Future Internet Monitoring and Measurement (Mo/Me) Requirements

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Joint MOMENT-PRISM Workshop on Future Internet Design:
Aspects of network monitoring, privacy and security

Monday, 28 Sept. 2009, Brussels

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Internet Evolution

- Internet Evolution has an enormous speed
  - Multiple dimensions
    - Content, Network & Services
  - Still growing amount of users and applications
  - Increased complexity
  - New business models
  - Major problems circumvented by “patching”

Future Internet

- Pervasive and Trustworthy
  - High-speed, scalable, ubiquitous, efficient, …
  - Autonomic, Cognitive Networks
  - FOT: Federated, Open, Trusted Platforms
- Revolution vs. Evolution
  - Clean-slate: Many applied patches could be avoided, all-in-one simplified architecture
  - Incremental: Complexity will increase further, autonomous networking required

2 Major Questions

- What challenges are implied on Future Internet Mo/Me?

- How can the Internet Mo/Me Community support Future Internet developments?

Mo/Me Reasons

- Mo/Me for network/service exploration
  - "only difference between network research and hacking is intention"
- Mo/Me for network/service operation
  - Closed or open loop controls
- Mo/Me for legal requirements
  - Data retention, legal interception

Mo/Me Challenges (I)

- Major network developments
  - Bandwidth
  - Number of connected devices
  - Virtual networks
    - How predictable are virtual links?
    - How to distribute slices?
  - Overlay networks
  - Critical infrastructure
    - Privacy & Security Threats
  - Extensive mobility
  - Extensive firewalling
  - QoS sensible applications
    - Measurement information across domain boundaries
- How can we approach those challenges?

Mo/Me Challenges (II)

- Increasing Mo/Me flexibility
  - Programmability of measurements
  - Configurability at runtime
  - Stay technology independent
- Providing integrated analysis
  - Apply prediction models (e.g. for mobility)
- Considering control theory
  - Performance, delay in feedback loops
    - How fast we can get measurements?
    - How accurate are they?
  - Noise-removal
  - Stability
  - Adaptive control, adaptive measurements
  - Centralised and/or distributed control

Mo/Me Challenges (III)

- Using standard metrics
- Using standard formats
  - Enable exchange of measurement data
- Introducing utility-awareness
- Considering scalability
  - Different device types
  - Different load situations
- Introducing access control
  - Encrypted storage
- Abstracting different time scales
  - Longer time scales ➔ higher abstractions

Mo/Me Challenges (IV)

- Summary
  - Environments are increasingly complex
    - Treat results correctly is a challenge
    - *Standardised models of networks*
  - Be aware of the aftermath
    - Plan measurements accordingly
  - Keep the balance
    - Path between insufficient and exhaustive monitoring is narrow

A Look Towards ANMS

(Autonomic Network Management System)

- (Autonomic) network management is a major Mo/Me application area
- Autonomic computing introduced by IBM in 2001
  - Self-CHOP properties
    - -configuration, -healing, -optimization, -protection
  - Implies self-KNOWLEDGE

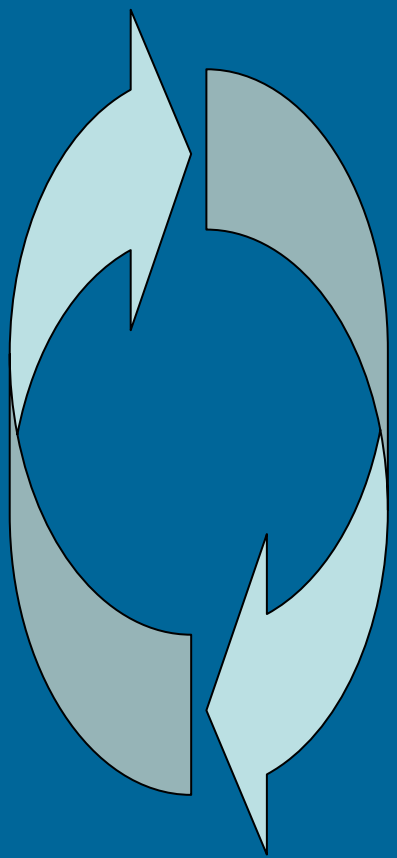
➔ **ANMS requires a network knowledge-base system (NKBS)**

