules such as, service-based, subscription-based, or pre-defined PCRF internal policies to derive the authorized QoS to be enforced for a service data flow.
 - at IP CAN bearer level
 - support control of QoS reservation procedures (UE-initiated or network-initiated) for IP CAN bearers in the PCEF or the BBERF
 - Details of QoS reservation procedures are IP CAN specific



Policy-based Management (PBM)

Policy Support in Mobile Networks

- Flow Based Charging
- Charging control
 - The process of associating packets, belonging to a service data flow, to a charging key and applying online charging and/or offline charging, as appropriate.
 - Examples of Service Data Flow Charging
 - An operator offers a zero rating for network provided DNS service. A PCC rule is established setting all DNS traffic to/from the operators DNS servers as offline charged. The data flow filter identifies the DNS port number, and the source/destination address within the subnet range allocated to the operators network nodes.



Policy-based Management (PBM)

Policy Support in Mobile Networks

- Policy provisioning challenges
 - Initially based on COPS-PR (R5-R6) [RFC 3084]
 - Common Open Policy Service -Policy Provisioning
 - Failed to gain significant market acceptance because it failed to fully address SNMP deficiencies and introduced complexity
 - Maintenance costs and lack of backward compatibility further restricted its adoption.
 - Now based on DIAMETER (R7-R9) [RFC 3588]
 - Vendor specific extensions/implementations
 - AAA (authentication, authorization and accounting)



Policy-based Management (PBM)

Policy Support in Mobile Networks

- Future (mobile) networks automation
 - Product focus: PCRF or policy engine server
 - PCRF: Policy Charging and Rules Function
 - Latest: 3GPP Release 9
- Industry outlook
 - “Light Reading Mobile” Article on Policy Vendors at the Barcelona Mobile World Congress MWC2010
 - http://www.lightreading.com/document.asp?doc_id=187922
 - “Policy control, and its role in service and subscriber management, has emerged as one of the key talking points in the wireless industry in the past year or so...”
 - Several vendors and commercial products mentioned



Policy-based Management (PBM)

Policy Support in Mobile Networks

“Traffic management is the No. 1 catalyst today for deploying policy tools – primarily PCRF-based policy servers and associated enforcement (PCEF) appliances and software – as operators struggle to control the torrents of new data traffic flowing through the network.”

– Heavy Reading

“Operators aim to use their policy platforms to develop new charging models and develop tiers of services, so they can move away from the flat-rate mobile data models that currently prevail.”

– Heavy Reading



Outline

- Introduction
- Network Management Basics
- Autonomics and Policy-based Management (PBM)
- Policy Management and Control for LTE/4G
- Conclusions



Conclusions

Summary

- Future Mobile Networks need to increase automation during all phases
 - Planning
 - Deployment
 - Optimization
 - Maintenance
- Extremely important in order to offer a competitive mobile broadband experience → 4G
 - Higher bitrates (more access & core network traffic)
 - Scalability (denser deployments, more devices)
 - OPEX reduction (heterogeneity, interoperability)



Conclusions

Summary

- Mobile networks automation can benefit from autonomic principles
 - Policy-based management
 - Self-awareness and context-awareness
 - Modular implementations of self-* capabilities
 - Control theory for closed-loop management
 - Distributed organisation and decision-making
- Future (mobile) networks automation
 - Researchers, SDOs, and Industry actively involved
 - Standards in place/progress → first market products



Conclusions

Summary

- Mobile Network Operators can benefit significantly from policy control and policy-based management
 - Increase management automation
 - Decrease network operator costs
 - Policy engine functionality aims at improving QoE
- Critical issues remain open:
 - Scalability and interoperability
 - Centralised vs. distributed control
 - Conflicting policies and policy analysis
 - Net Neutrality/Transparency controversy



Further Reading Bibliography

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