Challenges and opportunities for LTE Network Management

Antonis M. Hadjiantonis
Research Fellow
Kios Research Center
University of Cyprus

antonish@ucy.ac.cy
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

- 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
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

- Smartphone = x 24*
- Handheld Gaming Console = x 60*
- Tablet = x 122*
- Mobile Phone Projector = x 300*
- Laptop = x 515*

* 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](image)
Outline

– Introduction

– Network Management Basics

– Autonomics and Policy-based Management (PBM)

– Policy Management and Control for LTE/4G

– Conclusions
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
  - Fault
  - Configuration
  - Accounting
  - Performance
  - Security

Figure 1. FCAPS model
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)
SML: Service Management Layer (Service Level Agreements (SLAs))
BML: Business Management Layer (budgeting and billing)

Figure 1. FCAPS model
Network Management Basics

**Functional areas of management**

- **Next Generation Networks (NGN)**
  - 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 strata.

- **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](image)

Overview of 3GPP Telecom Management Domains
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
  – 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 the 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.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Example</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Secure</td>
<td>SSH, TLS, BEEP/TLS, SOAP/HTTP/TLS, ...</td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2) Messages</td>
<td>&lt;rpc&gt;, &lt;rpc-reply&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;notification&gt;</td>
</tr>
<tr>
<td>(3) Operations</td>
<td>&lt;edit-config&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4) Content</td>
<td>Configuration data</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Notification data</td>
</tr>
</tbody>
</table>

Figure 1: NETCONF Protocol Layers
Outline

– Introduction

– Network Management Basics

– Autonomics and Policy-based Management (PBM)

– Policy Management and Control for LTE/4G

– 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.

---

“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

– Introduction

– Network Management Basics

– Autonomics and Policy-based Management (PBM)

– Policy Management and Control for LTE/4G

– Conclusions
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

- Mobile Internet and Policies in Long Term Evolution (LTE)
  - LTE: Enhanced Packet Core (EPC) + LTE Radio Access Network
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
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, etc.
    - 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.

![Diagram of Policy Support in Mobile Networks]

Subscription Profile Repository (SPR)

Policy and Charging Rules Function (PCRF)

Bearer Binding and Event Reporting Function (BBERF)

Policy and Charging Enforcement Function (PCEF)

AN-Gateway

PDN-Gateway
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
    - “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

• “Perfecting policy control – strategies for end-to-end support and convergence - Ericsson.” Available Online
• An e-Guide to Policy Control, Light Reading Sponsored Whitepaper Available Online