ref: SAMAAN and KARMOUCH: TOWARDS AUTONOMIC NETWORK MANAGEMENT: AN ANALYSIS OF CURRENT AND FUTURE RESEARCH DIRECTIONS

ANMS - NKBS

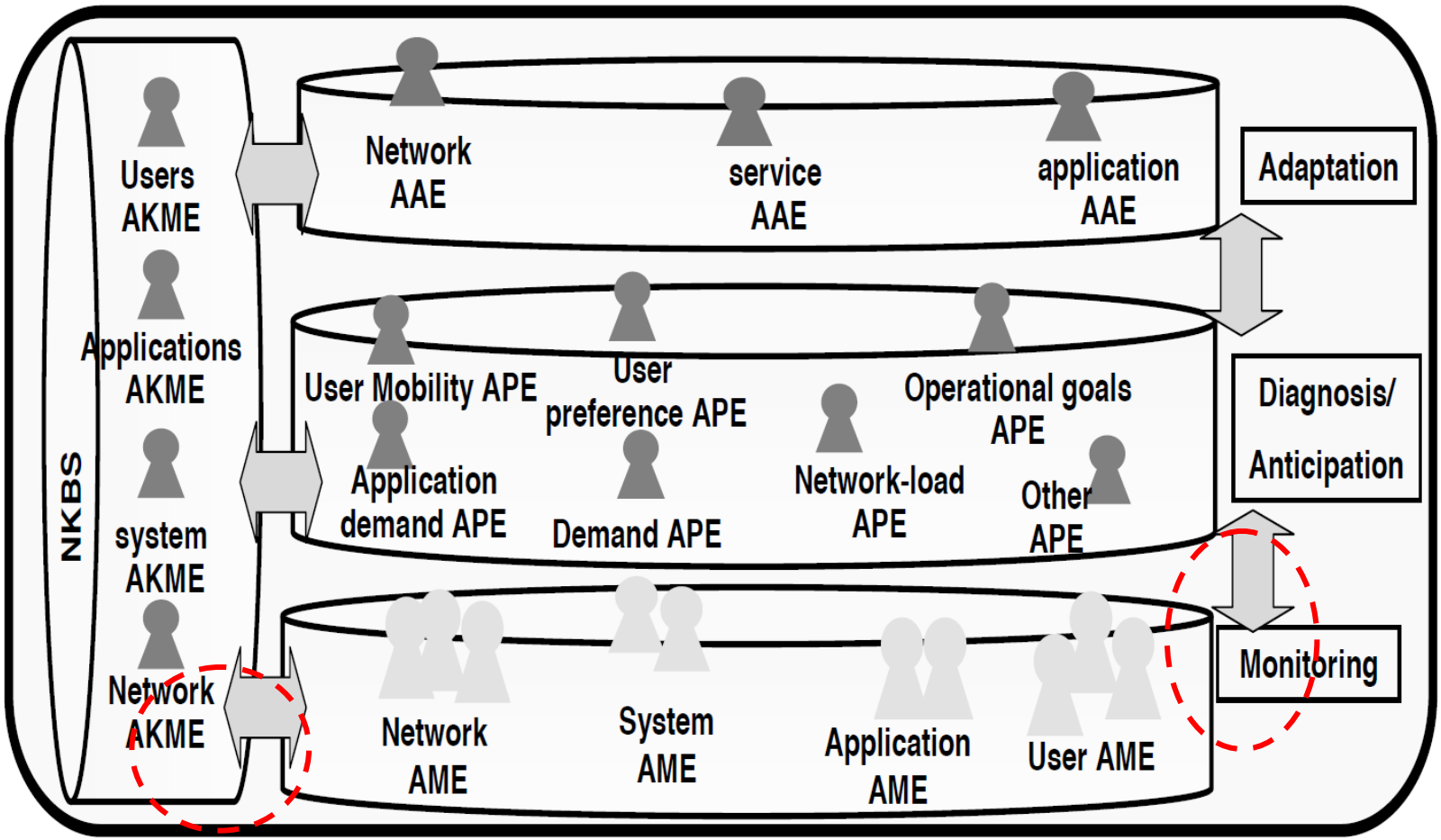
- Knowledge base
  - Key factor in autonomic management
- Types of knowledge
  - DOMAIN
    - STRUCTURE & BEHAVIOUR
    - e.g. topology and queuing mechanisms
  - CONTROL
    - Management actions: e.g. increasing buffer size
- Described in (semantic) models of
  - Network, Users, Applications, Business goals, System (Services) ➔ ETSI ISG: MOI

ANMS – the MAPE loop



- Sensor
  - Monitor
    - Symptom
  - Analyze
    - Request for change
  - Plan
    - Changed plan
  - Execute
- Effector

Mo/Me in ANMS



AKME: Autonomic Knowledge Management Entity
NKBS: Network Knowledge-Base System
APE: Autonomic Prediction Entity
AAE: Autonomic Adaptation Entity
AME: Autonomic Monitoring Entity
ADE: Autonomic Diagnosis Entity

Autonomic Monitoring in ANM

- Continuously adjust operations
  - Accuracy vs. overhead
- Different approaches
  - Active / passive / hybrid
  - Distributed / centralized
  - Granularity
    - Detail level: byte / packet / flow / aggregate
    - Sampling rate: seconds / min / hours / …
    - Spatial: end-to-end / link properties
  - Timing: interval-based / event-based
  - Programmability: dynamic modification

Conclusions

- What challenges are implied on Future Internet Mo/Me?
  - Many ➔ must keep pace with developments
- How can the Internet Mo/Me Community support Future Internet developments?
  - Provide know-how on behaviours
  - Develop new future Mo/Me applications
    - QoE-driven routing
    - Automatic identification and description of anomaly & malicious traffic/software
    - etc.

Discussions welcome!

Acknowledgements to the MOMENT+PRISM consortium members

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